US-Korea Conference

Korean-American Scientists & Engineers Association (KSEA)

UKC 2026 Florida

From Imagination to Innovation
- Into Reality

Proceeding

August 5-8, 2026
Omni Orlando Resort
https://ukc.ksea.org

Co-Organized with

The Korean Federation of Science and Technology Societies (KOFST)

The Korea-U.S. Science Cooperation Center / National Research Foundation of Korea (KUSCO / NRF)

Korean - American Scientists and Engineers Association (KSEA)

UKC 2026

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UKC 2026 Organizers

Conference Chair / Co-chair

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Oh Nam Kwon	President of KOFST	UKC 2026 Co-Chair

Program, Executive, and Workshops

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About UKC 2026

Welcome to the 39th U.S.–Korea Conference on Science, Technology, and Entrepreneurship (UKC 2026), to be held August 5–8, 2026, in Orlando, Florida. Organized by the Korean-American Scientists and Engineers Association (KSEA) in celebration of its 55th anniversary, UKC 2026 brings together leaders from academia, industry, government, and research institutions to advance global collaboration and innovation.

Under the theme ***"From Imagination to Innovation – Into Reality"*** UKC 2026 will explore how scientific ideas and technological breakthroughs are transformed into real-world impact. Through plenary lectures, signature symposia, forums, and networking opportunities, the conference will highlight the critical roles of creativity, convergence, and collaboration in an era shaped by AI, data-driven science, and advanced technologies.

As KSEA's flagship conference, UKC serves as a premier platform for sharing cutting-edge research, fostering U.S.–Korea partnerships, and nurturing the next generation of science and engineering leaders. We look forward to welcoming you to an inspiring environment where ideas become innovation and collaboration shapes the future.

US-Korea Conference (UKC)

UKC provides an environment where convergence and innovation can be ignited and implemented. It can play a major role in the Creative Economy that requires interdisciplinary integration.

UKC can play a major role in reducing the technology gap with policy makers, and build the framework to tackle global challenges through science diplomacy.

UKC fosters peer networking and mentoring, and provides a platform for current and future leaders to meet in an environment where meaningful partnerships and friendships can form and grow.

UKC Communicates Science and Technology with the public, and cultivates Science, Technology, Engineering and Math (STEM) education to empower future generations.



재미한인과학기술자협회
KSEA
Korean-American Scientists and Engineers Association

KUSCO NRF
KOREA-U.S. SCIENCE COOPERATION CENTER
National Research Foundation of Korea

KOFST
Korean Federation of

https://ukc.ksea.org

UKC History

No.	Year	Dates	Venue	KSEA President
1	1974	7/28-8/8	Seoul, Korea	Inyong Ham
2	1976	7/26-8/6	Seoul, Korea	Chong Wha Pyun
3	1978	7/10-13	Seoul, Korea	Sang-il Choi
4	1980	7/14-19	Seoul, Korea	Kwang Bang Woo
5	1982	7/13-21	Seoul, Korea	Kyungsik Kang
6	1991	11/29-12/2	Arlington, VA	Moo Young Han
7	1994	9/22-26	Alexandria, VA	Moon Won Suh
8	1995	8/31-9/4	San Francisco, CA	Dewey Doo-Young Ryu
9	1997	2/21-24	McLean, VA	Saeyoung Ahn
10	1998	4/23-25	Chicago, IL	Kyong Chul Chun
11	1998	10/22-24	Vienna, VA	Ki Dong Lee
12	1999	8/12-14	Los Angeles, CA	Hong Taik (Thomas) Hahn
13	2000	9/2-5	Chicago, IL	Howard Ho Chung
14	2001	8/10-12	Cambridge, MA	Nak Ho Sung
15	2002	7/8-11	Seoul, Korea	Chan Il Chung
16	2003	8/7-9	Caltech, CA	Quiesup Kim
17	2004	8/12-14	RTP, NC	Sung Won Lee
18	2005	8/11-13	Irvine, CA	Kwang-Hae (Kane) Kim
19	2006	8/10-13	Teaneck, NJ	Sung K. Kang
20	2007	8/9-12	Reston, VA	Kang-Won Wayne Lee
21	2008	8/14-17	San Diego, CA	Kang-Wook Lee
22	2009	7/16-19	Raleigh, NC	Chueng-Ryong Ji
23	2010	8/11-15	Seattle, WA	Jae Hoon Kim
24	2011	8/10-14	Park City, UT	Hosin David Lee
25	2012	8/8-11	Los Angeles, CA	Hyungmin Michael Chung
26	2013	8/7-10	New York, NY	Myung Jong Lee
27	2014	8/6-9	San Francisco, CA	Kookjoon Ahn
28	2015	7/29-8/1	Atlanta, GA	Youngsoo Richard Kim
29	2016	8/10-13	Dallas, TX	Jaehoon Yu
30	2017	8/9-12	Washington, DC	Eun-Suk Seo
31	2018	8/1-4	New York, NY	K. Stephen Suh
32	2019	8/14-17	Chicago, IL	Jun-Seok Oh
33	2020	12/14-17	Virtual	Soolyeon Cho
34	2021	12/15-18	Los Angeles, CA	Byungkyu Brian Park
35	2022	8/17-20	Washington D.C.	Young-Kee Kim
36	2023	8/2-5	Dallas, Texas	Yongho Sohn
37	2024	8/21-24	San Francisco, CA	Tae (Tom) Oh
38	2025	8/5-9	Atlanta, GA	Jae Hyeon Ryu

* Note the moratorium practiced in the 4th meeting, 1980.

Opening Remarks from UKC 2026 Chair



Yong Kyu "YK" Yoon

UKC 2026 Chair
President of KSEA
Professor in Electrical and
Computer Engineering,
the University of Florida

Dear KSEA Members, Distinguished Guests, Colleagues, and Friends,

On behalf of the Korean-American Scientists and Engineers Association (KSEA), it is my great honor to welcome you to the 39th U.S.–Korea Conference on Science, Technology, and Entrepreneurship (UKC 2026), held in Orlando, Florida, from August 5–8, 2026.

Since its founding in 1971, KSEA has grown into the largest Korean-American scientific and engineering organization in the United States, connecting researchers, engineers, entrepreneurs, educators, students, and leaders while advancing science, technology, and innovation and strengthening the U.S.–Korea partnership.

Together with our co-hosts, the Korean Federation of Science and Technology Societies (KOFST) and the Korea–U.S. Science Cooperation Center/National Research Foundation of Korea (KUSCO/NRF), we are delighted to welcome more than 1,000 participants from academia, industry, government, national laboratories, and research institutions.

The theme of UKC 2026, "***From Imagination to Innovation – Into Reality***," reflects our shared belief that bold ideas become transformative innovations through creativity, collaboration, and perseverance.

UKC 2026 features world-class plenary speakers, Signature Symposia in AI, Space, and Semiconductors, technical symposia, leadership and policy forums, entrepreneurship programs, sponsor forums, career development activities, and extensive networking opportunities. More importantly, it is a place where new collaborations begin, lasting friendships are built, and future leaders are inspired.

Supporting the next generation remains one of KSEA's highest priorities. Through programs such as Scientists and Engineers Early Career Development (SEED), Fostering Innovation in Rising Experts (FIRE), and the Innovation & Entrepreneurship Symposium (IES), we aim to empower students and early-career professionals to develop their careers while expanding their global perspectives and professional networks.

This year, we have also introduced several new initiatives, including organizing our 16 Clustered Technical Groups into integrated technical symposia and launching an Entertainment Technology track to reflect the growing impact of digital media, immersive technologies, and AI on education, communication, and knowledge sharing.

My administration is guided by the 4Cs—Communication, Collaboration, Community, and Creativity. These values remind us that scientific excellence is achieved not only through individual accomplishments but also through open dialogue, trusted partnerships, and a vibrant community.

I extend my sincere gratitude to our organizing committee, volunteers, sponsors, speakers, exhibitors, and participants whose dedication has made UKC 2026 possible.

I hope this conference sparks new ideas, meaningful collaborations, and lifelong friendships. Thank you for joining us in Orlando, and welcome to UKC 2026.



Yong Kyu "YK" Yoon
55th President

Welcoming Remarks from KOFST



Oh Nam Kwon

President of the Korean Federation of Science and Technology Societies (KOFST)

Distinguished scientists and engineers from Korea and the United States, and honored guests, It is my great privilege to welcome you to the 2026 US-Korea Conference on Science, Technology and Entrepreneurship (UKC-2026).

Allow me to express my heartfelt gratitude to President Yong Kyu Yoon and all the members and organizers of the Korean-American Scientists and Engineers Association (KSEA), whose dedication has made this conference possible. I offer KSEA my warmest
congratulations on its 55th anniversary this year; for more than half a century it has stood at the very center of scientific and technological exchange between Korea and the United States, and I hold its devotion in the highest regard.

Held each year to advance exchange and cooperation among Korean and American experts in science and technology, UKC reaches its 39th edition this year. It has become a leading international forum where the scientists and engineers of both nations gather to share knowledge and experience and to chart the future course of collaboration.

That UKC has come this far is owed to all of you — the more than one thousand participants who bring this gathering to life each year. Orlando, our host city, is a place where imagination and daring live side by side. Disney World, which has shaped humanity's dreams into reality, and the Kennedy Space Center, which launched those dreams into space, stand together beside this one city.

A place that reveals, at a single glance, the whole path from imagination to reality, Orlando is the perfect stage for this year's theme. The theme of this year's conference is "***From Imagination to Innovation — Into Reality***."

Einstein once said, "***Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world***." The world is not something already finished; it lies open with possibilities not yet drawn. Imagination is the power to picture, ahead of its time, what has not yet come. Every advance in science and technology has begun with those who first imagined and drew out the latent, not-yet-realized possibilities of the world — which is how things once thought impossible have become innovations, and at last realities that change our lives.

At this very moment, across artificial intelligence, semiconductors, biotechnology, quantum technology, and aerospace, those possibilities are crossing over into reality. Yet imagination alone does not become reality.

On the eve of humanity's journey to the Moon, President Kennedy declared, "***We choose to go to the Moon ... not because they are easy, but because they are hard***," and that audacious dream became reality right here, at the Kennedy Space Center on the coast of Florida.

The power to draw what is not yet into reality has always lain in the courage to take, willingly, the hardest road. And that courage needs a direction.

In recent interviews I have stressed that in an age of AI, science must take up all the more clearly its role of asking "***why.***" The more AI quickens the speed and efficiency of research, the more deeply we must ask where our technology ought to be headed, and why a given problem is worth solving. Imagination draws what is not yet; courage walks the road; and the question "***why***" sets its direction.

This year also marks the 60th anniversary of the Korean Federation of Science and Technology Societies (KOFST). KOFST has adopted "***Innovation through Resonance***" as its new vision as it prepares for the next sixty years. We believe greater innovation becomes possible when the capabilities and voices of scientists and engineers resonate together across different fields, generations, and nations.

UKC is precisely such a place of connection and resonance between the scientists and engineers of Korea and the United States — a place where our shared journey, choosing to go far together rather than fast alone, carries on. May UKC-2026 be more than an occasion for academic exchange: may it be a place where the scientists and engineers of Korea and the United States stand together, for the sake of future generations, before the hardest questions.

Here in Orlando, where imagination and reality meet in a single city, I trust that the insights and bonds you share will become the force that draws what is not yet into reality.

Thank you.

Welcoming Remarks from KUSCO/NRF President



Won-Hwa Hong

President of Korea-U.S. Science Cooperation Center

President of National Research Foundation of Korea

Distinguished Guests,

It is my great pleasure to welcome you to the 2026 US–Korea Conference on Science, Technology, and Entrepreneurship.

I would like to extend my heartfelt congratulations on the convening of UKC 2026 in Florida — an occasion that, year after year, bridges the scientific and technological communities of Korea and the United States, reaffirming our deep mutual trust, enduring partnership, and shared vision for a brighter future.

This year holds special significance, as the Korean-American Scientists and Engineers Association (KSEA) celebrates its 55th anniversary. As we mark the 39th UKC, I wish to express my profound appreciation to KSEA for its unwavering dedication and tireless efforts over the decades — serving as a vital bridge between researchers of both nations, fostering meaningful networks, and strengthening research partnerships.

As we move from 2025 into 2026, science and technology once again find themselves at the crest of a transformative wave. Artificial intelligence has not only become woven into the fabric of everyday life, but is now driving an entirely new paradigm of scientific discovery.

In this context, the United States has officially launched the Genesis Mission to accelerate AI-driven scientific research, while Korea has embarked on the K-Moonshot Program — an initiative to harness the convergence of AI and S&T in addressing national strategic challenges and leading innovation. I deeply realize that we are living in a time when fundamental changes in the research environment have already begun.

Against this backdrop, expectations for UKC 2026, which will be held under the theme "***From Imagination to Innovation—Into Reality***", are higher than ever. This conference will explore how scientific ideas and technological breakthroughs translate into real-world impact, and will illuminate the critical roles of creativity, convergence, and collaboration in an era shaped by AI, data-driven science, and advanced technology.

In October 2025, Korea and the United States signed a Memorandum of Understanding on Technological Prosperity, expanding our bilateral research partnership into key strategic domains including artificial intelligence, quantum technologies, biotechnology, and space. The strategic partnership will enable the alliance between the two countries to be much stronger.

I firmly believe that addressing the complex and pressing challenges facing our world today requires close cross-border cooperation, and above all, collaboration among our scientists and engineers is essential.

In this spirit, the National Research Foundation of Korea (NRF) is fully committed to expanding opportunities for researcher exchanges, joint research, and other scientific activities within the framework of bilateral/multilateral cooperation between Korea and the United States. We will continue to build close partnerships that transcend national boundaries and maintain flexible frameworks for research collaboration.

I am confident that UKC 2026 will once again yield valuable insights and proposals that help shape the future direction of Korea-US science and technology cooperation. The NRF will remain steadfast in its support, ensuring that researchers from both nations can engage in open dialogue and drive innovation together.

In closing, I wish to express my deepest gratitude to Professor Yong Kyu Yoon, President of KSEA, Professor Oh Nam Kwon, President of Korean Federation of Science and Technology Societies (KOFST), and all those who have worked tirelessly to make this year's UKC a great success.

I wish you all good health and prosperity.

Thank you very much.

August 2026

Won-Hwa Hong

President, Korea-US Science Cooperation Center
President, National Research Foundation of Korea

Welcoming Remarks from UKC 2026 Program Chair



Gloria J. Kim

UKC 2026 Program Chair

Dear Participants of UKC 2026,

It is my great honor to welcome you to the 39th U.S.-Korea Conference on Science, Technology, and Entrepreneurship (UKC 2026).

For nearly 40 years, UKC has served as a premier forum where scientists, engineers, entrepreneurs, educators, and policymakers from the United States and Korea come together to exchange ideas, foster collaboration, and build lasting partnerships. This year's theme, "***From Imagination to Innovation – Into Reality***," celebrates the journey from bold ideas to transformative discoveries and real-world impact. It reflects our shared commitment to advancing science and technology that benefits society through creativity, collaboration, and innovation.

We are delighted to host UKC 2026 in Orlando, Florida, a city recognized not only as a world-renowned destination but also as a growing center for aerospace, simulation, advanced technologies, and entrepreneurship. With its proximity to Florida's Space Coast and vibrant innovation ecosystem, Orlando provides an ideal setting for exploring new frontiers in science and technology while strengthening U.S.–Korea collaboration.

This year's program features an outstanding lineup of Plenary Sessions, Technical Group Symposia, Signature Symposia, Sponsor and KSEA Forums, and special programs including SEED (Science and Engineering Early Career Development), FIRE (Fostering Innovation in Rising Experts), and the Innovation & Entrepreneurship Symposium (IES). The Poster Session will showcase cutting-edge research from students, postdoctoral researchers, and professionals, creating valuable opportunities to exchange ideas and build new collaborations.

I extend my sincere appreciation to our co-organizing societies, sponsors, organizing committee, technical group leaders, KSEA staff, and dedicated volunteers whose hard work and commitment have made UKC 2026 possible.

It is a privilege to welcome all of you to UKC 2026. I hope this conference inspires new ideas, meaningful collaborations, and lasting friendships. May your time in Orlando be intellectually rewarding, professionally enriching, and personally memorable.

Thank you for being part of UKC 2026, and I wish you a productive and inspiring conference.

Warmest regards,

Gloria J. Kim

Assistant Professor, Department of Engineering Education
Affiliate Faculty, Department of Electrical and Computer Engineering
Herbert Wertheim College of Engineering, University of Florida

Congratulatory Remarks

August 6, 2026



YOUNG KIM
40TH DISTRICT, CALIFORNIA

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WASHINGTON, DC 20515
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ANAHEIM, CA 92808
PHONE: (714) 984-2440

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200 CIVIC CENTER
MISSION VIEJO, CA 92691
PHONE: (949) 268-6706

www.youngkim.house.gov
@REPYOUNGKIM

Young Kim

Member of Congress,
40th District, California

Dear Friends:

I want to welcome everyone to the 39th U.S.–Korea Conference on Science, Technology, and Entrepreneurship. Thank you to the Korean-American Scientists and Engineers Association (KSEA) for bringing together scientists, engineers, entrepreneurs, policymakers, and industry leaders from both the United States and Korea.

With this year's theme of "***From Imagination to Innovation– Into Reality***", I know you will be exploring how to turn scientific ideas and technological breakthroughs into real world impacts.

I trust that this conference will be a productive forum of sharing cutting-edge research, fostering stronger U.S.–Korea partnerships, and nurturing the next generation of science and engineering leaders.

It is an honor to serve you in the United States Congress, and I look forward to working with you to serve our community. Once again, congratulations and best wishes for a successful event.

Sincerely,

Young Kim
Member of Congress, 40th District

Congratulatory Remarks

Consul General
of the Republic of Korea
Atlanta, Georgia

August 6, 2026



Joon Ho Lee

Consul General of the Republic of Korea in Atlanta

To all who have gathered to participate in the 2026 U.S.-Korea Conference on Science, Technology, and Entrepreneurship (UKC), congratulations on the opening of UKC 2026.

Now in its 39th year, UKC has grown into one of the premier forums for Korean-American scientists and engineers, as well as leading researchers from both Korea and the United States. It is a place where the defining scientific challenges of our time are explored, ideas are exchanged, and bridges are built across generations, disciplines, and borders. It brings together senior and emerging leaders in science and engineering, while fostering closer collaboration among academia, industry, and government.

As the United States commemorates the 250th anniversary of its independence this year, it is especially fitting that the Korean-American Scientists and Engineers Association (KSEA) celebrates its 55th anniversary—a milestone of steadfast commitment to advancing Korea-U.S. cooperation in science and technology. The phrase our two governments use to describe our relationship—a "***future-oriented comprehensive strategic alliance***"-finds one of its clearest expressions in gatherings like UKC, where partnerships are strengthened, innovation is advanced, and the future of our alliance is shaped.

This year's theme, "***From Imagination to Innovation - Into Reality,***" is especially meaningful as artificial intelligence continues to transform our world at an extraordinary pace. Even in the age of AI, imagination remains uniquely human—and so does the determination to turn imagination into reality. I hope you will challenge and inspire one another, forge new partnerships, and together transform today's imagination into tomorrow's innovation, creating solutions that contribute to peace, prosperity, and the well-being of people around the world.

Once again, congratulations on the opening of UKC 2026. I wish you a productive and inspiring conference, and continued progress in strengthening the scientific partnership between Korea and the United States.

Sincerely,

Joon Ho Lee
Consul General of the Republic of Korea in Atlanta

Congratulatory Remarks



Alexander N. Cartwright

President of University of Central Florida

On behalf of the University of Central Florida, it is my pleasure to welcome you to Central Florida for the 2026 U.S.–Korea Conference on Science, Technology, and Entrepreneurship.

This conference brings together researchers, entrepreneurs, industry leaders, and students who share a common belief: that the world's most important challenges are best addressed through collaboration, discovery, and the exchange of ideas.

For decades, the partnership between the United States and the Republic of Korea has advanced scientific discovery, strengthened technological innovation, and created opportunities that extend far beyond our two nations. Universities have helped sustain that progress by educating talent, advancing research, and bringing people together around shared challenges. This conference continues that tradition by fostering new relationships, encouraging interdisciplinary collaboration, and inspiring the next generation of innovators.

I extend my sincere appreciation to the conference organizers, volunteers, sponsors, and participants whose commitment makes this gathering possible. Your work reflects the spirit of curiosity, partnership, and shared purpose that drives progress.

I hope your time in Central Florida is productive, inspiring, and filled with meaningful conversations that lead to new ideas and lasting collaborations.

Welcome, and congratulations on successful UKC 2026.

Alexander N. Cartwright
President
University of Central Florida

Aerospace / Ocean

The Role of Submerged Aquatic Vegetation in Coastal Protection and Resilience

Hyun Dong Kim[1]
[1]Department of Civil and Environmental Engineering, Old Dominion University, h1kim@odu.edu

I. SUMMARY

Nature-based solutions (NBS) are increasingly recognized for their role in enhancing coastal resilience. Among these, submerged aquatic vegetation (SAV) serves as an effective means of dissipating flow energy, promoting sediment deposition, and stabilizing coastal systems. However, the hydrodynamic behavior of flexible vegetation under varying flow conditions remains insufficiently understood. To address this knowledge gap, this study integrates laboratory experiments and computational fluid dynamics (CFD) modeling to investigate the flow–vegetation interactions and turbulence characteristics of flexible SAV.

II. METHODS

Physical experiments were conducted in a 4-m-long wave flume equipped with artificial vegetation patches (1,200 stems/m²) as shown in Figure 1. The flexible stems, constructed from cellophane with a Young's modulus of 1,325 MPa, simulated the natural motion of SAV. Flow velocities were measured at multiple vertical layers and longitudinal positions using a 2D L-shaped velocimeter. 2D and 3D CFD models were developed in OpenFOAM to analyze hydrodynamic responses under steady flow as shown in Figure 2. The 2D model quantified stem deformation and flow resistance at various Cauchy (Ca) numbers, while the 3D model resolved wake development, vortex shedding, and turbulent kinetic energy (TKE) distribution downstream of the vegetation patch. Model development and validation followed methodologies described in Kim et al. (2024) and Kim (2025).

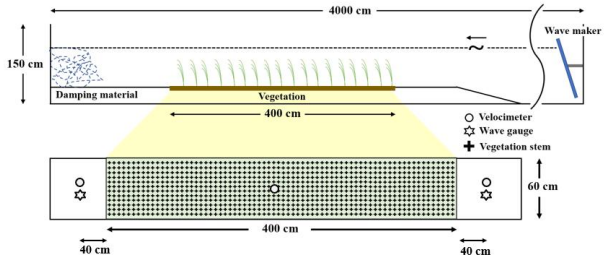


Figure 1: Physical Model Experiment Setup

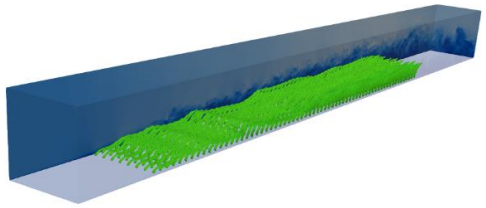


Figure 2: Example Case for the 3D CFD Simulation

III. RESULTS AND DISCUSSION

Experimental measurements showed a significant reduction in mean velocity and turbulence intensity within the vegetation region, confirming the damping effect of flexible SAV as shown in Figure 3. The 2D CFD simulations indicated that vegetation flexibility enhances flow–structure coupling, leading to increased stem deformation and decreased drag coefficients. The 3D model revealed coherent vortices and wake recovery zones, with TKE concentrated near stem tips and downstream shear layers. These results highlight the strong dependency of hydrodynamic patterns on vegetation stiffness and flow regime, demonstrating how flexibility influences momentum exchange and energy dissipation.

IV. CONCLUSION

This study provides a comprehensive understanding of the hydrodynamic mechanisms of flexible submerged vegetation through combined experimental and numerical analyses. The results emphasize the critical role of vegetation flexibility in modulating turbulence and flow resistance, offering valuable insights for designing vegetation-based coastal protection systems and advancing predictive modeling of NBS applications.

REFERENCES

1. Kim, Yu, Kaplan (2024): Steady flow over a finite patch of submerged flexible vegetation, *Water Resources Research*, vol. 60, issue 1, pp. e2023WR035222.
2. Kim, H. D. (2025): Fluid–structure interactions of submerged aquatic vegetation in the coastal system: Integrating steady and oscillatory flow dynamics through coupled simulation (Doctoral dissertation, University of Florida).

Performance Evaluation of Transport Algorithms in the General Ocean Model (GOM)

Jungwoo Lee
Department of Engineering, East Carolina University, Greenville, NC, 27858

I. Introduction

The General Ocean Model (GOM) is a three-dimensional ocean circulation model based on an unstructured grid framework, incorporating both finite-volume and finite-difference approaches. To improve its capability in simulating density-driven flows in coastal and estuarine environments, two advanced transport schemes have recently been integrated: a second-order Total Variation Diminishing (TVD) scheme and an unconditionally stable Eulerian–Lagrangian Method (ELM) for scalar transport.

II. Transport Equations in GOM

The scalar transport equation in a Cartesian coordinate system can have the following form (Lee et al., 2025):

$$\frac{\partial C}{\partial t}+\frac{\partial uC}{\partial x}+\frac{\partial vC}{\partial y}+\frac{\partial wC}{\partial z} = K_h\left(\frac{\partial^2 C}{\partial x^2}+\frac{\partial^2 C}{\partial y^2}\right)+\frac{\partial}{\partial z}\left(K_v\frac{\partial C}{\partial z}\right)$$

where $u, v,$ and w are the velocity components in the horizontal $x, y,$ and z direction; K_h and K_v are the horizontal and vertical turbulent eddy diffusivities; and C denotes the concentration of any scalar transported species.

The TVD scheme consists of a first-order upwind portion and a second-order flux limiter portion (Lee et al., 2025). The ELM scheme involves backtracking Lagrangian trajectories. Tracking begins at an element face of a velocity node, after which the foot of the trajectory is determined. Once the trajectory foot is located, the Eulerian velocity is evaluated using one of the interpolation functions.

III. GOM – Application in Mobile Bay

The TVD and ELM transport algorithms were implemented in GOM and applied to Mobile Bay, USA. The model grid comprises 18,718 nodes and 35,127 elements, with horizontal resolution varying from 67 m to 4.5 km, and 40 vertical layers. Each algorithm was tested using an identical time step of 150 s over a simulation period of 180 days.

IV. Results

This study evaluates the computational performance of implemented transport schemes using a Mobile Bay case study. Simulation time comparisons yield a relative performance ratio of 1 (ELM): 2.2 (upwind): 3.7 (TVD), indicating that the ELM scheme is the most computationally efficient. However, the ELM scheme exhibits noticeable numerical dissipation (Figure 1), whereas the results from the 1st-order upwind scheme are comparable to those of the TVD scheme.

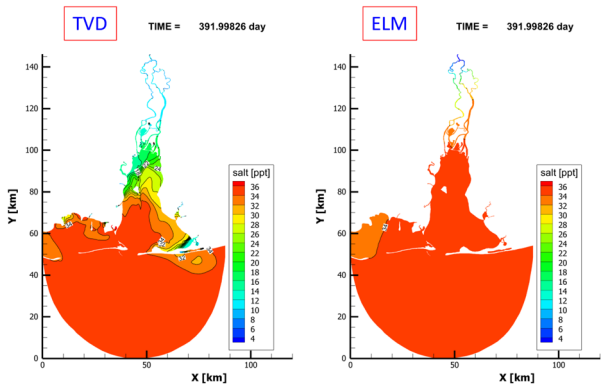


Figure 1: Comparison of salinity simulation results obtained with the TVD and ELM transport schemes.

ACKNOWLEDGEMENTS

The author acknowledges support from startup funding provided by East Carolina University.

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CABLESSail: Solar Sail Momentum Management Using Shape Control

Soojeong Lee, Ryan J. Caverly
Department of Aerospace Engineering and Mechanics, University of Minnesota, Minneapolis, MN

I. INTRODUCTION

Solar sails provide the possibility for spacecraft propulsion without fuel, opening up missions that would otherwise require unrealistic amounts of fuel. Future solar sails are being designed with larger areas to increase their efficiency, which causes them to have more structural flexibility. This increases the likelihood of the sail taking on undesirable shapes and experiencing significant disturbance torques. Although reaction wheels can be used to control the attitude of the solar sail in the presence of disturbance torques, they face limits on their operational speed and require additional actuation for momentum management to allow them to desaturate. Even though there exist actuators such as the active mass translator and reflectivity control devices (RCDs) to assist with this, momentum management remains a significant challenge, particularly with the design of larger solar sails.

II. MOMENTUM MANAGEMENT METHOD

The Cable-Actuated Bio-inspired Lightweight Elastic Solar Sail (CABLESSail) concept, shown in Figure 1, is being developed at the University of Minnesota to address some of the challenges of solar sail momentum management. It is composed of cables routed along the solar sail's booms actuated by motors in the spacecraft bus, where tensioning the cables allows for controlled deformation of the booms. An advantage of CABLESSail over other momentum management actuation methods is that it takes advantage of the inherent structural flexibility to enable control over the shape of the sail. This allows for the cable-driven actuators to be lightweight and scale with the size of the sail, as the actuation torques scale with the disturbance torques.

III. DEVELOPMENT OF CABLESSAIL CONCEPT

This presentation provides an update on the development of the CABLESSail concept, including the generation of an open-source dynamic model for the concept; static and dynamic analyses of CABLESSail's torque-generation capabilities; the design and analysis of a feedback control method to reliably deform the booms using cable actuation; and testing with a small-scale CABLESSail prototype. It is particularly noteworthy that the analysis performed in this work indicates that CABLESSail is capable of generating roll torques that are at least as large as those produced by RCDs. A significant portion of the presentation will focus on our proposed control allocation technique that determines which booms to deform with CABLESSail to reliably generate the desired momentum management torque. This is not trivial, as there exist multiple boom deflection combinations that generate the same torques, and uncertainty in the shape of the sail membrane makes it difficult to do this reliably. Our proposed control allocation approach determines the optimal combination of boom deflections at a specific sun incidence angle and clock angle, while assessing the range of uncertainty on the torque generated due to membrane shape uncertainty. This paper presents critical simulation and experimental results towards increasing CABLESSail concept to technology readiness level 3.

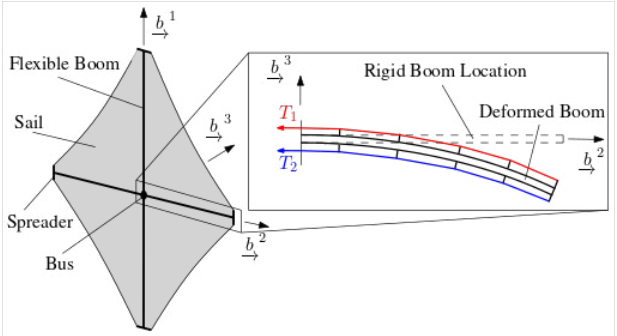


Figure 1: An illustration of the CABLESSail concept.

ACKNOWLEDGEMENTS

This work was supported by an Early Career Faculty grant from NASA's Space Technology Research Grants Program under award No. 80NSSC23K0075.

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µLIBS : ELEMENTAL MAPPER, IN SITU PLANETARY EXPLORATION

Dong Jae Lee[1], H. T. Manelski[1] , C. C. Bedford[1] , R. C. Wiens[1] , S. Clegg[2] , W. Rapin[3]

[1]Department of Earth, Atmospheric, and Planetary Sciences, Purdue University, [2]Los Alamos National Laboratory, [3]Institut de Recherche en Astrophysique et Planétologie, CNES

I. Introduction: Mineral prospecting for KREEP-rich material and quantifying volatile inventories on the lunar surface are not only subjects of investigations outlined in the Artemis Since Definition Team Report but also of major geopolitical significance [1]. A diversity of terrains has been observed in the solar system from orbit or even in situ, yet remain of uncertain origin, holding clues to major planetary science questions [2]. To address these, recent instrument deployments have demonstrated the power of fine-scale composition analysis. It took the PIXL instrument onboard NASA's Perseverance rover a single elemental map to prove the cumulate nature and alteration history of rocks in the Jezero crater floor [3]. Micro-mapping associates chemical composition with submillimeter-scale components crucial to reconstruct the processes that generated these features.

Laser Induced Breakdown Spectroscopy (LIBS) provides elemental abundances at submillimeter scales on exposed rocks while removing surface dust. It can quantify the abundance of major elements (Si, Fe, Mg, Al, Ca, K, Na, Ti) in addition to all light elements relevant to organics and volatiles (C, H, N, O, P, S) and other minor or trace elements (Li, Sr, Cr, Rb, Mn...), providing essential insights into geological processes of either rocky or icy planetary surfaces.

II. Technology and LIBS Mapping

LIBS is now widely used in the laboratory for micro-mapping. On Mars [4–6] it proved a reliable and capable tool for geological investigation and also performed in lunar conditions. However, none of these instruments were capable of fine-scale mapping. Based on SuperCam heritage and recent miniaturization efforts, we propose a new ≤ 1.5 kg instrument to perform LIBS micro-mapping. LIBS mapping—dense raster scanning at 150–200 µm spacing—creates mm- to cm-scale chemical maps, revealing heterogeneity within a geological sample. This capability greatly enhances landed mission science by identifying mm-scale textures, similar to PIXL XRF on Perseverance, but with the added advantage of detecting light elements such as hydrogen. LIBS's ability to detect hydration and volatiles makes it particularly valuable for Lunar exploration.

This study describes a planetary mission-relevant LIBS mapping experiment using a µLIBS system in a vacuum chamber under Lunar and Mars atmospheric conditions, combined with custom software and PCA-based visualization. Major element calibration with a flight-relevant lunar LIBS setup and applies it to commonly applied to LIBS calibrations (GBR, and Elastic Net). These algorithms use the entire spectrum, or large parts of it, to consider many emission lines and the dependencies that may exist between them.

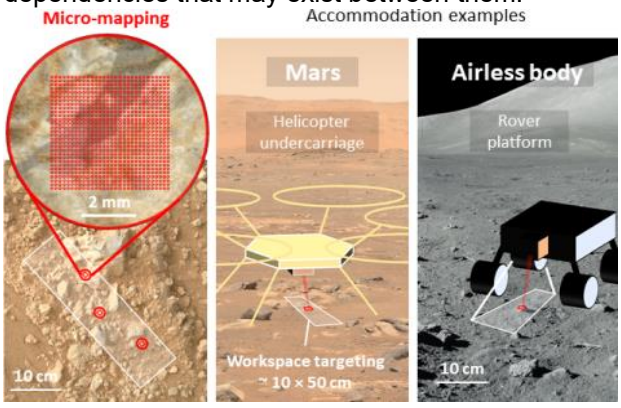


Figure 1: µLIBS, a compact opto-electronic system. Workspace targeting and micro-mapping with 30x30 points grid on target. µLIBS accommodations onboard ~30 kg platforms.

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Knowledge-Graph Integrated Agentic Physical/Shadow AI for Autonomous Ships: A Hybrid Approach with LLM and Ontology

Geon-Woo Kim[1], So-Won Choi[1], Eul-Bum Lee[1]
[1]Graduate Institute of Ferrous and Eco Materials Technology (GIFT), Pohang University of Science and Technology (POSTECH), 77 Cheongam-Ro, Nam-Ku, Pohang, 37673, Korea. Email: dreblee@postech.ac.kr

I. INTRODUCTION

The practical deployment of Maritime Autonomous Surface Ships (MASS) requires AI decisions that are safe, explainable, and compliant with international navigation rules. In autonomous vessels, the Physical AI perceives and assesses the operational situation from sensor inputs and actively performs physical control of the ship. In contrast, the Shadow AI operates within a digital-twin environment that mirrors the actual vessel, and plays a central role in autonomous navigation by verifying the behavior of the Physical AI and learning from previously unseen scenarios. This study proposes a Shadow AI model that integrates a maritime ontology, a knowledge graph (KG), GraphRAG, and an LLM.

II. METHODOLOGY

A. Maritime Ontology and KG

The proposed maritime-domain ontology encompasses COLREG Rules 5–19, vessel entities, encounter situations, marine environmental conditions, vessel maneuvering characteristics, and collision-risk indicators. It is grounded in the ISO 21838-2 basic formal ontology. Collected maritime knowledge assets are normalized as Subject–Predicate–Object (SPO) triples and assembled into a KG. The resulting KG semantically links the diverse encounter situations arising during navigation to their applicable COLREG provisions and recommended actions, thereby providing a knowledge base on which MASS can perform rule-based reasoning.

B. GraphRAG and LLM Reasoning

GraphRAG traverses KG relationships to retrieve COLREG provisions, encounter types, risk indicators, and historical cases relevant to the current navigational context, thereby providing grounding evidence to the LLM. Based on this evidence, the LLM generates an explanation covering situation awareness, applicable rules, risk assessment, and recommended actions. The generated output is validated against SHACL constraints for semantic consistency. Through this process, the Shadow AI presents—for every autonomous decision made during navigation—the applied rules, supporting provisions, risk assessment, and recommended actions in natural language, thereby ensuring the explainability of MASS operation.

C. Edge–Cloud Deployment

The proposed system adopts a two-tier edge–cloud architecture comprising shipboard edge and shore-based data center cloud components. At the edge, a lightweight ontology and a small language model support real-time inference under communication-constrained conditions. In the cloud, the full ontology, KG, GraphRAG, and LLM are used to analyze decision-gap intervals and retrain the Shadow AI.

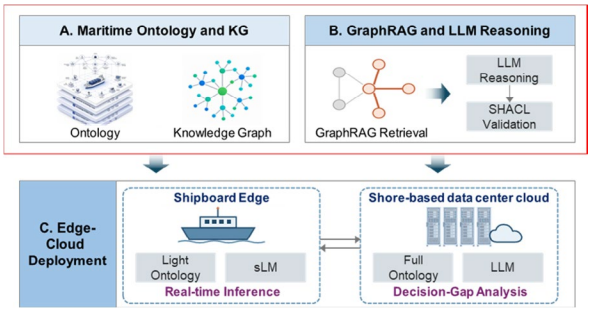


Figure 1: The development process of the ontology and LLM-based Shadow AI for MASS

III. CONCLUSIONS

The proposed system will be developed over the next four years, progressing from maritime-domain ontology and KG construction to the GraphRAG–LLM reasoning pipeline, edge–cloud integration, and real-vessel validation. Using an expert-reviewed COLREG QA dataset and an ontology triple-validation set, the final targets are set at 95% LLM-AI response accuracy and 95% ontology semantic accuracy. This work is expected to provide applicable technical evidence for MASS verification and certification, public maritime AI development, and IMO/ISO standardization discussions.

ACKNOWLEDGEMENTS

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Geometry-Controlled Deployment Energy in FW-TAK Kirigami

Yeongeun Ki[1], James Gibert[1]

[1] Purdue University, School of Mechanical Engineering, West Lafayette, USA

I. SUMMARY

Folding-wall tension-activated kirigami (FW-TAK) is a class of cut-sheet structures that converts flat sheets into three-dimensional folded walls when pulled in tension, enabling lightweight, conformable load-bearing architectures. While prior work has demonstrated that these folding-wall patterns can achieve stiffness and strength comparable to honeycomb cores, the detailed mechanics of their deployment pathway and the role of geometric parameters remain underexplored.

In this work, we develop a parametric finite element framework to study how slit geometry and prescribed geometric imperfections govern the deployability and force–rotation response of FW-TAK systems. Abaqus/Standard simulations are constructed for baseline parallel-slit folding-wall architectures and for tapered “hourglass” slit designs, and the predictions are compared against experiments using 3D-printed thermoplastic polyurethane (TPU) specimens under uniaxial tension. The model captures the onset of out-of-plane buckling and the transition from the flat state into the folded-wall configuration, reproducing the key qualitative features of the experimentally observed deployment sequence.

We then perform parametric studies over slit taper and prescribed imperfection amplitude to quantify their effects on activation force and maximum hinge rotation. For the range of imperfection amplitudes considered, both standard and tapered FW-TAK patterns are largely insensitive to the specific imperfection magnitude, indicating that modest geometric imperfections are sufficient to trigger the desired folding mode. In contrast, the slit geometry strongly affects performance: tapered hourglass patterns achieve larger folding angles at lower activation forces than parallel-slitted counterparts. This behavior is attributed to the shortening of the effective hinge length as taper increases, which reduces local bending stiffness in the neck region and thereby lowers the force required to drive rotation.

Together, these results show that FW-TAK deployment and structural response can be systematically tuned by geometric design rather than material changes alone. By selecting slit taper and related geometric parameters, designers can prescribe both the maximum hinge rotation and the activation force, enabling bounded and self-limiting deployment pathways or more monotonic, highly deployed configurations as needed. The proposed parametric framework provides a geometry-driven route for designing deployable kirigami structures for applications such as conformable structural panels, morphing surfaces, and protective metamaterial skins.

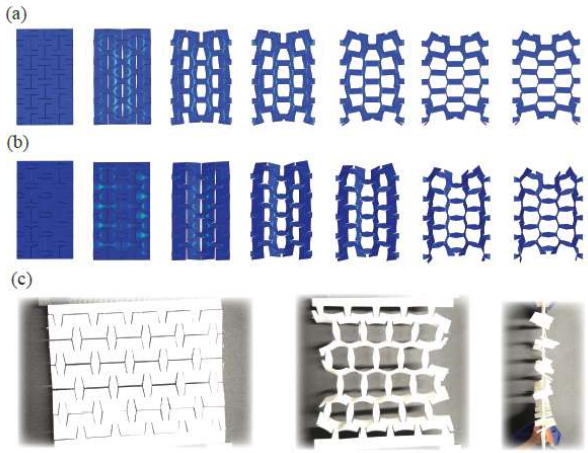


Fig. 1. Deployment and force–rotation response of folding-wall tension-activated kirigami (FW-TAK) structures, showing how slit taper controls activation force and maximum hinge rotation.

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Beyond the Cradle: Structural Foundations for the First Step of Human Civilization on the Moon

Simon Shim, P.E.
New Jersey Institute of Technology & Active Design Group

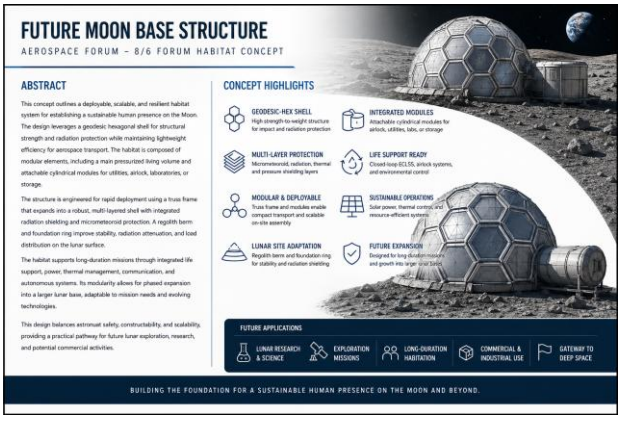
Humanity is entering a new era of space exploration. NASA recently announced plans for a permanent lunar base targeted for completion by 2033. With the success of Artemis II in demonstrating the practicality of sending four astronauts beyond Earth orbit, the vision of a long-term lunar settlement is becoming increasingly realistic within our generation. At the same time, the American Society of Civil Engineers published an article in March 2026 titled *"Civil Engineers Can Help Make Mars a Second Home for Humanity."* Combined with the discoveries of the James Webb Space Telescope and the upcoming launch of the Nancy Grace Roman Space Telescope, it is clear that we are living in an unprecedented and exciting period of exploration and technological advancement. As engineers, we must align ourselves with this momentum through innovation, research, and interdisciplinary collaboration.

The Moon represents humanity's nearest opportunity for extraterrestrial settlement and serves as the essential proving ground for future Mars missions. Establishing a permanent lunar presence requires an interdisciplinary strategy integrating structural engineering, deployable architecture, robotics, and in-situ resource utilization (ISRU).
The proposed habitat adopts a hybrid structural system composed of geodesic and hexagonal shell geometries designed for impact resistance and efficient load distribution, combined with pressurized internal habitation modules. A prefabricated truss framework, optimized for launch efficiency, enables robotic deployment and phased expansion over time. This concept aligns with a NASA Class II habitat while providing a pathway toward Class III fully in-situ constructed infrastructure as the settlement grows.

ISRU forms the logistical and structural backbone of the lunar settlement strategy. Compacted lunar regolith can provide radiation shielding and thermal mass without dependence on Earth-supplied materials. Foundation systems must efficiently transfer loads under one-sixth Earth gravity conditions, while modular docking interfaces support scalable future growth.

In parallel, critical life-support infrastructure must be developed alongside structural systems. Water extraction from lunar polar ice, oxygen generation through electrolysis, and integrated solar and nuclear power systems are essential components civil engineers will help design and deliver for sustainable habitation. Grounded in NASA's Functional Capabilities Work Breakdown Structure, this framework positions civil and structural engineers as primary contributors throughout every project phase — from site surveying and material validation to autonomous construction and lifecycle management.

The Moon is therefore not only humanity's first home beyond Earth, but also the indispensable testbed for autonomous construction technologies, ISRU material performance, and habitat resilience before any permanent commitment to Mars exploration.



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Indigenous Development of High-Resolution Optical Camera for CAS500(Compact Advanced Satellite 500) -1 and -2 in Korea

Deoggyu Lee[1], Youngsun Kim[1], Eunsu Kang[1], Jingwang Kim[1], Seunghun Ha[1]
[1]Korea Aerospace Research Institute

I. What is CAS500(Compact Advanced Satellite 500) -1 and -2

Korean MSIT(Ministry of Science and ICT) has decided to develop middle class satellite(~ weight 500kg) in an attempt to get satellite development be cost effective, high performance, indigenous key components and most of all satisfy various civilian needs. The first two satellites of the program, CAS500(Compact Advanced Satellite 500) -1 and -2, supported by Korean MOLIT(Ministry of Land, Infrastructure and Transport) have been developed for Korean land and Resources monitoring and 3-D stereo imaging with optical camera(GSD 0.5m and swath 12km). The first satellite(CAS500-1) in the series was launched on 22 March 2021 and has successfully completed its mission life(4 years) as of 22 March 2025. CAS500-1 has not only produced complete images of Korean territory but also provided satellite image services for International Charter Space and Major Disasters. The second satellite (CAS500-2) was launched on 3 May 2026 and now under rigorous calibration process.

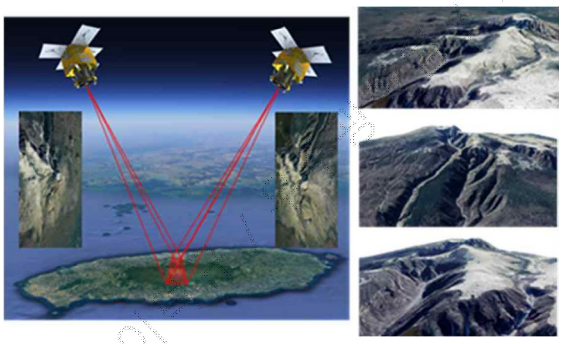


Figure 1: CAS500-1 and CAS500-2 satellites in constellation

II. How were High-Resolution Optical Cameras for CAS500(Compact Advanced Satellite 500) -1 and -2 indigenously developed in Korea

High Resolution Optical Cameras mounted on the CAS500 satellites, so called AEISS-C(Advanced Earth Imaging Sensor System-Compact) were developed by the Joint team of KARI(Korea Aerospace Research Institute) and Korean Industries. All development activities from design, key component fabrications, system integration through performance verification were indigenously carried out by Korean engineers and in Korean facilities. All key units including mirrors, high stability telescope structure, focal plane electronics, image data handling unit, X-band transmitter and X-band Antenna were indigenously developed by Korean industries. We are proud to have been able to localize 98.6% of the key components and core technologies that have been dependent upon overseas technology until now.

Table 1: Key units indigenously developed in Korea

Unit		Manufacturer	Key performance
Mirror		KRISS (@KOREA)	D: 0.6m WFE < 24nm
High Stability Telescope Structure		DACC (@KOREA)	Eigenfrequency > 80Hz Thermal deformation < 2㎛
CCD		Foreign Vendor	Pixel pitch: 7㎛
Camera Electronics		HANWHA (@KOREA)	Line rate: 15,000lines/sec
Image Data Handling Unit		LUMIR (@KOREA)	Storage: 1.5Tbits
X-band Transmitter		GENOCHO (@KOREA)	Downlink 640Mbps
X-band Antenna		KUKDONG (@KOREA)	2 axis gimbal, Dual Polarization

ACKNOWLEDGEMENTS

This project was supported by Korean MOLIT (Ministry of Land, Infrastructure and Transport) and Korean MSIT (Ministry of Science and ICT)

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Generating Machining Sound Using Operational Context

Eunseob Kim[1], Junho Sohn[2], Asif Tanveer[2], Yuseop Sim[2], Junyoung Oh[2], Martin B.G. Jun[2]
[1]Department of Mechanical Engineering, Wayne State University, Detroit, MI, USA,
[2]School of Mechanical Engineering, Purdue University, West Lafayette, IN, USA

I. SUMMARY

Machining sound contains rich information about cutting conditions, machine behavior, and process anomalies. Experienced machinists often interpret cutting sound together with operational information to assess machining conditions and adjust machining processes. This work explores whether AI can generate expected machining sound from operational context. A sound generation model was developed using machining operational context, including cutting parameters and MTConnect standard data [1], to predict machining sound represented as mel-spectrograms. Generated and measured sound were compared for anomaly analysis without requiring labeled failure data. Preliminary results demonstrate that the model can reproduce characteristic sound patterns under normal cutting conditions and capture deviations associated with abnormal machining behavior, highlighting the potential of sound generation for intelligent manufacturing monitoring.

II. Machining Sound Generation Framework

Figure 1 illustrates the proposed machining sound generation framework. Machining sound measured near the machining zone was converted into mel-spectrograms, while operational context information, including machining parameters, G-code information, and MTConnect machine data, was used as model input. A temporal AI model learned the relationship between operational context and machining sound, generating mel-spectrograms that were reconstructed into waveform audio using the Griffin-Lim algorithm.

The framework was trained using normal machining data from the Multi-Sensor and MTConnect (MSM) dataset [1] and additional experiments to learn expected machining sound patterns under given operational conditions. During inference, generated sound was compared with measured sound to evaluate consistency between expected and observed machining behavior. Increased dissimilarity under abnormal conditions suggests the potential of expected-versus-observed sound comparison for identifying machining anomalies and unexpected cutting behavior.

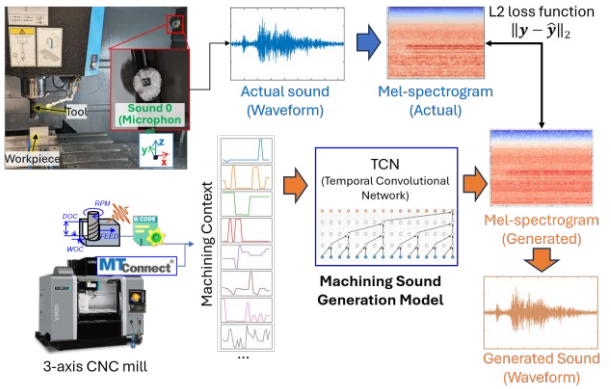


Figure 1: Overview of the proposed machining sound generation framework

III. Result and Discussion

Preliminary results showed that the proposed framework can generate characteristic machining sound patterns from operational context. Under normal cutting conditions, generated sound exhibited similar spectral behavior to measured sound. Larger discrepancies were observed under abnormal conditions, suggesting that differences between expected and measured sound may provide useful indicators of machining anomalies. These results demonstrate the potential of operational-context-driven sound generation for intelligent manufacturing monitoring.

ACKNOWLEDGEMENTS

This work was supported by Wayne State University.

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Structural Reorganization of the Global Container Shipping Network under Geopolitical Risk: The Case of the Red Sea Crisis

Suyeon Park, Sang-yoon Lee
Graduate School of Logistics, Inha University

I. SUMMARY

This study analyzes the resilience of the global container shipping network under geopolitical risks in maritime transport. Focusing on the Red Sea Crisis triggered by attacks on merchant vessels near the Red Sea from November 2023 onward, we use approximately 1.6 million AIS-based port call records to construct monthly directed and weighted port-to-port networks and apply network analysis together with MRQAP regression. Preliminary results show that Suez-related port-pair connections and visits to the Suez chokepoint declined markedly, whereas the overall network exhibited a pattern of reorganization rather than a simple collapse marked by denser intra-community connections and stronger hub pairs. From the perspective of Complex Adaptive Systems (CAS) [4], these findings suggest the possibility of adaptive resilience through structural reorganization.

II. DATA & METHOD

Using AIS-based port call records [3], we construct monthly directed and weighted port-to-port networks [1],[2] over June 2023 to September 2024, divided into a base and a post period, and track network-level changes. To examine what drives these changes, the change in port-pair edge weight between the post and base periods (ΔW) was specified as the dependent variable, and an MRQAP model was estimated with BaseW, SuezExposure, SameRegion, SameCommunity, and HubPair as explanatory variables, testing whether these factors are systematically associated with changes in port-pair connections.

III. RESULTS

A. Network Analysis

The Suez-related edge share fell from 1.48% in November 2023 to 0.93% in December 2023 and stayed lower throughout 2024. Centrality of major hubs generally declined, though Singapore remained top-ranked across weighted degree, betweenness, and PageRank in both periods. Increased-weight edges were dispersed across multiple regions, whereas decreased-weight edges concentrated among Suez related pairs. At the same time, intra-community connections became denser.

B. MRQAP

The MRQAP results show negative coefficients for Suez exposure and base-period edge weight, and positive coefficients for same-community membership and hub-pair status. These results indicate a relative weakening of Suez-exposed edges, while existing community and hub structures were maintained or reorganized.

IV. PRELIMINARY IMPLICATIONS

The Red Sea Crisis reflects reorganization rather than collapse, leveraging existing hub and community structures [6]. This suggests that resilience should be understood not as a return to the pre-shock state, but as the maintenance of network function through structural reorganization [5].

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Fabrication and Synthesis of the Nickel Cobalt Sulfide Nanowire Woven Kevlar Fiber and Polyester Composites

Hyung Wook Park[1], Ankita Hazarika[1], Biplab K. Deka[1]

[1]Department of Mechanical Engineering, Ulsan National Institute of Science and Technology
[+]E-mail: hwpark@unist.ac.kr

I. INTRODUCTION

Frosting of wing edges, wind turbines, and tails of aerospace structures in extreme cold environments can be very dangerous; ice accumulation damages aircraft structures and the performance of the aircraft, creating a serious safety threat[1]. Aircraft blades are carefully designed to provide the airflow necessary to assist in buoyancy; the existence of ice on the blade and wings of aircraft promotes shape change and surface roughness that can affect aerodynamic performance by disrupting airflow around the blades.

Among the various de-icing strategies, deicing chemicals are primarily used; despite their cost-effectiveness, these chemicals are harmful as they pollute groundwater and cause corrosion[2]. Joule heating is an efficient deicing electrothermal practice occurring in an electrically conductive material in which voltage-applied heating ensues from the dissipation of electrical power. In this work, different concentrations of hydrothermally synthesized, hierarchical $NiCo_2S_4$ nanowire-grown woven Kevlar® fiber (WKF) and polyester resin (PES) with dispersed rGO were utilized to fabricate unique hybrid WKF/$NiCo_2S_4$/rGO/PES composites via vacuum-assisted resin transfer molding (VARTM).

II. EXPERIMENTAL SECTIONS

Woven Kevlar® fibers sheets (Kevlar® 49) were received from JMC Co., Ltd. (Gyeongsangbuk-do, South Korea). Nickel chloride hexahydrate ($NiCl_2.6H_2O$), cobalt chloride hexahydrate ($CoCl_2.6H_2O$), urea, and sodium sulfide were obtained from Sigma Aldrich (South Korea). Hexadecyl trimethyl ammonium bromide and rGO were supplied by Sigma Aldrich (South Korea).

Prior to synthesizing $NiCo_2S_4$ nanowires on the surface of WKF, the samples were cut to a size of 75 × 75 mm^2, washed thoroughly with acetone and ethanol solution, and dried in oven at 80°C.

III. RESULT AND DISCUSSION

SEM images present the nanowires grown with different concentrations of the precursors. The growth density of the nanowires was very sparse when concentration A of the precursors was used. The low precursor concentration suppressed homogeneous nucleation for uniform growth of the nanowires. When concentration B of the precursors was used in the growth solutions, vertically aligned, highly dense nanowire growth was obtained, with uniform distribution over the WKF surface.

IV. RESULT AND DISCUSSION

$NiCo_2S_4$ nanowires were grown on the surface of WKF by a hydrothermal technique with three concentrations. This WKF composite can also be used as an electric heating device in various applications such as window or mirror deicing, floor heating, water heating, road deicing, and functional textiles.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea (NRF) Grant funded by the Ministry of Science (NRF-2022R1A2C3007963, RS-2025-02223634, RS-2025-24523265) and the Industrial Technology Alchemist Project (No. 20025702) funded by the Ministry of Trade, Industrial and Energy (MOTIE, Korea)

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Interpretable Prediction of Stem-to-Stem Contact-Regime Boundaries in Submerged Aquatic Vegetation using a Physics-guided Teacher-Student Surrogate Framework

Sebin Oh[1], Hyun Dong Kim[1]
[1]Dept of Civil and Environmental Engineering, Old Dominion University, Norfolk, VA

I. INTRODUCTION

Submerged Aquatic Vegetation (SAV) attenuates wave energy and stabilizes sediments, making it essential for nature-based shoreline protection (Kim et al., 2024). Predicting stem-to-stem contact under oscillatory flow is critical, as it significantly alters hydrodynamics. However, CFD simulations are prohibitively expensive for parametric exploration and conventional surrogates lack interpretability (Rudin, 2019). This study develops a physics-constrained neural surrogate that predicts contact onset across Cauchy number (*Ca*), Keulegan-Carpenter number (*KC*), and normalized stem spacing (*d/l*), and distills the decision boundary into a closed-form equation.

II. METHODS

A Teacher-Student framework implementing Learning Using Privileged Information (LUPI) was trained on 40 CFD cases (Vapnik & Vashist, 2009; Lopez-Paz et al., 2016). Each case pairs three dimensionless physics inputs with a 16-frame vorticity image sequence (Kim et al., 2024). The Teacher processes both images and physics; the Student uses physics alone. A monotonicity penalty enforces known physical relationship. The threshold boundary is extracted from the Student calibrated probability field via Marching Cubes, and symbolic regression (PySR) discovers closed-form equations from the isosurface vertices (Cranmer, 2023).

III. RESULTS

The Student model accurately predicts the contact events while competently separating the contact vs. non-contact regime boundary. The regime boundary derives a physically meaningful relationship between the physics parameters. The boundary is fitted with symbolic regression, and the closed-form equation that faithfully explains the regime boundary is extracted. Based on the explicit equation, Contact Threshold number, C_T, is defined so that rapid evaluation of contact expectation is achieved: when $C_T > 0$, "No Contact" should be expected, when $C_T < 0$, "Contact" should be expected. The explicit equation presents an inspectable reference for stem-to-stem contact prediction in nature-based solutions design.

$$C_T = 1.45\log(d/l) + \frac{1.45\log(d/l)}{\log_{10}(\mathrm{Ca})} - KC + 6.80$$

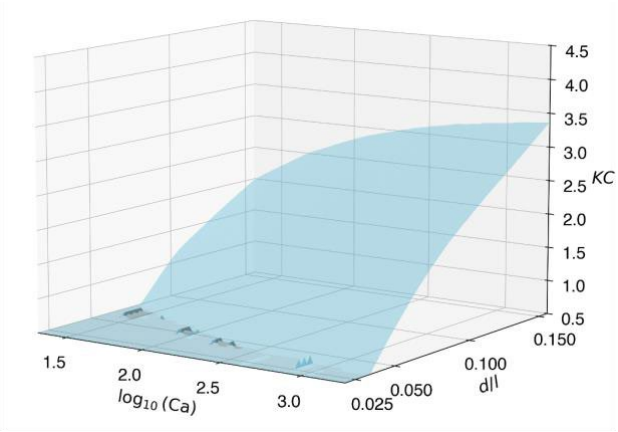


Figure 1: Final Ensembled Boundary Surface

Table 1 : Performance Metrics of the Student model from 5-Fold Cross Validation

FOLD	ACCURACY	AUROC	F1
FOLD 1	1.000	1.000	1.000
FOLD 2	0.875	0.938	0.889
FOLD 3	1.000	1.000	1.000
FOLD 4	1.000	1.000	1.000
FOLD 5	1.000	1.000	1.000
MEAN ± STD	0.975 ± 0.056	0.988 ± 0.028	0.978 ± 0.050
POOLED	0.975	0.997	0.977

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Agriculture / Food / Nutrition

Obesity-Induced Epigenetic Dysregulation of Hypothalamic Leptin Signaling

Min-Hyun Kim[1]
[1]College of Health Solutions, Arizona State University, Phoenix, AZ, United States

Obesity is a chronic metabolic disease characterized by dysregulated energy balance and impaired hormonal control of appetite. A hallmark of obesity is leptin resistance, in which the hypothalamus becomes less responsive to leptin despite elevated circulating levels. Because leptin normally suppresses food intake and promotes energy expenditure, leptin resistance represents a major obstacle to effective obesity therapy. Although multiple mechanisms have been implicated, reduced expression of the long-form leptin receptor (LepRb) is increasingly recognized as a key determinant of impaired leptin responsiveness.

The molecular basis for obesity-associated LepRb suppression remains poorly defined. Histone modifications are compelling candidates because they dynamically respond to nutritional cues while governing chromatin accessibility and transcription. Among these, methylation of histone H3 lysine 27 (H3K27) is a repressive mark linked to metabolic gene regulation. We previously showed that obesity-induced activation of the transcription factor Slug promotes H3K27 methylation at the *LepRb* promoter, suppressing LepRb expression and impairing leptin signaling [1]. These findings raised the possibility that H3K27 methylation functions as a reversible epigenetic switch controlling hypothalamic leptin sensitivity in obesity.

To test this, we examined the H3K27 demethylase Jumonji domain-containing protein 3 (JMJD3) in diet-induced obese C57BL/6J mice. Among multiple histone-modifying enzymes analyzed, JMJD3 was selectively downregulated in the ventromedial hypothalamus (VMH), a region enriched in LepRb-expressing neurons and central to feeding regulation and glucose homeostasis. VMH-targeted JMJD3 overexpression protected mice from obesity, hyperphagia, glucose intolerance, insulin resistance, and hepatic steatosis. A catalytically inactive mutant had no effect, confirming that JMJD3's metabolic actions depend on its demethylase activity.

Mechanistically, JMJD3 overexpression reduced H3K27 methylation at the *LepRb* promoter, restored LepRb expression, and enhanced leptin-induced Signal transducer and activator of transcription 3 (STAT3) signaling. Conversely, hypothalamic *Jmjd3* knockdown increased H3K27 methylation, suppressed LepRb, impaired leptin responsiveness, and promoted obesity even without an obesogenic diet, establishing a causal role for this pathway in leptin resistance.

We next examined whether nutritional deprivation engages the same mechanism. Alternate-day fasting (ADF) improved leptin responsiveness in obese mice before any reduction in body weight or adiposity was detectable. These improvements coincided with increased LepRb expression, reduced H3K27 methylation at the *LepRb* promoter, and elevated hypothalamic JMJD3. Stereotaxic *Jmjd3* knockdown abolished fasting-induced demethylation, blocked LepRb upregulation, and eliminated the metabolic benefits of ADF, demonstrating that JMJD3 is required for fasting-mediated restoration of leptin sensitivity.

Together, these findings support a model in which nutritional excess and deprivation exert opposing effects on H3K27 methylation at the *LepRb* locus. Obesity promotes accumulation of repressive H3K27 methylation, reducing LepRb expression and blunts leptin signaling, whereas fasting reverses these chromatin changes and restores leptin responsiveness. Reversible H3K27 methylation therefore functions as an epigenetic switch linking nutritional status to central leptin sensitivity. By identifying JMJD3-dependent chromatin remodeling as a key regulator of this process, our studies establish epigenetic regulation as a fundamental mechanism underlying hypothalamic leptin resistance and highlight chromatin-targeted approaches as potential therapeutic strategies for obesity and metabolic disease.

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Developing and Evaluating a Social Media Intervention to Promote Locally Grown Fruit and Vegetable Consumption Among College Students

Seung Eun Jung
Department of Human Nutrition, Hospitality and Sport Management
The University of Alabama

I. SUMMARY

Background: College students often consume inadequate amounts of fruits and vegetables (F&V) and face barriers to maintaining healthy and sustainable dietary practices. Increasing consumption of locally grown F&V may provide both health and environmental benefits by improving diet quality while supporting local food systems and reducing environmental impacts associated with food transportation. Social media platforms have emerged as effective channels for nutrition education among young adults, and peer-led educational approaches have been shown to enhance knowledge, self-efficacy, and motivation for healthy eating behaviors. However, limited research has examined the development and evaluation of theory-based social media interventions designed to promote locally grown F&V consumption among college students.
Objective: This study aimed to develop and evaluate a Theory of Planned Behavior (TPB)-based social media intervention and examine its feasibility, acceptability, and preliminary effects on knowledge, attitudes, and intentions regarding locally grown F&V consumption among college students.
Methods: Guided by a formative assessment based on TPB (Francis et al., 2004), a social media intervention was developed. Participants were recruited from a large public university in the southern U.S. Eligibility criteria included age ≥18, active use of social media platforms, and no purchase of locally grown Alabama produce in the past 6 months. The intervention included weekly recipes, cooking videos, seasonal produce highlights, and local farmers' market content. A quasi-experimental pre-post design assessed changes in knowledge, attitudes, subjective norms, perceived behavioral control, and intentions. Post-intervention interviews were conducted to evaluate feasibility and acceptability, and qualitative data were analyzed using thematic analysis.
Results: Paired-samples t-tests were conducted to examine changes in TPB constructs. Significant increases were observed in knowledge, attitudes, subjective norms, perceived behavioral control, and intentions. Participants reported high clarity and generally positive implementation experiences, including increased awareness and motivation related to locally grown F&V. Overall acceptability was high, with participants reporting that social media delivery and peer cooking increased engagement, motivation, and perceived usefulness of the intervention, with most participants expressing satisfaction with the program components and suggesting minimal improvements.
Conclusion: This TPB-based social media intervention was highly feasible and acceptable among college students and showed positive effects on psychosocial determinants of locally grown F&V consumption.

ACKNOWLEDGEMENTS

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Toward Precision Zinc Nutrition: From Vitamin B5 Metabolism to Aging-Associated Zinc Dyshomeostasis

Sangyong Choi, Evelyn Nathania, Kristofer Terrell, Suyun Choi
Department of Nutritional Sciences, University of Connecticut, Storrs, CT, USA

I. SUMMARY

This presentation will introduce precision zinc nutrition as a framework for linking nutrigenomics with zinc homeostasis. I will discuss two emerging studies from our lab: a vitamin B5/PPCDC-linked pathway that regulates cellular zinc levels, and senescence-associated zinc dyshomeostasis in intestinal epithelial cells. These findings provide new insight into how genetic and aging-related mechanisms may shape zinc biology and nutritional health.

II. BACKGROUND AND RATIONALE

Zinc is an essential micronutrient with broad biochemical roles in catalysis, protein structure, and cellular signaling. Although zinc deficiency and excess are known to impair health, defining optimal zinc status remains challenging because zinc homeostasis is influenced by diet, genetics, metabolism, tissue-specific regulation, and age. Precision nutrition offers a useful framework to address this challenge by linking individual biological variation with nutrient response. Our laboratory applies this concept to zinc by studying dietary factors, host genetic variants, metabolic pathways, and aging-related processes that regulate zinc status and zinc signaling.

III. EMERGING MECHAINSMS OF ZINC REGULATION

First, we will discuss a genetic-metabolic pathway linking vitamin B5 metabolism to zinc regulation. A blood zinc-associated variant near PPCDC, a gene involved in coenzyme A biosynthesis, prompted us to test whether this locus influences cellular zinc homeostasis. Using prime-edited cell models carrying rs2120019 alleles, our preliminary data suggest that the alternative allele reduces cellular zinc concentration and is associated with altered PPCDC expression. In addition, coenzyme A supplementation reduced intracellular zinc levels, suggesting a potential connection between vitamin B5/CoA metabolism and zinc regulation. These observations raise new questions about whether metabolic pathways beyond classical zinc transporters contribute to zinc homeostasis.

Second, we will discuss aging-associated zinc dyshomeostasis. Older organisms often show altered zinc status, and aging shares several biological features with zinc deficiency, including inflammation, oxidative stress, and impaired tissue function. Recent work from our group focuses on intestinal epithelial cell senescence as a contributor to disrupted zinc regulation. In senescence models, zinc accumulates in intestinal epithelial cells together with altered expression of zinc transporters, including ZIP4 and ZnT7, and chelation of accumulated zinc reduces senescence markers. These findings suggest that aging-related cellular states may actively remodel zinc distribution rather than simply reflecting reduced zinc intake or absorption.

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Development and Validation of an AI-Generated Food-as-Medicine Recipe Platform

Heewon L. Gray, PhD, RDN[1], Tingting Zhang, PhD[2]
[1]Department of Community Health Sciences, College of Public Health, University of South Florida, [2]School of Hospitality & Sport Management, Muma College of Business, University of South Florida

I. INTRODUCTION

Obesity and other diet-related chronic diseases are leading causes of mortality and major public health concerns. Cost-effective, evidence-informed nutrition guidance and recipes are needed, and easy-to-use AI-generated recipes may serve as great alternatives to in-person nutrition counseling or education sessions.

II. OBJECTIVES

The aim of the study was to develop and evaluate the validity of an AI generated recipe platform, Lotus AI, to provide evidence-informed recipes for patients with chronic diseases such as obesity, type 2 diabetes, and hypertension. The objectives were to examine the platform's cohesiveness, functionality, utilization, food item availability, and user experience; and to validate the nutrient content generated by Lotus AI against the Automated Self-Administered 24-Hour (ASA24®) Dietary Assessment Tool.

II. METHODS

A. Development of Lotus AI

The USF AI team developed a website. More than 15,000 sample recipes from credible sources (e.g., USDA) were entered into the system along with age-matched nutrient recommendations. The platform features a food basket that allows users to add food items for recipe generation, options to specify the number of recipes to generate, meal type, age, cultural cuisine, cooking instrument, health conditions, and allergens. Recipe components include a title, serving size, reasons for the recipe recommendations, ingredients, instructions, a QR code for PDF download, and a nutrition fact label based on a serving size.

B. Evaluation and Validation

A two step process was completed: (1) Nine trained research staff independently tested the Lotus AI platform and completed the evaluation form; and (2) each person generated 20 recipes, and the nutrition fact values were compared with those obtained using the ASA24.



Figure 1: The front page of Lotus AI: Food-as-Medicine recipe generation platform

III. RESULTS

Evaluation is ongoing and will be completed by the end of July, which will be presented. The evaluation criteria to be reported are listed in Table 1.

Table 1: Evaluation Categories and Nutrients Compared

Categories	Nutrients
Cohesiveness	Calories; Fats;
Range of recipe options	Cholesterol; Sodium;
Customization	Carbohydrate; Sugars;
Utilization of food basket	Protein; Calcium; Iron; Magnesium;
Food items available	Phosphorus; Potassium;
User experience	Vitamin A, C, & K

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We would like to thank undergraduate and medical school students who assisted with this project.

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The Effect of US-Grown Teff (Eragrostis Tef) Consumption on Obesity-Associated Metabolic Dysfunction in Mice

Ji-Young Lee[1], Hayoung Woo[1], Ella Goodney[1], Jaeeun Lee[1], Claire Gallagher[1], Jason Wong[1], Eshani Karkun[1], Young-Ki Park[1]

[1]Department of Nutritional Sciences, University of Connecticut, USA

SUMMARY

Teff (Eragrostis tef) is an ancient grain native to Ethiopia and Eritrea, offering several health benefits. It is rich in nutrients, including fiber, protein, vitamins, and minerals such as iron, calcium, and magnesium. As a gluten-free grain, teff is an excellent choice for individuals with celiac disease or gluten sensitivity. Its high fiber content supports digestive health, helps manage blood sugar levels due to its low glycemic index, and promotes satiety, which can be beneficial for weight management. Teff farming in the US has been expanding across several states, including Nevada, Idaho, Oregon, and Washington. However, scientific studies on the potential health benefits of US-grown teff are lacking. This project aimed to determine whether teff consumption can prevent obesity-associated metabolic dysfunction using a diet-induced obesity mouse model. Male C57BL/6J mice were fed a low-fat (LF) diet, an LF diet supplemented with 20% (w/w) US-grown teff, an obesogenic high-fat/high-sucrose (HF/HS) diet, or an HF/HS diet supplemented with 20% teff for 17 weeks. We evaluated body weight, fat mass using an EchoMRI, energy expenditure and activity via the Comprehensive Lab Animal Monitoring System, and oral glucose tolerance test (OGTT) during the feeding period. We found that teff consumption did not change weight gain, fat mass, metabolic rate, or energy expenditure in either the LF or HF/HS groups. Plasma glucose and triglyceride levels did not differ significantly between the control and teff groups on either the LF or HF diet at 8 weeks. However, at 12 weeks on the experimental diets, teff consumption significantly decreased plasma triglyceride concentrations in the LF diet. Plasma alanine aminotransferase (ALT) activity, a marker of liver injury, was decreased by teff in the HF groups at both 8 and 12 weeks. OGTT analysis demonstrated that, in the HF groups, consuming teff prevented the development of glucose intolerance in obesity. The results suggest that teff prevents glucose intolerance and liver injury induced by an obesogenic diet without altering body weight.

Repeated Weight Cycling Disrupts Hypothalamic Neuroendocrine Signaling Through Gut Microbiota Remodeling

Judy Kim, Seokhee Seo, and Soonkyu Chung[1]
[1] Department of Nutrition, University of Massachusetts, Amherst, MA, 01007. USA

I. SUMMARY

Emerging evidence suggests that weight cycling (WC) induces significant alterations in the gut microbiota. However, its effects on hypothalamic pathways that regulate hunger and satiety, particularly across different dietary compositions, remain poorly understood. This study investigated the dynamic relationship between the gut microbial composition and hypothalamic neuroendocrine signaling during WC. Our work demonstrated that repeated weight-loss dieting induces persistent alterations in the gut microbiota that influence gut-hypothalamic pathways and contribute to long-term susceptibility to body weight regain.

II. INTRODUCTION

Many individuals experience repeated cycles of weight loss and regain, commonly referred to as weight cycling (WC) or the “yo-yo effect”, ultimately worsening overall metabolic health. Macronutrient composition is another important determinant of body weight regulation as the macronutrients differentially influence insulin secretion, lipid metabolism, and energy homeostasis. This study also aimed to determine how differences in macronutrient composition during caloric restriction, specifically carbohydrate restriction through a ketogenic diet (CR_{KD}) versus fat restriction through a standard low-fat caloric restriction (CR), affect overall metabolism, hypothalamic neuroendocrine signaling, and gut microbial composition

III. Results

A. Weight cycling with different fat compositions resulted in distinct metabolic outcomes.

Female C57BL6/J mice (40 weeks old) underwent three cycles of WC, consisting of alternating periods of 50% caloric restriction and ad libitum feeding, while non-dieting controls were continuously maintained on a Western diet. Two caloric restriction approaches were evaluated: the ketogenic diet-based calorie restriction (CR_{KD}) and a standard low-fat calorie restriction diet (CR) (Figure 1).

Following three cycles, mice in the CR_{KD} group exhibited more rapid weight regain than those in the CR group.

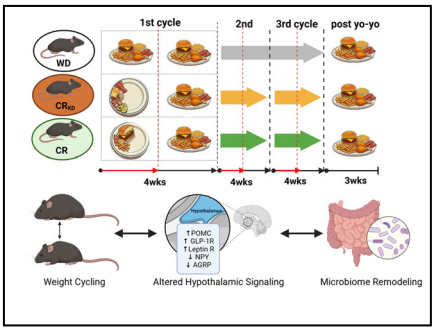


Fig1.Schematic representation of the experimental design showing dietary interventions and weight cycling phases. Experimental groups included ad libitum Western Diet (WD), weight cycling with carbohydrate restriction (ketogenic diet, CR_{KD}), and weight cycling with fat restriction (CR).

B. Weight cycling revealed novel gut-brain axis regulation

Cecal contents were collected for 16S rRNA sequencing to characterize gut microbial composition, and the hypothalamic tissues were analyzed for neuropeptide gene expression. Despite the differences in body weight regain between the CR_{KD} and CR groups, both exhibited similar gut microbial profiles that remained distinct from those of the non-dieting controls. The Spearman's rank correlation analysis demonstrated that WC-associated increase in *Clostridia UCG-014*, *Muribaculum*, and *UCG-010* were negatively associated with hypothalamic Glp1r expression and positively correlated with plasma Dpp4 activity. In addition, elevated levels of *Erysipelatoclostridium* and *Lactobacillus* were inversely associated with hypothalamic Agrp, an appetite stimulator, whereas reduced abundance of *Epuloiscium*, *Hydrogeno-anaerobacterium*, and *Anaerovorax* was associated with decreased hypothalamic Pomc expression

III. Conclusions and Working Hypothesis

This work demonstrated that repeated weight-loss dieting induces persistent alterations in the gut microbiota that influence gut-hypothalamic pathways and contribute to long-term susceptibility to body weight regain.

ACKNOWLEDGEMENTS: USDA-HATCH

Temperature-Dependent Energy Allocation Drives Growth and Storage Trade-Offs in Juvenile Black Sea Bass

Gwangseok Rex Yoon[1], Jessica Maguire[1], Max D. Zavell[2], Will Kochtitzky[1], John Mohan[3]

[1] University of New England, 11 Hills Beach Road, Biddeford, ME 04005

[2]University of Massachusetts Dartmouth, 836 South Rodney French Blvd., New Bedford, MA 02744

[3] North Carolina Division of Marine Fisheries, 3441 Arendell St., Morehead City, NC 28557

I. SUMMARY

Rapid ocean warming in the Gulf of Maine is driving poleward shifts in marine species distributions, including the expansion of black sea bass (*Centropristis striata*) into northern habitats. While species distribution models predict where suitable habitat may occur, it remains unknown how the physiological mechanisms drive these shifts. This study examines how temperature and exposure duration influence metabolic performance, digestion, and energy allocation in juvenile black sea bass. We tested the hypothesis that temperature would change in aerobic capacity, driving variation in growth and digestive efficiency. Our results indicate that temperature increases growth through shifts in energy allocation rather than through direct changes in aerobic metabolism or digestive capacity. Our study has important implications for understanding how phenotypic plasticity may allow the expansion of marine species in rapidly changing environments.

II. MATERIALS AND METHODS

Juvenile black sea bass were exposed to three temperature treatments (14°C, 17°C, and 20°C) for two and five weeks. We quantified whole-body metabolic rate using intermittent-flow respirometry, thermal tolerance, digestive capacity (trypsin and lipase activity), and growth and energy storage metrics (body mass, length, condition factor, hepatosomatic index, gut somatic index). Data were analyzed using Bayesian linear mixed models to estimate temperature- and time-dependent effects.

III. RESULTS AND INTERPRETATION

Growth increased significantly at 20°C with higher body mass and length after five weeks while condition factor remained unchanged. In contrast, Hepatosomatic index decreased at 20°C indicating reduced energy storage and suggesting a temperature-dependent shift in energy allocation from storage to somatic growth. Metabolic responses did not fully explain growth patterns. Standard metabolic rate remained stable across temperature treatments, indicating that basal metabolic costs were maintained. Aerobic scope data showed inconsistent responses across temperature treatments. Thermal tolerance increased with acclimation temperature, demonstrating physiological adjustment of upper thermal limits. Digestive enzyme activity remained largely stable across temperatures although trypsin activity showed a positive trend with warming. The stability of digestive capacity, despite variation in growth and metabolic performance, suggests that digestion is maintained as a priority physiological function across environmental conditions. These results provide a mechanistic framework for understanding how physiological plasticity contributes to the success of expanding black sea bass in the Gulf of Maine, one of the fastest warming waters in the world.

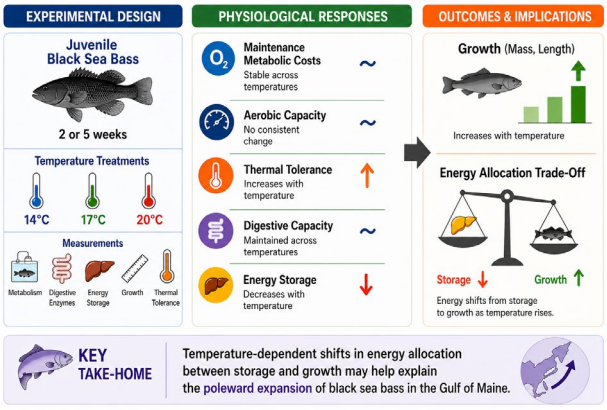


Figure 1: Temperature alters energy allocation rather than aerobic capacity to drive growth variation in juvenile black sea bass (*C. striata*).

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A novel DNA-based vaccine for reduction of *Salmonella* in broilers

Young Min Kwon
Department of Poultry Science, University of Arkansas Division of Agriculture, Fayetteville, AR72701

SUMMARY

Nontyphoidal *Salmonella* is a major human pathogen that frequently enters the human food chain through contaminated chicken meat. This raises significant concerns for both the poultry industry and public health. Vaccinating chickens is a key approach to reducing *Salmonella* prevalence in broiler flocks, thereby lowering the risk of human infections. Despite extensive research, there is still a need for *Salmonella* vaccines that are both safer and more effective. This ongoing challenge demands the urgent development of innovative strategies to effectively control *Salmonella* colonization of the gut in broilers.

We developed a vaccine complex targeting CD40 based on rolling circle amplification (RCA) product to reduce *Salmonella* gut colonization in broilers. CD40 is an immune signaling receptor on the surface of professional antigen-presenting cells. It is known for its ability to stimulate dendritic cells, increase macrophage pro-inflammatory activity, and promote B-cell maturation. We first developed DNA aptamers with agonistic activity for the CD40 receptor, which were then used to produce RCA products displaying the aptamers. The RCA products were conjugated with killed *Salmonella* cells as antigens to form the vaccine complex. The two different designs of the vaccine complex [RCA_v3 + S. Enteritidis (SE) and RCA_v5 + SE] were evaluated for their efficacy using two different methods sequentially: (1) macrophage activation assay using the HD-11 cell line (see Figure 1) and (2) *Salmonella* oral challenge model of chickens. The two different designs of our vaccine complex significantly activated macrophages ($P < 0.05$) and significantly reduced *Salmonella* cecal colonization ($P < 0.05$) compared with the challenge control group. The results of our research show that our novel CD40-targeting strategy has great potential to overcome the limitations of current *Salmonella* vaccines in broilers, enabling more effective control of *Salmonella* gut colonization. We are currently exploring options to enhance its efficacy while reducing production costs, paving the way for field application.

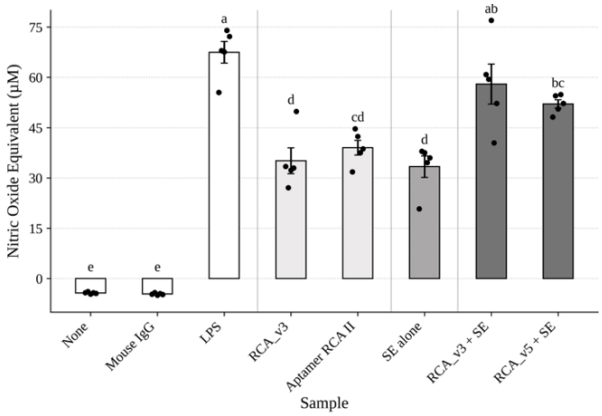


Figure 1. Nitric oxide release assay using HD11 cells treated with two different vaccine complexes (RCA_v3 + SE and RCA_v5 + SE).

ACKNOWLEDGEMENTS

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Roles of non-starch polysaccharide degrading enzymes to mitigate non-starch polysaccharide interference with intestinal health in pigs

Hyunjun Choi, Yesid Garavito-Duarte, Zixiao Deng, Sung Woo Kim
Department of Animal Science, North Carolina State University, Raleigh, NC 27695, USA

I. Introduction

Plant-based diets (PBD) are commonly used to reduce feed costs. Although these diets contain high levels of nutrients, they also possess a significant amount of non-starch polysaccharides (NSPs) that cannot be digested or absorbed by pigs, thereby compromising intestinal health. Specifically, high-NSPs diet increase jejunal digesta viscosity, which in turn hinders nutrient digestibility. The remaining undigested nutrients in the intestine alter the composition of the intestinal microbiota, potentially triggering inflammatory responses. Consequently, supplementation with enzymes capable of degrading NSPs is a viable strategy for intestinal health when utilizing these PBDs for pigs.

II. Hypothesis and Objectives

This study tested the hypothesis that PBDs containing high levels of soybean meal (SBM) or corn distiller dried grain with solubles (DDGS) compromises the intestinal health of nursery pigs, and that supplementation with carbohydrase mitigates these negative impacts. Thus, the objectives were to evaluate the roles of carbohydrases, the combined use of xylanase and β-glucanase, or β-mannanase, on the intestinal health and growth of nursery pigs.

III. Materials and Methods

Exp. 1: Forty pigs (6.5 ± 0.4 kg initial body weight) were assigned to 5 dietary treatments (n = 8) and fed for 35 d across 3 phases (11, 9, and 15 d). The basal diets primarily consisted of corn, SBM, and corn DDGS. Treatments consisted of 5 increasing levels of an enzyme blend (XG) providing xylanase (TXU/kg) and β-glucanase (TGU/kg), respectively: 1) 0 and 0, 2) 280 and 125, 3) 560 and 250, 4) 840 and 375, and 5) 1,120 and 500. The XG intake was calculated to overall average daily feed intake (g/d) multiplied by the level of XG. On d 35, jejunal mucosa, tissues, digesta, and ileal digesta were collected.

Exp. 2: Eighteen pigs (6.2 ± 0.2 kg initial body weight) were assigned to 3 dietary treatments (n = 6) and fed for 42 d across 3 phases (10, 10, and 22 d). Treatments consisted of 1) control diet (CON), 2) High-SBM diet (HSD; 14% more SBM than CON), and 3) HSD+β-mannanase (800 TMU/kg β-mannanase). On d 42, jejunal mucosa, jejunal tissues, and ileal digesta were collected.

IV. Results and Conclusion

Exp. 1: Increasing XG intake tended to quadratically decrease (p=0.059) jejunal digesta viscosity [min: 1.74 mPa·s at 751/335 (TXU/TGU)/kg] and quadratically increased (p<0.05) relative abundance (RA) of *Lactobacilaceae* [max: 40.3% at 608/271 (TXU/TGU)/kg] in the jejunal mucosa. Increasing levels of XG tended to linearly decrease (p=0.073) jejunal IgG content and tended to quadratically increase (p=0.085) jejunal villus height and crypt depth ratio [max: 2.62 at 560/250 (TXU/TGU)/kg]. Increasing XG intake tended to linearly increase the apparent ileal digestibility (AID) of dry matter (p=0.087) and ether extract (p=0.065).

Exp. 2: The HSD increased (p<0.05) the RA of *Coriobacteriaceae*, tended to increase (p=0.073) jejunal IL-6, and decreased (p<0.05) the AID of ether extract compared to CON. HSD+β-mannanase decreased (p<0.05) the RA of *Coriobacteriaceae*, decreased (p<0.05) jejunal IL-8, increased (p<0.05) the AID of EE compared to HSD.

In conclusion, supplementation with carbohydrases, the combined use of xylanase and β-glucanase, or β-mannanase, mitigates the negative impacts of dietary NSPs fed to pigs. These enzymes improve intestinal health of pigs by reducing digesta viscosity, positively modulating the mucosal microbiota, reducing intestinal inflammation, and improving nutrient ileal digestibility.

From Genome Editing to Adaptive Evolution: Engineering Yeast for Better Fermented Foods

Yong-Su Jin[1,2]

[1]Department of Food Science and Human Nutrition, University of Illinois, Urbana-Champaign, Urbana IL, USA, [2]Centre for Precision Fermentation and Sustainability (PreFerS),Illinois Advanced Research Center at Singapore (Illinois ARCS), Singapore

I. SUMMARY

Yeast has been used for thousands of years to make bread, beer, wine, and many traditional fermented foods. Today, advances in biotechnology are creating new opportunities to improve the quality, flavor, safety, and performance of these food fermentations. In this presentation, I will introduce our recent efforts to improve food fermentation yeasts using two powerful approaches: genome editing and adaptive laboratory evolution (ALE).

Using natural *Saccharomyces cerevisiae* strains isolated from Korean Nuruk, a traditional fermentation starter, we applied Cas9-based genome editing to develop yeast strains with enhanced industrial properties. By modifying genes involved in sugar sensing and nitrogen metabolism, we improved carbon dioxide production for breadmaking, reduced acrylamide formation in potato-based foods, and enhanced fruity, floral, and savory flavor production during Korean rice wine (Makgeolli) fermentation. Importantly, these strains were developed without introducing foreign DNA, which may reduce regulatory concerns associated with genetically modified organisms (GMOs).

As a complementary non-GMO approach, we also used adaptive laboratory evolution to improve freeze–thaw tolerance in baker's yeast. By evolving yeast under nitrogen-limited conditions, we obtained evolved strains with increased trehalose accumulation, improved survival during freezing stress, and enhanced breadmaking performance. Genome analysis and reverse engineering identified mutations associated with improved stress tolerance.

Together, these studies demonstrate how modern yeast engineering and evolution-based approaches can be used to develop next-generation fermentation yeasts for producing safer, tastier, and higher-quality fermented foods.

II. ILLUSTRATION

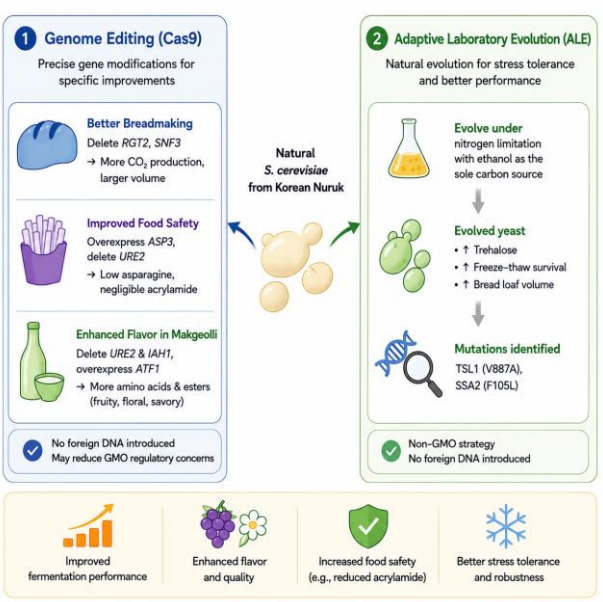


Figure 1: Engineering yeast for better fermented food: two complementary approaches (genome editing and adaptive laboratory evolution) for food-friendly applications

ACKNOWLEDGEMENTS

This research is supported by the National Research Foundation, Prime Minister's Office, Singapore, under its Campus for Research Excellence and Technological Enterprise (CREATE) programme.

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Milk oligosaccharides for mucosal microbiota and mucosa immunity in the jejunum of young pigs post-weaning

Sung Woo Kim, Alexa R. Gormley, and Jung Yeol Sung
North Carolina State University

SUMMARY
The transition from sow milk to solid diets during weaning increases intestinal inflammation and oxidative damages, resulting in villus destruction, diarrhea, and even death of nursery pigs. To minimize post-weaning stress associated with the transition from sow milk to solid diets, whey permeate derived from bovine milk is commonly used in nursery pig diets to provide highly digestible nutrients similar to those in sow milk. However, considering that whey permeate is derived from bovine milk, the intestinal environment could still be compromised due to sudden changes in the amounts and types of milk oligosaccharides that intestinal microbiota has been influenced. According to our recent review (Gormley et al., 2024), content of milk oligosaccharides in bovine milk is 2 g/L whereas that in porcine milk is 12 g/L, indicating quantitative difference by 6 folds. Comparing the composition of milk oligosaccharides between bovine and porcine sources, the composition of GOS in porcine milk (51%) is 2 folds greater than that in bovine milk (26%) and FL is similar at 7%.

It is hypothesized that enriched whey permeate with GOS and FL would provide enhanced opportunities for nursery pigs for better intestinal health to prevent post-weaning diarrhea, resulting in improved growth after weaning. This study evaluated the effects of GOS, FL, and their potential additive effects, at inclusion rates mimicking porcine milk, on intestinal health and growth performance of nursery pigs. Thirty-two pigs (6.8 ± 0.2 kg body weight) weaned at 3 weeks-of-age were allotted into 4 dietary treatments based on a 2 × 2 factorial arrangement with GOS (0.0 or 1.5%) and FL (0.0 or 0.2%) as factors. Diets were fed for 21 d in 2 phases. On d 21, pigs were euthanized for collection of jejunal mucosa and tissue samples. Data were analyzed using the PROC MIXED of SAS 9.4 and orthogonal contrasts were used to evaluate the effects of GOS, FL, and their combination (interaction).

The GOS did not affect the alpha diversity indices, whereas FL tended to reduce the Shannon and Simpson indices ($P = 0.083$ and 0.093, respectively). These indices reduced ($P < 0.05$) by FL when GOS was not supplemented, whereas they were unaffected by FL with GOS supplementation. The GOS tended to decrease absolute abundance, whereas FL tended to increase relative and absolute abundance of Helicobacteraceae. The FL increased and tended to increase the relative and absolute abundance of Helicobacteraceae without GOS, respectively, whereas they were unaffected by FL with GOS. The GOS tended to increase, whereas FL decreased expression of Toll-like receptor 2 in the jejunum. The FL increased the expression of Toll-like receptor 4. The GOS increased expression of nucleotide binding oligomerization domain containing 1. The GOS did not affect, whereas FL tended to increase jejunal villus height. Villus height increased by FL with GOS supplementation, whereas it was unaffected by FL without GOS supplementation. The GOS tended to increase average daily gain. The GOS increased average daily feed intake, whereas FL had no effect. Feed intake increased by FL with GOS supplementation, whereas it was unaffected by FL without GOS supplementation.

Based on the results, it is concluded that GOS and FL exerted individual effects, however, the combination of GOS and FL may better support intestinal health and growth performance of nursery pigs.

ACKNOWLEDGEMENTS
NC Agricultural Foundation (Raleigh, NC), USDA-NIFA (Washington DC), and all member of Kim Lab

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Kahweol, a diterpene found in coffee, reduces fat accumulation and extends lifespan in *Caenorhabditis elegans*

Yeonhwa Park[1], Zixuan Teng[1], Junhyo Cho[1,2]
[1]Department of Food Science, University of Massachusetts, Amherst, [2]Department of Nutrition and Food Science, University of Maryland, College Park

SUMMARY
Coffee is one of the most widely consumed beverages in the world and is known to contain various food bioactives. In particular, kahweol, a diterpene found in coffee, significantly reduced fat accumulation and extended lifespan in the invertebrate model *Caenorhabditis elegans*. Further studies indicate that the underlying mechanisms of kahweol's effects on lipid metabolism and aging were independent; Kahweol significantly reduced food intake, thereby reducing fat accumulation. Meanwhile, kahweol targeted insulin/insulin-like growth factor-1 and AMP-activated protein kinase signaling pathways to extend lifespan. These results suggest that many food bioactives, including kahweol, elicit health benefits via various biological mechanisms.

I. INTRODUCTION

Caenorhabditis elegans is a microscopic, transparent roundworm that naturally resides in moist, temperate soils and has many advantages over other vertebrate animal models as a research model, including a short lifespan (~3 weeks at room temperature), easy handling, many self-fertilizing hermaphrodites with large reproductive capacity (~300 eggs/ worm), and >22,000 mutants available at low cost [1]. Moreover, given the significant overlap in genes and mechanisms of lipid metabolism and aging between *C. elegans* and mammals [2], this model has been extensively used for lipid metabolism and aging studies [2]. Thus, the goal of this study was to determine the role of kahweol in lipid metabolism and lifespan using *C. elegans* as a model system.

II. RESULTS

When young adult *C. elegans* were treated with kahweol (Fig. 1, 30-120 μM) for 2 days, there was a significant 7-17% reduction in overall triglyceride accumulation compared to the control [3]. There was no significant effect of kahweol on movement, a representative of physical activity, compared to the control. However, treatment of Kahweol significantly reduced the pharyngeal pumping rate, suggesting that kahweol reduced food intake. This effect was further confirmed by testing kahweol in the *eat-2* mutant, which exhibits reduced food intake [3].

Because caloric restriction is well known to extend lifespan in various animal models, including *C. elegans*, we next tested whether kahweol extends lifespan [4]. Kahweol treatment at 25 μM significantly extended lifespan in wild-type *C. elegans*; however, this effect was independent of reduced food intake [5]. Kahweol extended lifespan via insulin/insulin-like growth factor-1 and AMP-activated protein kinase signaling pathways [5].

Although these findings are limited in the *C. elegans* model and additional studies are required, overall, these results suggest that food bioactives may elicit their biological activities via multiple target pathways.

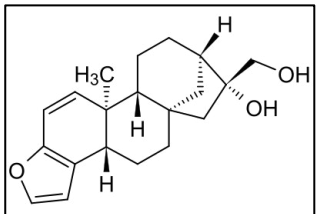


Figure 1. Structure of Kahweol.

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Identification of Host-Associated Genomic Features in *Salmonella enterica* serovar Dublin Using Machine Learning

Suyeun Noh[1,2], Yuting Zhai[1,2], Kwangcheol C. Jeong[1,2]*
[1]Emerging pathogens Institute, University of Florida, Gainesville, FL
[2]Department of Animal Sciences, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL

I. SUMMARY

Salmonella enterica serovar Dublin (*S*. Dublin) is a cattle-adapted pathogen that causes systemic disease in cattle and invasive infections in humans, commonly linked to zoonotic transmission through contaminated beef and dairy products. Previous studies have suggested that host adaptation in *Salmonella* is associated with genomic changes, including the acquisition of mobile-genetic elements and gene loss. However, it remains unclear whether cattle- and human-derived *S*. Dublin isolates exhibit distinct host-associated genomic characteristics. Therefore, this study aimed to evaluate host-associated genomic differences in *S*. Dublin and identify candidate genes associated with host specificity using machine learning approaches.

II. MATERIALS AND MEHODS

A total of 3,573 *S*. Dublin genomes, combining publicly available sequences and newly sequenced isolates, were analyzed. Gene presence/absence matrices were generated through pangenome analysis. To reduce multicollinearity among highly correlated genes, hierarchical clustering based on Spearman correlation coefficients was performed and representative features were selected. Machine learning models were evaluated using nested 10-fold-cross-validation, and permutation importance analysis was conducted to identify genomic features contributing to host classification.

III. RESULTS

Clustering and phylogenetic analyses showed limited host-specific clustering, whereas supervised machine learning models successfully classified host origin, with the Support Vector Machine (SVM) achieving the highest performance. Notably, host-specific genetic features were identified by permutation importance analyses including the IS3 family transposase ISSty2, which drives genetic variability, impacting virulence and resistance; the *psiB* gene, which is a conjugative plasmid-associated gene involved in inhibition of the host bacterial SOS response; *nanT* gene, which encodes a proton-dependent transporter responsible for the uptake of sialic acid that are abundant in host mucosal environments.

These findings demonstrate that *S*. Dublin has adapted to specific hosts through the acquisition of key genetic traits. Understanding these host-associated genetic features can help reduce zoonotic transmission and persistence and may provide targets for controlling *S*. Dublin in both animals and humans.

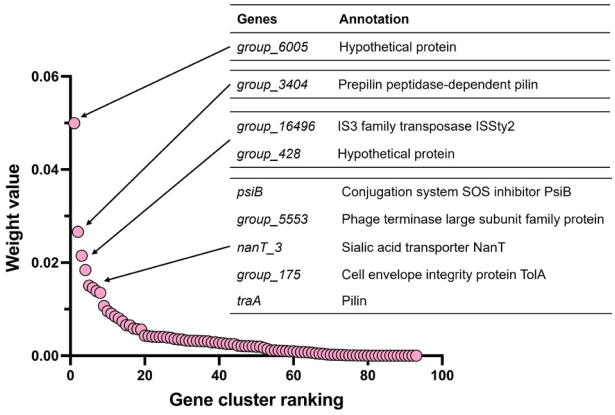


Figure 1: Top-ranked genomic features identified for host specificity classification in *Salmonella* Dublin

ACKNOWLEDGEMENTS

This work is supported by the Bennink Foundation to K.C.J.

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Dynamic remodeling of DNA methylation during fruit ripening in octoploid strawberry

Seonghee Lee[1], Hosung Jang[1]

[1]IFAS Gulf Coast Research and Education Center, University of Florida, Wimauma, FL

I. SUMMARY

Cultivated strawberry (Fragaria × ananassa) is an economically important octoploid fruit crop, and Florida is a major winter strawberry-producing region in the United States. Strawberry fruit ripening involves dramatic changes in color, texture, aroma, and flavor. These developmental transitions require extensive transcriptional reprogramming that may be mediated by epigenetic mechanisms, including DNA methylation. In strawberry, DNA methylation has been implicated in ripening-associated processes, particularly through the regulation of genes involved in fruit softening and aroma compound accumulation (Cheng et al., 2018; Li et al., 2023). Nevertheless, genome-wide methylation dynamics during ripening remain insufficiently characterized in commercially important Florida cultivars.

Here, we used the recently established telomere-to-telomere, haplotype-phased reference genome of 'Florida Brilliance', a major Florida cultivar, to characterize DNA methylation dynamics during fruit ripening. Using this reference, we first established a leaf DNA methylome as a vegetative baseline (Jang et al., 2026). We then collected fruits at the green, white, half-red, and red stages and analyzed biologically replicated samples by whole-genome bisulfite sequencing and RNA sequencing.

Leaf and green-stage fruit exhibited similar overall methylation profiles, whereas ripening was accompanied by a global reduction in DNA methylation, most prominently in transposable elements (TEs). TE-associated CG methylation declined progressively throughout ripening, while CHG methylation decreased from green to half-red fruit and stabilized thereafter. CHH methylation showed a pronounced reduction during the white-to-half-red transition. These trajectories were consistent across all four subgenomes, indicating coordinated epigenetic remodeling during ripening. RNA-seq revealed decreased *CMT3* and increased *DME* expression at the white stage, suggesting their potential involvement in methylation loss. Together, these findings provide a framework for identifying epigenetically regulated genes underlying fruit maturation and quality traits for strawberry breeding.

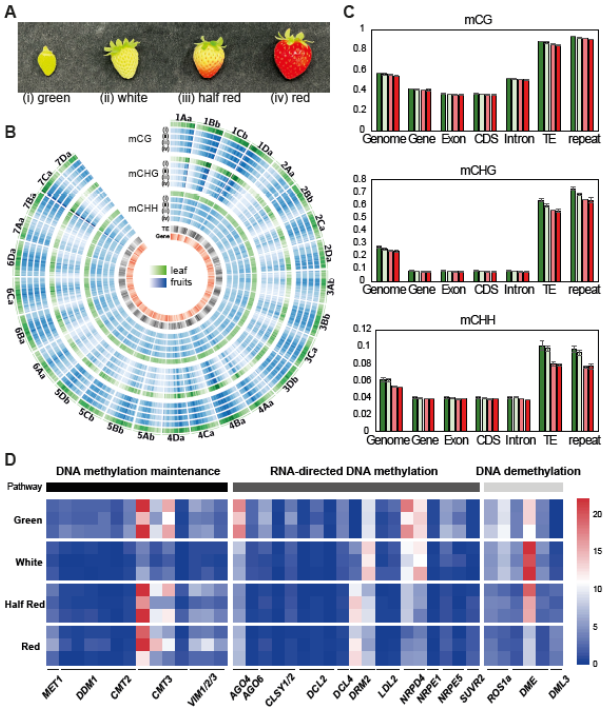


Figure 1: DNA methylation dynamics during 'Florida Brilliance' fruit ripening. (A) Fruits at four ripening stages. (B) Genome-wide methylation map of leaf and ripening fruits. (C) CG, CHG, and CHH methylation across genomic features, with prominent changes in TEs. (D) Expression heatmap of DNA methylation-related genes during ripening.

ACKNOWLEDGEMENTS

Add appropriate acknowledgements as needed.

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Effect of processing and cooking conditions on chicken aroma characteristics evaluated by instrumental and consumer evaluation

Jihye An, Jodie Jones, Michelle Hayden, Jacob Dees, Sungeun Cho
Department of Poultry Science, Auburn University, 260 Lem Morrison Drive, Auburn, AL, 36849

I. INTRODUCTION

Chicken aroma and flavor are influenced by various factors, including processing conditions and cooking methods (Jayasena et al., 2013; Wojtasik-Kalinowska et al., 2023). Meat quality is one of the important factors in measuring the market competitiveness of meat products and has a direct impact on consumers' purchasing choices and eating experiences (Li et al., 2025). The objective of these studies was to investigate aroma changes in chicken products under various processing, storage, and reheating conditions and to evaluate treatment-related differences using instrumental and consumer evaluation.

II. MATERIALS AND METHODS

• Study 1: Over the three storage days (1,3, and 7), regular chicken thigh consumers (n = 52) evaluated sensory attributes and consumer acceptability of raw and cooked chicken thighs with four different treatments: electric-stunned (ES), gas-stunned (GS), marinated ES, marinated GS. Aroma profiles of the samples were evaluated using an E-Nose to compare samples.

• Study 2: Chicken thigh samples were cooked using four different methods (boiling, pan-frying, oven cooking, and air frying) and reheated using both the same cooking method and microwave heating. Reheating was performed 0, 1, 2, or 3 times. Aroma profiles of the samples were evaluated using both an E-Nose and a portable E-Nose to determine differences in aroma characteristics among samples.

III. RESULTS

For raw chicken samples, the results revealed that overall aroma intensity and salty/brined intensity were significantly influenced by the interaction of storage day, stunning method, and marination ($P < 0.05$). In contrast, sweetness intensity and overall aroma quality were not significantly affected by any main or interaction effects. In addition, off-odor intensity, sour/fermented odor intensity, salty/brined odor intensity, and overall aroma liking were significantly influenced by the storage day ($P < 0.05$) while stunning method significantly affected all sensory attributes and consumer acceptability ratings ($P < 0.05$) except sweetness intensity and overall aroma quality. For cooked chicken samples, no significant interactions were observed for any of the sensory attributes or consumer acceptability ratings. Notably, off-odor intensity and sour/fermented odor intensity were significantly influenced by the storage day, while salty/brined odor intensity was significantly affected by the stunning method ($P < 0.05$), and overall aroma liking and freshness were significantly influenced by marination ($P < 0.05$).

IV. CONCLUSIONS

These results provide insight on how various factors affect sensory profiles and attributes of chicken thigh and may help the industry optimize processing to maintain consumer acceptability.

ACKNOWLEDGEMENTS

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Development of AI and Omics-Based Quantitative PCR (qPCR) Assay for Food Safety and Quality

Si Hong Park[1], Eiseul Kim[2], Seung-Min Yang[2], Hyun Jung Kim[3]

[1]Department of Food Science and Technology, Oregon State University, Corvallis, OR 97331, [2]Major of Food Science and Biotechnology, Gyeongkuk National University, Andong, Republic of Korea, [3]Korea Food Research Institute, Wanju-gun, Republic of Korea

SUMMARY

Rapid and reliable diagnostic tools are essential for protecting public health, ensuring regulatory compliance, and preserving product integrity within food production systems. In this study, we developed a data-driven quantitative PCR (qPCR) platform for next-generation food diagnostics that integrates omics-based insights, artificial intelligence (AI)-assisted marker selection, and a portable microfluidic system.

To enable risk-based pathogen detection, we first applied a pangenome-guided approach to identify molecular markers linked to stress resistance in *Listeria monocytogenes*. Comparative genomic analysis revealed key stress-response genes, which were incorporated into a portable microfluidic qPCR assay for on-site detection. The assay exhibited high specificity and sensitivity, with a detection limit of 10 CFU, and maintained strong performance in complex food matrices. This approach allows rapid assessment of strain-level risk traits beyond traditional species identification.

We further developed an AI-driven framework for seafood authentication to address the challenge of distinguishing closely related gadiform species in processed surimi products. Using supervised machine learning, we identified the cytochrome c oxidase subunit I (COX1) gene as the most informative marker. Integration of this target into a portable microfluidic qPCR platform enabled species-level identification of six gadiform species within 30 minutes. The assay achieved 100% specificity and showed complete agreement with commercial labeling in field validation.

In conclusion, this omics- and AI-enabled molecular diagnostic platform represents a scalable and regulator-ready solution for proactive food safety surveillance, fraud detection, and quality control. Its flexible design supports broad application across foodborne pathogen detection and food authenticity verification.

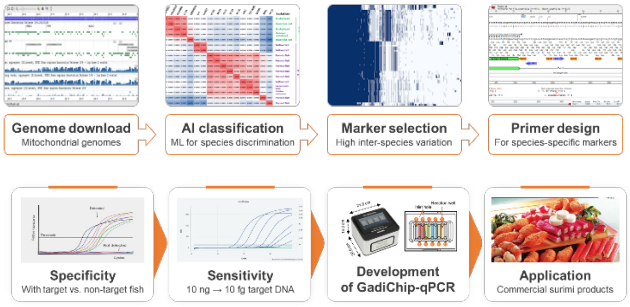


Figure 1: Overview of research design for the authentication of surimi-based seafood.

Gene	Function	Primer	Size (bp)
dasC	Oxidative stress	F-GTT GAT AGT GCT CGG GTG TA R-AAC ACA CCG CAA CAA TCA TT	200
malL	Salt stress	F-ACC AGG TGA GGA AAA CAT GT R-GAA AAC CAA GCC ATC TTC CC	217
gtfA	Multiple stress	F-TTT TGC GTC TTG ATG CCT TT R-AAC GAG TAC AGC ATC ACC AT	229
thiE	Oxidative stress	F-GGC AAA ACG ACG AGG AAA TT R-ATC CGC TTT TGA AAT CGT GG	164

Table 1: Specific primer sequences and amplicon size for detecting stress-resistance genes in *Listeria monocytogenes*.

ACKNOWLEDGEMENT

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Upcycling Agri-Food Biowastes into Functional Fibers for Sustainable Molded Pulp Packaging

Jooyeoun Jung[1], Xiaofang Bai[1]
[1]Department of Food Science and Technology, Oregon State University

I. SUMMARY

This study systematically evaluates 9 agri-food biowastes as alternative lignocellulosic feedstocks for molded pulp packaging by linking composition, fiber structure, and functional performance through peracetic acid (PAA) delignification. Biowastes exhibited wide compositional variability, including high phenolic contents (up to ~2132 mg GAE/100 g) and diverse lignocellulose fractions, which influenced both processing behavior and end-use functionality. PAA treatment effectively reduced lignin and enriched cellulose but resulting fiber morphology varied: fibrous materials such as hemp hurd, hemp fiber, and rhubarb pomace produced well-dispersed fibers with favorable drainage and strong mechanical properties, while particulate residues (e.g., shells and coffee grounds) showed poor bonding and limited sheet formation. Overall, fiber morphology and composition govern processability and performance, with fibrous, cellulose-rich feedstocks emerging as the most promising for sustainable molded pulp packaging applications

II. METHODS

Agri-food biowastes were characterized for chemical composition, total phenolic content, and lignocellulosic fractions using standard analytical methods, including Soxhlet extraction, Folin–Ciocalteu assay, and modified NREL protocols with HPLC quantification of sugars. Fiber pulps were then produced via peracetic acid (PAA) delignification (acetic acid/hydrogen peroxide at 85 °C for 3 h), followed by alkaline treatment and washing. The resulting pulps were analyzed for morphology (light microscopy), drainage behavior (°SR freeness), and mechanical properties (tensile, burst, and elongation) using standardized sheet formation and texture analysis methods to evaluate their suitability for molded pulp packaging applications

III. RESULTS

Table 1. Chemical composition of Agri-food biowaste samples; Carbohydrates were calculated by subtracting other components from 100.

	Fat	Protein	Carbohydrate
Apple pulp	0.36 ± 0.51	2.43 ± 0.08	95.60
Brewer's spent grain	7.56 ± 0.21	22.58 ± 0.34	64.55
Hazelnut shell	0.17 ± 0.06	1.62 ± 0.02	96.98
Hemp fiber	ND	3.38 ± 0.22	95.29
Rhubarb pomace	1.24 ± 0.07	14.94 ± 0.19	73.08
Spent coffee grounds	13.04 ± 0.39	14.48 ± 0.10	70.51
Wine grape pomace	1.73 ± 0.37	14.66 ± 0.10	73.69

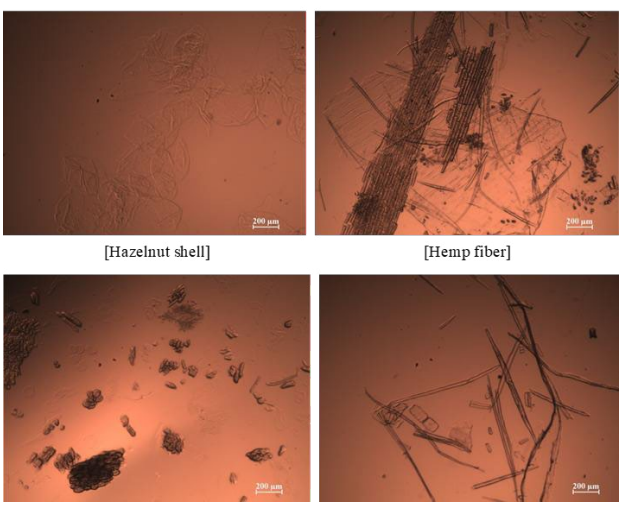


Figure 1: Light microscope images of PAA-treated Agri-food biowaste samples in 1% water suspension.

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Development and evaluation of a bench-scale flume washer for ozone micro-nano bubble washing of fresh produce

Haknyeong Hong[1], Lynne A. McLandsborough[2], Jiakai Lu[2]
[1]Department of Food Science and Technology, University of California, Davis, CA, USA, 95616,
[2] Department of Food Science, University of Massachusetts, Amherst, MA, USA, 01003

I. SUMMARY

Fresh produce is a major vehicle for foodborne disease, highlighting the need for effective and sustainable washing technologies. Ozone micro-nano bubble water has potential as an alternative sanitizer, but its performance under industrially relevant continuous washing conditions remains unclear. In this study, a bench-scale flume washer was developed to simulate the hydrodynamic conditions of industrial produce washing and to compare ozone micro-nano bubble treatment in batch and continuous systems. The side-stream system achieved comparable microbial reduction at 1 ppm ozone to the batch system at 3 ppm, suggesting that side-stream ozone micro-nano bubble delivery can reduce ozone demand while maintaining antimicrobial efficacy. These findings support the potential of ozone micro-nano bubble technology as a sustainable and scalable approach for improving fresh produce safety.

II. Materials and Methods

A. Development of a bench-scale flume washer

A bench-scale flume washer was developed to simulate the hydrodynamic conditions of industrial fresh produce washing. The system incorporated rotating impellers to generate turbulent sanitizer flow and 3D-printed cages to hold fresh produce samples during treatment. The impeller rotation speed was adjusted to achieve Reynolds numbers comparable to those observed in industrial flume washers.

B. Comparison between batch and continuous washing systems

Ozone micro-nano bubble water was applied to inoculated fresh produce samples using both a conventional batch system and the bench-scale flume washer. Treatments were conducted at different ozone concentrations for 1 min, and antimicrobial efficacy was compared between the two systems.

C. Effect of side-stream flow rate on microbial reduction under continuous washing conditions

To improve ozone delivery in the continuous system, ozone micro-nano bubbles were supplied through a side-stream flow equivalent to 10% of the main flow. The antimicrobial efficacy of this system was compared with that of the batch system.

III. Results

The bench-scale flume washer successfully reproduced dynamic washing conditions by combining controlled turbulent flow with produce movement. At 3 ppm ozone for 1 min, the batch washing system achieved greater microbial reduction than the bench-scale flume washer. The lower antimicrobial efficacy observed in the continuous system was associated with rapid ozone decomposition under rotational flow and turbulence. When a side-stream flow equivalent to 10% of the main flow was introduced, the antimicrobial efficacy of the continuous system was improved. Notably, the side-stream ozone micro-nano bubble system achieved comparable microbial reduction at 1 ppm ozone to that of the batch system at 3 ppm ozone.

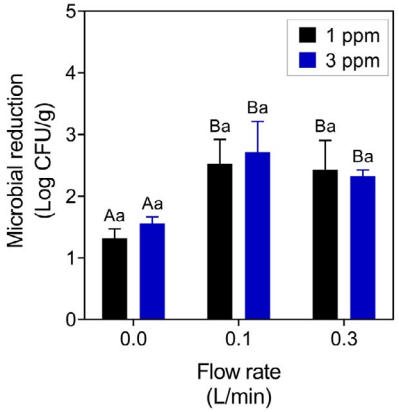


Fig. 1. Microbial log reduction of *E. coli* K12 pEGFP on romaine lettuce treated with ozone micro-nano bubble water under different side-stream flow rates.

ACKNOWLEDGEMENTS

This work is supported by the USDA National Institute of Food and Agriculture, AFRI project 2020-03324

Blue Light Treatment of Whole Avocados to Inactivate *Listeria monocytogenes* and *Salmonella enterica* on their Exocarp Surfaces

Minji Hur[1], Francisco Diez-Gonzalez[2]
[1,2]Center for Food Safety and Department of Food Science and Technology, University of Georgia, Griffin, Georgia, USA

SUMMARY
Introduction: Antimicrobial blue light (aBL) can be an effective bactericidal technology against foodborne pathogens on different surfaces. Although several studies have reported killing *Salmonella* and *Listeria* on fruit surfaces with continuous exposure, research on simulated fruit-handling conditions is limited. The goal of this study was to determine the viability reduction of *Salmonella enterica* and *Listeria monocytogenes* by 405-nm aBL on whole fresh avocado peel (exocarp) under conditions simulating constant rotation.
Methods: Avocados were spot-inoculated with 5-strain mixtures of *L. monocytogenes* and *S. enterica* (3 to 4 Log CFU/spot) on three locations: top, middle, and bottom. Avocados were exposed to aBL for up to 1 h at 4°C, using three aBL lamp setups (single LED100, single LED500, and dual LED500 lamps) while continuously rotated at 5 and 100 rpm on spinning bases. Bacterial counts were determined before and after treatment to determine bacterial inactivation.
Results: The largest viability reduction of *L. monocytogenes* was 2.8 Log CFU/spot, observed with two LED500 lamps; however, *S. enterica* was never inactivated more than 1 Log CFU/spot. *L. monocytogenes* count was reduced approximately 1.3 Log CFU/spot in all inoculated locations at fast speed with a single LED500. Increasing rotation speed from 5 to 100 rpm enhanced *L. monocytogenes* reduction; however, *S. enterica* was largely unaffected by speed or position on the avocado exocarp (surfaces). Inoculation spots did not influence the viability reduction within the tested conditions ($p>0.05$). Dual LED500 lamps resulted in the greatest reduction under all conditions.
Significance: These findings may contribute to assessing the potential application of aBL for decontaminating avocados or similar fruits.

Table1. Calculated light doses (J/cm²) for 405-nm exposure by aBL configurations at 4°C. Illumination was applied for 45 min with LED100 and 1 h with LED500 or 2-LED500, at slow (5 rpm) and fast (100 rpm) rotation speeds. Calculations used a rotating 6 cm-diameter avocado, with light beam widths of 3.0 cm for LED100 and 1.5 cm for LED500.

Lamp	LED100		LED500		2-LED500	
Rotation speed	Fast	Slow	Fast	Slow	Fast	Slow
Location						
Top	67.3	64.7	25.4	26.2	50.8	52.4
Middle	112.2	111.3	46.1	38.1	91.1	76.2
Bottom	88.3	76.3	26.8	23.5	53.6	47.1

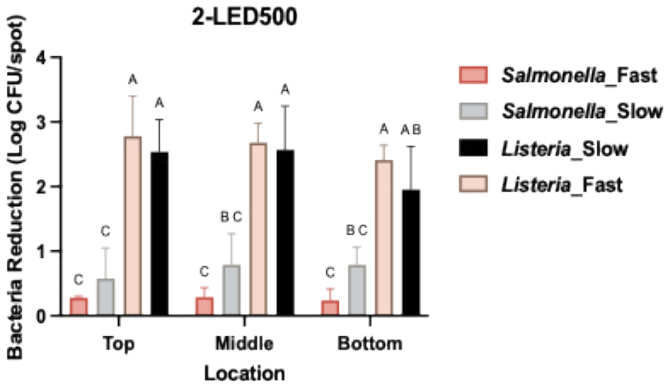


Figure1. Bacterial reduction (Log CFU/spot) of *Salmonella* or *Listeria* on whole avocado exocarp after 1 h of dual LED500 aBL treatment at 4°C while avocados were rotated at 5 and 100 rpm, respectively. Different letters indicate statistical significance ($p<0.05$).

ACKNOWLEDGEMENTS
The research was supported by an internal grant of the Center for Food Safety at the University of Georgia and the Food Safety and Defense Funding Program (A1332), project award number 2022–67017-36307, from the U.S. Department of Agriculture's National Institute of Food and Agriculture.

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Comparative Evaluation of Expert and AI Greenhouse Climate Control for Winter Strawberry Cultivation

Yuseok Jeong[1], Hyojun Bae[1], Eunju Lee[1], Youngsin Hong[1], Taehyun Kim[1], Inchan Choi[1]

[1] Department of Agricultural Engineering, National Institute of Agricultural Sciences, Jeonju 54876, Republic of Korea

I. SUMMARY

Greenhouse climate control is essential for winter strawberry production because indoor air temperature should be adjusted according to crop growth requirements under low outdoor temperatures and variable solar radiation. This study compared the indoor air temperature of an AI-controlled greenhouse with that of an expert-controlled greenhouse during winter strawberry cultivation from January to February 2026. One-minute environmental and control data from both greenhouses were synchronized by timestamp, and 63,052 matched records were analyzed. The AI-controlled greenhouse maintained a mean indoor temperature of 12.70℃, while the expert-controlled greenhouse maintained 12.38℃. The daytime temperature difference was only −0.05℃, and the AI-controlled greenhouse maintained a slightly higher nighttime temperature by +0.61℃. These results indicate that AI-assisted climate control can maintain a thermal environment comparable to expert control.

II. METHODS

Environmental and control data were collected from two smart greenhouses used for winter strawberry cultivation: one operated by expert-based climate control and the other by an AI-based climate control system utilizing a Long Short-Term Memory (LSTM) network, which is well-suited for processing sequential environmental data. The datasets included outdoor weather conditions, solar radiation, indoor air temperature, relative humidity, CO_2 concentration, day/night status, and ventilation and heating temperature setpoints. The two datasets were synchronized using timestamp information, and only matched one-minute records from both greenhouses were used for analysis. Mean indoor temperature and day/night temperature differences were analyzed to evaluate whether the AI-controlled greenhouse maintained a thermal environment comparable to expert control.

III. RESULTS AND DISCUSSION

The AI-controlled greenhouse maintained an indoor temperature pattern comparable to that of the expert-controlled greenhouse. Across the full evaluation period, the mean indoor temperature difference was +0.32℃. During the daytime, both greenhouses maintained nearly identical temperatures, with a difference of −0.05℃. At night, the AI-controlled greenhouse maintained a slightly higher mean temperature by +0.61℃.

These results show that AI-assisted greenhouse climate control can provide temperature management comparable to expert operation for winter strawberry cultivation. Further validation is required to improve environmental control precision through actuator-level precision control and to evaluate crop growth, yield, fruit quality, and energy consumption under comparable cultivation conditions.

Table 1: Comparison of indoor air temperature between AI-controlled and expert-controlled greenhouses

Period	AI (℃)	Expert (℃)	AI−Expert (℃)
Daytime	17.29	17.34	-0.05
Nighttime	9.14	8.53	+0.61
Overall	12.70	12.38	+0.32

ACKNOWLEDGEMENTS

This study was supported by the Research Program for Agricultural Science & Technology Development (Project No. PJ01767001) of the National Institute of Agricultural Sciences, Rural Development Administration, Republic of Korea.

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Development of an End-Effector System for Apple Harvesting Using Modular Design and a Custom PCB

Sang-Hyeon Kang[1], Kyung-Do Kwon[1], Chulwoo Lee[1], Young-ki Hong[1*]
[1]Division of Agricultural Robot, National Institute of Agricultural Sciences, Rural Development Administration, Jeonju, Republic of Korea

I. SUMMARY

Apple harvesting requires intensive labor, but rural workforce shortages driven by population aging have created urgent demand for automation. Previous apple harvesting end-effectors suffered from fragile 3D-printed components and unstable breadboard electronics, resulting in poor field performance. This study presents a robust 3-degree-of-freedom (3-DoF) end-effector featuring a modular hardware design and a custom printed circuit board (PCB) for reliable field operation. The system integrates a ball-screw-driven gripper, a rotational joint, and a linear actuator that together replicate the human "twist-and-pull" harvesting motion. Through five iterative field trials in commercial orchards, the modular architecture demonstrated superior durability and significantly higher harvesting success rates compared to conventional single-DoF systems.

II. SYSTEM DESIGN

A. Modular Hardware Architecture

The end-effector employs a modular design philosophy using laser-cut plates, CNC-machined blocks, lathe-processed shafts, with 3D-printed components only where complex geometries are unavoidable. A FEETECH STS3215 servo motor drives a ball-screw mechanism actuating a three-finger gripper capable of handling apples ranging from 30 to 180 mm in diameter. To address silicone pad detachment observed in early prototypes, EcoFlex 0020 silicone pads are cast with increased thickness and mechanically fastened with bolts rather than adhesive bonding. The 3-DoF "twist-and-pull" strategy combines gripping, rotation, and linear motion, closely mimicking natural human harvesting and significantly outperforming rotation-only methods.

B. Custom PCB and Control Integration

A custom PCB replaces the previous unstable breadboard electronics, managing power distribution from a 24V input down to 12V for the servo drivers and 5V for the Raspberry Pi Pico microcontroller. Three tactile switches provide manual control of forward/backward linear motion and gripper opening/closing operation. Real-time current sensing enables multi-stage torque monitoring, allowing the system to adaptively control gripping force, balancing sufficient force for reliable detachment against the risk of fruit damage.

III. FIELD VALIDATION

Five field tests were conducted in commercial orchards, revealing and resolving critical issues: (1) silicone pad detachment, solved through EcoFlex molding with bolted attachments; (2) electronic instability, eliminated via PCB integration; and (3) poor stem preservation rate, improved by adding a linear degree of freedom. Results confirmed that vertical harvesting motion outperformed horizontal approaches by reducing branch interference. The modular hardware design enabled rapid field repairs and component replacements, substantially reducing downtime compared to more integrated designs.

IV. CONCLUSION

This study successfully developed a robust, modular 3-DoF end-effector that addresses the key limitations of previous apple harvesting prototypes. The combination of modular manufacturing, custom PCB-based control, and the human-inspired "twist-and-pull" harvesting strategy significantly improved field reliability, maintainability, and overall harvesting performance. Future work will focus on integrating autonomous perception and developing adaptive control algorithms using the accumulated field data.

ACKNOWLEDGEMENTS

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*Corresponding author

Haplotype-resolved genome assembly of strawberry cultivars ‘Florida Encore®’ and ‘Florida Ember®’

Jaejoon Lee[1], Hyundae Han[1], Hosung Jang[1], Seonghee Lee[1]
[1]PLANT BREEDING GRADUATE PROGRAM, UNIVERSITY OF FLORIDA

I. SUMMARY

Strawberry is a high-value fruit crop in Florida because it supplies the fresh market during the winter and early spring, when production from many other U.S. regions is limited. Cultivar improvement is essential for maintaining marketable yield, fruit quality, disease resistance, and production efficiency. Because of complex genome in cultivated strawberry, it is difficult to identify sequence variants associated with important breeding traits. Recent studies have used genome-wide markers, multi-omics approaches, and genome assemblies to identify genes and haplotypes associated with traits such as fruit flavor and disease resistance [1,2]. The objective of this study was to generate haplotype-resolved genome assemblies of two recent commercial varieties, ‘Florida Encore®’ and ‘Florida Ember®’. The genome resources will be valuable not only for genomics-enabled breeding but also for other fruit crop genomics research.

In this study, PacBio long-read sequencing produced 70.05 Gb of data for ‘Florida Encore®’ and 66.22 Gb for ‘Florida Ember®’, with read N50 values of 17.7 kb and 14.3 kb, respectively. Reads were quality-checked using FastQC and SeqKit. Genome assembly was performed using Hifiasm, followed by scaffolding with RagTag. Assembly quality was evaluated using QUAST, BUSCO, QV, LAI. The ‘Florida Encore®’ hap1 and hap2 assemblies were 780.6 Mb and 768.6 Mb, with 177 and 126 contigs, respectively. The ‘Florida Ember®’ hap1 and hap2 assemblies were 804.9 Mb and 783.9 Mb, with 695 and 174 contigs, respectively. Contig N50 values ranged from 18.8 to 27.3 Mb, and no Ns were detected in the assemblies. BUSCO analysis showed 99.3% complete genes across all haplotypes. QV values ranged from 63 to 74, and LAI values ranged from 17.68 to 20.48.

The genome assemblies provide a genomic resource to find allelic variations associated with fruit quality, runner production, disease resistance, and other breeding traits. Future analyses will combine these assemblies with phenotypic data, genome-wide markers, transcriptome profiles, and pangenome resources to identify candidate genes and structural variants. This work will support trait discovery and provide tools for marker-assisted and genomic selection for breeding.



Figure 1: Image of ‘Florida Encore®’ and ‘Florida Ember®’ recently released in Florida.

Table 1: Genome assembly quality metrics

Metric	‘Encore’ hap1	‘Encore’ hap2	‘Ember’ hap1	‘Ember’ hap2
Contig #	177	126	695	174
Genome size(Mb)	780.6	768.6	804.9	783.9
Contig N50	24.2Mb	18.8 Mb	27.3 Mb	26.3 Mb
BUSCO	99.30%	99.30%	99.30%	99.30%
QV	72	74	63	72
LAI	19.19	20.48	17.68	19.18
N	0	0	0	0

BUSCO: Conserved gene completeness. QV: Base-level assembly accuracy. LAI: LTR retrotransposon assembly quality. N per 100K: Ambiguous bases per 100 kb.

ACKNOWLEDGEMENTS

Add appropriate acknowledgements as needed.

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Exploring Drought Adaptation Mechanisms in Soybean Genotypes: A Pathway-Based Metabolomics Approach

Namhee Lee[1], Donna K. Harris[2], Zenglu Li[3], Joon Hyuk Suh[1]

[1]Department of Food Science and Technology, University of Georgia, Athens, Georgia, USA,
[2]Department of Plant Sciences, Sheridan Research and Extension Center, University of Wyoming, Sheridan, WY, USA
[3]Department of Crop and Soil Sciences and Institute of Plant Breeding, Genetics, and Genomics, University of Georgia, Athens, GA, USA

I. SUMMARY

Soybean (*Glycine max*) is a globally important crop, yet its productivity is highly susceptible to drought, with yield loss exceeding 50% in rainfed systems. Although physiological traits and genetic markers associated with drought tolerance have been studied[2], the underlying biochemical mechanisms, particularly the role of secondary metabolism, remains underexplored.

This study used a pathway-based metabolomics approach to compare leaf metabolite profiles of drought-tolerant and drought-susceptible soybean genotypes under both well-watered and drought conditions[1]. Metabolites including primary and secondary pathways were analyzed by LC-MS/MS, and discriminant compounds were identified through principal component analysis (PCA) and partial squares discriminant analysis (PLS-DA).

PCA revealed clear metabolic separation between genotype classes under drought stress, implying that water deficit triggers active metabolic reprogramming[1]. Tolerant genotypes exhibited lower overall metabolite levels, reflecting conservative strategy with selective resource allocation. Under drought, they selectively enhanced central carbon metabolism and shikimate pathway activity[3,4], while showing divergent regulation within phenylpropanoid and branched-chain amino acid pathways compared to susceptible genotypes[1].

Both genotype classes shared a core drought response involving hormonal activation, lipid remodeling, accumulation of phenylpropanoid intermediates, and osmoprotective amino acids. These findings suggest that drought adaptation involves an interplay between conserved responses with genotype-specific metabolic reprogramming. In future studies, we aim to leverage metabolite-level targets for breeding drought-resilient cultivars[1].

II. ILLUSTRATIONS

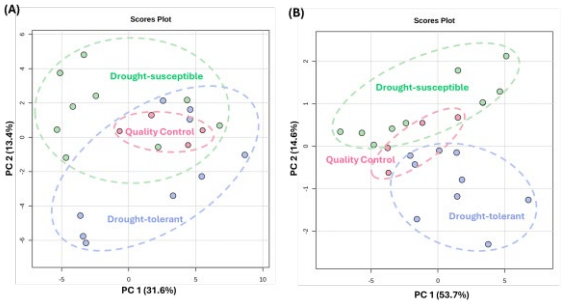


Figure 1: PCA score scatter plots illustrating metabolic variation between drought-susceptible and drought-tolerant genotypes under (A) normal-watered and (B) drought-stressed conditions.

ACKNOWLEDGEMENTS

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Anti-proliferative properties of *Humulus lupulus* (hops) flavonoids in human colorectal cancer cells

Seong-Ho Lee, Gillian Tamia, Darshika Amarakoon, Cheng-I Wei

Department of Nutrition and Food Science, College of Agriculture and Natural Resource, University of Maryland, College Park, MD 20742, USA

SUMMARY

CRC is the third most diagnosed cancer in the United States and is strongly associated with dietary habits and eating patterns. Plant-based diets rich in phytochemicals have been shown to protect against the initiation and progression of CRC.

Hops are the green, cone-shaped flowers of the *Humulus lupulus* plant and contain a variety of bioactive compounds with potential anti-tumorigenic properties. Among these compounds, XN is the most abundant prenylated flavonoid, while related derivatives such as IXN, 8-PN, and TXN have also been identified.

The present study investigated the anti-proliferative effects and underlying molecular mechanisms of these hop-derived flavonoids in human CRC cells. All four flavonoids significantly suppressed the proliferation of multiple CRC cell lines. Based on these findings, TXN and XN were selected for further mechanistic studies. Flow cytometric analysis demonstrated that both compounds significantly induced S-phase and G2/M-phase cell cycle arrest. Apoptosis assays further revealed marked increases in both early and late apoptotic cell populations. Western blot analysis showed significant reductions in cyclin A and CDK2 expression, increased cleavage of PARP, and elevated expression of CHOP, ATF4, and IRE1α, indicating activation of ER stress pathways. In addition, both TXN and XN induced dose-dependent increases in intracellular ROS, mitochondrial dysfunction, and the LC3II/LC3I ratio.

Collectively, these findings suggest that TXN and XN exert anti-cancer effects in human CRC cells through mechanisms involving ROS generation, ER stress, mitochondrial dysfunction, apoptosis, and autophagy [1].

Glossary: 8-PN, 8-prenylnaringenin; ATF4, activating transcription factor 4; CDK2, cyclin-dependent kinase 2; CHOP, CCAAT/enhancer-binding protein homologous protein; CRC, colorectal cancer; ER, endoplasmic reticulum; IRE1α, inositol-requiring enzyme 1α; IXN, isoxanthohumol; PARP, poly(ADP-ribose) polymerase; ROS, reactive oxygen species; TXN, tetrahydroxanthohumol; XN, xanthohumol

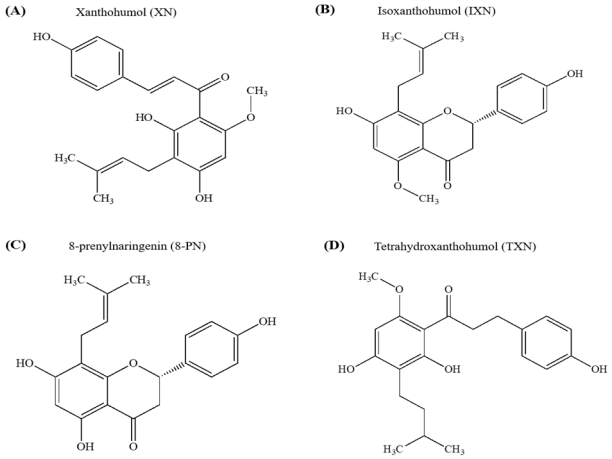


Figure 1. Chemical structure of the four *Humulus lupulus* (hops) flavonoids.

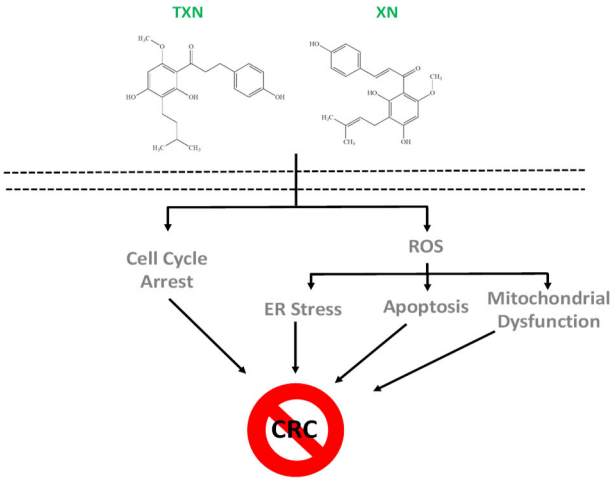


Figure 2. A proposed anti-proliferative mechanisms of *Humulus lupulus* (hops) flavonoids in human CRC cells.

ACKNOWLEDGEMENTS

- Hopsteiner Inc. (New York, USA) for TXN
- USDA NIFA Hatch grant to S-H Lee.

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Hemp Seed Attenuates Colon Tumorigenesis and Immune Responses in Colitis-Associated Colorectal Cancer Mouse

Jieun Woo[1,2], Qing Jiang [2,3], Weicang Wang [1,2,*]

[1] Department of Food Science, Purdue University, West Lafayette, IN, USA, [2] Interdepartmental Nutrition Graduate Program, Purdue University, West Lafayette, IN, USA, [3] Department of Nutrition Science, Purdue University, West Lafayette, IN, USA

I. INTRODUCTION

Colitis-associated colorectal cancer (CAC) is a major complication of chronic intestinal inflammation and is strongly linked to inflammatory bowel disease. Persistent inflammation promotes epithelial damage, immune cell infiltration, and tumor development in the colon. Hemp seed is a nutrient-dense plant-based food rich in polyunsaturated fatty acids, high-quality protein, fiber, and bioactive compounds with potential anti-inflammatory properties. Previous evidence suggests that hemp seed may improve intestinal barrier function and reduce inflammatory responses. However, its role in inflammation-associated colorectal tumorigenesis remains unclear. This study investigated whether dietary hemp seed supplementation attenuates tumor development and immune responses in an azoxymethane (AOM)/ dextran sulfate sodium (DSS)-induced CAC mouse model.

II. RESULTS

A. Hemp seed reduces tumor burden in the AOM/DSS-induced CAC mouse

Chronic intestinal inflammation promotes colorectal tumor development in the CAC mouse. Compared with the CAC group, mice receiving hemp seed showed lower tumor burden, including reduced tumor number and tumor size. These results suggest that hemp seed may attenuate inflammation-associated colorectal tumorigenesis and may serve as a potential dietary strategy for reducing CAC progression.

B. Hemp seed enhances anti-tumor immune responses in CAC mouse

$CD8^+$ T cells are critical mediators of anti-tumor immunity in the tumor microenvironment. Hemp seed supplementation increased CD8 expression in the colon, suggesting enhanced cytotoxic T cell–mediated anti-tumor immunity in the CAC mouse. In contrast, TGF-β expression was reduced in the hemp seed group, indicating decreased immunosuppressive and tumor-promoting signaling. These findings suggest that hemp seed may reshape the tumor immune microenvironment by enhancing anti-tumor immune activity and suppressing pro-tumorigenic inflammatory responses.

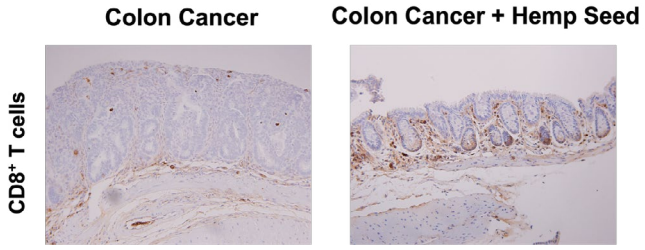


Figure 1. Immunohistochemical analysis of $CD8^+$ T cells in colon tissues from the Colitis-associated colorectal cancer mouse.

ACKNOWLEDGEMENTS

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Effect of Thermal Processing on Nutritional and Quality Parameters of Grape Juice

Moonsun Yang, Ph.D.[1], Josh Herring, Ph.D., and Martha Verghese, Ph. D.[2]

[1] School of Engineering and Science, Wilberforce University, Wilberforce, OH 45384,

[2] Department of Food and Animal Sciences. Alabama A&M University, Huntsville, AL 35811

I. SUMMARY

Fruit is considered an important food source for a healthy diet. Fruit juice is one of the convenient ways of consuming fruits. Thermal processing is commonly used by the food industry for food product safety. However, thermal processing may affect the product's sensory as well as nutritional qualities. Grape is one of the more popular fruits in the world and known to have beneficial effects for human health. The overall goal of this study is to evaluate the effects of thermal processing on nutritional and quality parameters of grape juice. Thermal processed and untreated fresh juices were prepared and used for the determination of Total phenolic content (TPC), Total flavonoid content (TFC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, Ferric Reducing Antioxidant Power (FRAP), Oxygen Radical Absorbance Capacity (ORAC), Trolox Equivalent Antioxidant Capacity (TEAC), pH and color were analyzed in grape. Results show TPC, TFC, TEAC and FRAP of untreated fresh juice (0.56±0.0 mg GAE/g, 0.38±0.0 mg CE/g, 231.33±5.92 mmol Trolox equivalents/g,5.82±0.19µmol FESO4/g, respectively) were significantly ($p \leq 0.05$) higher than traditional thermal processing (0.36±0.0 mg GAE/g, 0.12±0.01 mg CE/g, 198.35±5.34 mmol Trolox equivalents/g, 3.19±2.0µmol FESO4/g, respectively, respectively). Overall, thermal processing affects the grape juice's total phenolic content, total flavonoid content, antioxidant activity as well as physiochemical property.

II. INTRODUCTION

Fruit is an important food source for healthy diet. Several studies have shown that sufficient consumption of fruits play a significant role in human nutrition and health due to their bioactive compounds including phytochemicals, vitamins, minerals and dietary fibers. These bioactive compounds may prevent chronic diseases such as cancer, coronary heart disease, stroke and cataract formation (Dauchet et al., 2006; Oguntibeju, Esterhuyse & Truter, 2013). Fruits exist now in varied forms in the market including frozen, canned, dried, pureed, or juiced as well as fresh whole fruit and vegetables. Fruits juice is one of the convenient ways of consuming fruits. Nowadays, access to information and awareness regarding the consumption of a healthy and balanced diet have led to a substantial growth of the global juice market (Market, 2015). Grape (Vitis vinifera) is one of the most popular fruit and grown worldwide. Grape and grape derivatives contain a diversity of phytochemical, they are known to have beneficial effects for human health (Greyling et al., 2016). Peoples are able to consume grapes as various form not only fresh fruit, but also processed form such as juice. Thermal processing is the most widely used by food industry to aid and ensure juice type of products safety. However, heat applied in juices could affect the chemical integrity of the product that causes undesirable changes to sensory and nutritional attributes. Therefore, evaluation of work is necessary to understand about thermal processed grape juice.

OBJECTIVES

To evaluate the effects of thermal treatment on retention of bioactive component and quality parameters of grape juice.

Table 1: Color differences (L*, a* and b* values) of Non-thermal and thermal processed grape juice

Juice	L*	a*	b*
Non-thermal	1.57±0.02[b]	1.58±0.05[b]	9.36±0.01[b]
Thermal	27.82±0.25[a]	12.19±0.19[a]	-0.46±0.15[a]

ACKNOWLEDGEMENTS

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A Protective effect of Aged Parsnip Extract on Diet-induced Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) *in vivo*

Tongkewn Yoo[1], Jaehyun Ju[1], Menghao Huang[2], X. Charlie Dong[2] and Kee-Hong Kim[1]

[1]Department of Food Science, Purdue University, West Lafayette, IN,

[2]Department of Biochemistry, Molecular Biology and Pharmacology, School of Medicine, Indiana University, Indianapolis, IN

I. INTRODUCTION

Metabolic dysfunction-associated steatotic liver disease (MASLD) is characterized by excessive hepatic lipid accumulation in individuals with obesity, diabetes, or other metabolic abnormalities. MASLD can progress from simple steatosis to metabolic dysfunction-associated steatohepatitis (MASH), which involves inflammation, hepatocyte injury, and fibrosis and may eventually lead to cirrhosis. Because MASLD is strongly linked to systemic metabolic dysfunction, effective dietary strategies that reduce hepatic lipid accumulation and inflammatory injury may help prevent disease progression. Parsnip (*Pastinaca sativa*) contains bioactive phytochemicals, including flavonoids and furanocoumarins, with reported antioxidant and anti-inflammatory properties. This study investigated whether aged parsnip extract (AP), generated through post-harvest physical aging, protects against diet-induced MASLD and modulates hepatic SIRT6/inflammasome signaling.

II. Methods:

Sliced parsnip was subjected to a post-harvest aging process in dry-heat incubation. The resulting aged parsnip extract was incorporated into an in vivo dietary intervention. Male C57BL/6J mice were fed either a standard chow diet, a high-fat, high-sucrose, high-cholesterol diet (HFSCD), or HFSCD supplemented with AP for 17 weeks. AP was provided at approximately 1 mg/day/mouse.

II. Results

HFSCD feeding induced features of MASLD, including increased body weight, fat mass, liver weight, hepatic lipid accumulation, circulating glucose, triglycerides, total cholesterol, and inflammatory markers. AP supplementation attenuated HFSCD-induced increases in adipose and liver weights and reduced hepatic triglyceride and cholesterol accumulation. Histological analysis showed that AP improved liver pathology, including reduced hepatic ballooning, lipid deposition, and fibrosis. Blood analysis demonstrated lower plasma glucose, triglycerides, total cholesterol, and MASLD-related cytokine expression in the HFSCD+AP group. Mechanistically, AP increased hepatic SIRT6 expression and activity, reduced Histone H3K9 acetylation, and modulated inflammasome-associated proteins, including IL-1β, caspase-1, ASC, and serum amyloid A.

III. ILLUSTRATIONS

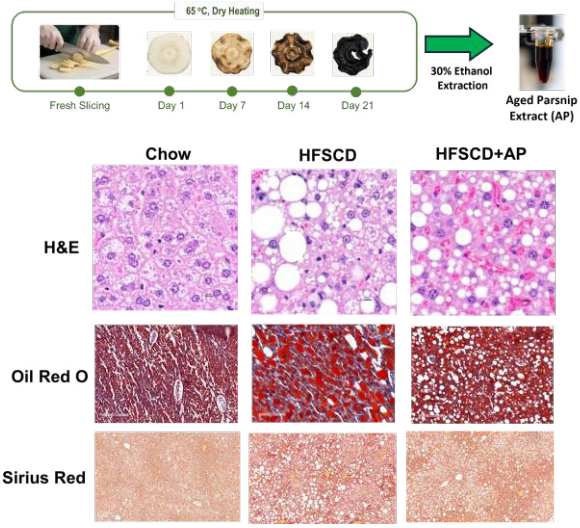


Figure 1: Aged parsnip extract (AP) preparation and liver histology. AP was prepared by dry-heating sliced parsnip at 65°C for up to 21 days, followed by extraction. Representative H&E, Oil Red O, and Sirius Red staining of mouse liver sections show hepatic morphology, lipid accumulation, and fibrosis, respectively.

ACKNOWLEDGEMENTS

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Autonomous Ground Robotics for Precision Strawberry Production in Florida

Daeun Choi[1], Md Didarul Islam[1], Uchechukwu Ilodibe[1]

[1]Department of Agricultural and Biological Engineering, Gulf Coast Research and Education Center, Institute of Food and Agricultural Science, University of Florida

I. SUMMARY

Florida strawberry production requires labor-intensive operations such as runner removal and pest management. Runners compete with fruit development for nutrients, increase disease risk through soil contact, and require repeated manual removal. At the same time, biological control programs are often applied uniformly despite substantial variation in plant health and pest pressure. Autonomous ground robots offer a potential solution by enabling plant-level management while reducing labor requirements.

An autonomous ground robotic platform was developed that integrates RGB-D perception, AI-based decision making, autonomous navigation, robotic manipulation, and variable-rate biological control. The platform was designed to operate within Florida's plasticulture production system and supports multiple crop-management functions through a shared sensing and mobility architecture.

For runner management, the system detects visible runner segments using computer vision and estimates three-dimensional locations for robotic cutting [1]. Instead of tracing the entire runner, the perception system identifies the first visible segment to simplify detection under complex canopy conditions. Field evaluations demonstrated successful cutting of detected runners, with overall cutting success exceeding 80%. Missed detections were primarily associated with canopy occlusion, variable illumination, and overlapping plant structures.

A variable-rate predatory mite dispensing module was also developed for targeted biological control [2]. The system identifies strawberry plants and dispenses different application rates according to plant condition. Indoor and outdoor experiments demonstrated greater than 95% targeting precision and recall while maintaining reliable dispensing performance. These results indicate the feasibility of plant-specific biological control using autonomous robotic systems.

The proposed platform demonstrates the potential of autonomous ground robotics for multiple strawberry management operations. Future work will focus on improving perception robustness, increasing operational efficiency, and integrating additional precision-management functions into a unified field-ready system.



Figure 1: Autonomous ground robotic platform used for robotic runner cutting and variable-rate predatory mite dispensing in Florida.

ACKNOWLEDGEMENTS

This work was supported by the USDA National Institute of Food and Agriculture (NIFA) under Accession No. 1034424 and Florida Strawberry Research and Education Foundation (FSREF).

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Biology / Biotechnology / Health

Ultrasound-induced Macrophage Mechanotransduction via Actin Reorganization and Ca^{2+} Responses

Myeong Ryeol Choi[1*], Jinhee Yoo[3], Hyung Ham Kim[1,2], Yong Joo Ahn[1,2]

Medical Science and Engineering, Pohang University of Science and Technology, Korea[1]

Convergence IT Engineering, Pohang University of Science and Technology, Korea[2]

Brigham and Women's Hospital, Harvard Medical School, Harvard University, USA[3]

I. Summary

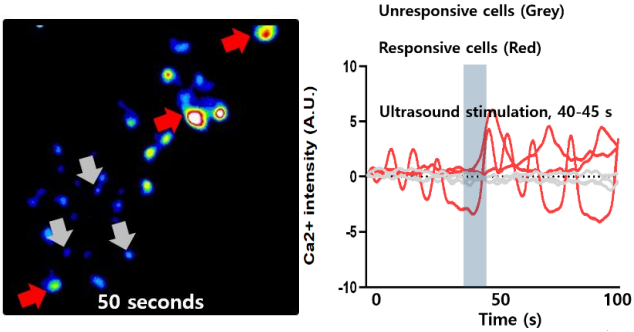
Mechanical regulation of macrophage function remains poorly understood. In this study, controlled ultrasound was applied to RAW264.7 to examine its effects on intracellular Ca^{2+} responses and actin organization. Ultrasound-induced rapid Ca^{2+} responses together with cortical actin remodeling, suggesting coordinated changes in cellular signaling and structure. These findings support the idea that ultrasound can serve as a controllable physical stimulus to modulate macrophage states and to study immune mechanobiology.

II. Method

RAW264.7 cells were used to analyze cellular responses to ultrasound stimulation. Intracellular Ca^{2+} responses were measured by Fluo-4 fluorescence imaging during a 100-s recording, with ultrasound applied for 5 s at 40–45 s (6 MHz center frequency, 20% duty cycle, 1 kHz PRF). Cytoskeletal changes were assessed by phalloidin staining of F-actin and confocal microscopy.

III. Results

As shown in Figure 1, intracellular Ca^{2+} intensity remained relatively stable before ultrasound stimulation but exhibited rapid, marked fluctuations after stimulation. These findings suggest that ultrasound can induce Ca^{2+} responses in macrophages, along with actin remodeling, and may indicate a link among membrane–cytoskeleton interactions, structural changes, and intracellular signaling.



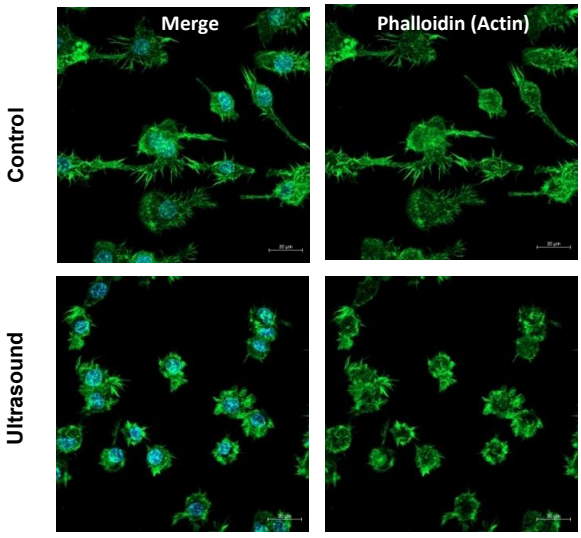


Figure 1: Ultrasound-induced single-cell Ca^{2+} responses and macrophage actin reorganization

ACKNOWLEDGEMENTS

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VASP, a F-actin polymerization factor, is a novel YAP-TEAD target gene in MDA-MB-231 cells

Tae-Hyung Kim[1], Wonkyung Lee[2], Seeun Oh[3]

[1]Department of Pathology, School of Medicine, University of New Mexico Health Sciences Center, Albuquerque, New Mexico, United States, [2]Yeungnam University, College of Medicine, Daegu, Republic of Korea, [1]Department of Pathology, School of Medicine, [3]Department of Molecular Genetics & Microbiology, School of Medicine, University of New Mexico Health Sciences Center, Albuquerque, New Mexico, United States

ABSTRACT

Triple negative breast cancer (TNBC) is an aggressive subtype lacking targeted therapies, highlighting the urgent need for novel treatment strategies. Clinical observations indicate that TNBC patients with obesity or diabetes, frequently accompanied by hyperglycemia, have a worse prognosis, underscoring the impact of metabolic dysregulation on disease progression. We previously demonstrated that extracellular glucose regulates F-actin assembly and non-muscle myosin activity via the cAMP-RhoA-ROCK pathway in TNBC cells, linking glucose metabolism to cytoskeletal remodeling and cell invasion. In this study, we aimed to further elucidate the molecular mechanisms by which extracellular glucose regulates cell mechanics and motility. We hypothesized that the Hippo pathway, particularly YAP, regulates expression of a cytoskeletal remodeling gene, VASP in response to glucose metabolic signaling.

To test the hypothesis, we utilized public ChIP-seq datasets, to identify four YAP-TEAD binding domains (CBDs) within the human VASP gene enhancer region in MDA-MB-231 cells. TEAD motif analysis using FIMO revealed predicted TEAD-binding sites in each region. We then experimentally validated those identified CBDs. These enhancer fragments were subcloned into luciferase reporters, and CBD4 exhibited the strongest transcriptional activity. For further exogenous validation, we measured luciferase activity following TEAD inhibitor treatment and performed site-directed mutagenesis to determine whether TEAD binding is required for VASP gene regulation.

To determine which TEAD isoforms contribute most to VASP regulation, we performed siRNA-mediated knockdown of TEAD1-4 and found that TEAD1 and TEAD4 were the most significant regulators of VASP expression. For endogenous validation of the YAP-TEAD-VASP axis, we conducted Western Blotting after 24 hours of TEAD inhibitor treatment. To test whether this regulatory axis is responsive to glucose levels, we performed glucose-dependent luciferase assays for exogenous validation, and RNA sequencing and Western Blotting to evaluate endogenous VASP expression under different glucose conditions. These analyses demonstrated that the YAP-TEAD-VASP axis is upregulated in high-glucose settings.

Finally, to explore the translational implications of these mechanistic findings, we assessed whether TEAD inhibitors could suppress migration in a hyperglycemic context. Because VASP promotes F-actin polymerization, we hypothesized that TEAD inhibition would reduce F-actin rearrangement and thereby suppress cell migration. In scratch wound healing assays, TEAD inhibitors significantly reduced cell migration across all glucose concentrations tested (1, 5, 11, and 25 mM).

In summary, we identify VASP as a novel YAP-TEAD target gene regulated under hyperglycemic conditions and demonstrate that TEAD inhibition suppresses migration in TNBC cells. These findings warrant further in vivo studies to evaluate whether TEAD inhibitors could reduce metastasis in diabetic TNBC animal models.

Key Words: VASP, YAP, TEAD, TNBC, Glucose, MDA-MB-231

ACKNOWLEDGEMENTS

This work was supported by NIH/NIGMS (R35GM157045), ACS-IRG, and Department of Pathology Start-up funds.

Effect of Aymara Enriched *NFKB1* SNP on Acute Mountain Sickness in Austrians Exposed to Acute Hypoxia

Grace H. Min[1], Jihyun Song[1]

[1]Division of hematology and Hematological Malignancies, Huntsman Cancer institute, University of Utah

I. Introduction

Acute mountain sickness (AMS) can occur with rapid ascent above 2,500m – severe cases leading to fatal edemas. Known genetic variants partially explain AMS susceptibility but incompletely predict AMS, implying the presence of additional genetic determinants. High-altitude populations offer key insights into hypoxic adaptations that elucidate why tolerance varies among individuals (1). The Aymara, a long-term high-altitude Andean population, have evolved genetic adaptations to environmental hypoxia. Genomic and transcriptomic studies of this population have identified variants in the *NFKB1* gene, one of the components of the NF-kB signaling pathway, which is a major regulator of inflammation. In the Aymara population, rs230511 T allele is highly enriched [allele frequency (AF): 0.878] and is associated with altered *NFKB1* splicing (skipping exon 4 and/or exon 5), increased inflammatory signaling, and elevated hemoglobin levels. Under inflammatory stress, this variant plays a protective role against excessive inflammation (2). It has been reported that inflammation contributes to AMS. Notably, this variant is also present at lower frequencies in other populations, including Asian (AF: 0.364) and Europeans (AF: 0.334) (3,4), indicating that it is not unique to the Aymara population and may have broader functional relevance in hypoxia and inflammatory responses. These findings suggest a potential role for *NFKB1* variant in AMS susceptibility.

II. Method

Seventy-seven healthy Austrian volunteers underwent 12 hours of normobaric hypoxia (equivalent to 4,500m) and were stratified via Lake Louise Score (LLS) (5). Genomic DNA was isolated from plasma using the QiAamp Circulating Nucleic Acid Kit (QIAGEN). Purified DNA was subsequently amplified using the Repli-G Kit (QIAGEN). Participants were genotyped for *NFKB1* rs235011 using Taqman genotyping assay (Thermo Fisher Scientific). Physiological parameters were measured before and after exposure to hypoxia (5). Statistical methods used for comparison between genotypes were performed using either Mann-Whitney or unpaired t-test with Welch's correction.

III. Results & Discussion

NFKB1 rs230511 T/T homozygotes had significantly lower LLS at 6 hours than wild-type, indicating protection against sustained AMS symptoms. T/T homozygotes maintained significantly higher SpO_2 (peripheral oxygen saturation), at 6 hours than wild-type, reflecting better oxygenation preservation. The hypoxia-induced decline in $PaCO_2$ (arterial carbon dioxide tension) was significantly less pronounced in both C/T and T/T carriers, consistent with a more efficient ventilatory response. Baseline SaO_2 (arterial oxygen saturation) was significantly lower in T/T homozygotes prior to hypoxic exposure, suggesting pre-existing physiological differences that may be advantageous under hypoxia. *NFKB1* carriers (C/T and T/T) had significantly higher systolic blood pressure (BP) under both normoxia and hypoxia. Diastolic BP was also significantly higher in C/T heterozygotes during hypoxic exposure, suggesting more stable hemodynamic regulation.

III. Conclusion

We conclude that Aymara enriched *NFKB1* genetic variants, present at lower frequency in Europeans, influence acute hypoxia responses, supporting their role in physiological resilience and their potential as biomarkers to identify individuals at risk for AMS prior to high-altitude exposure.

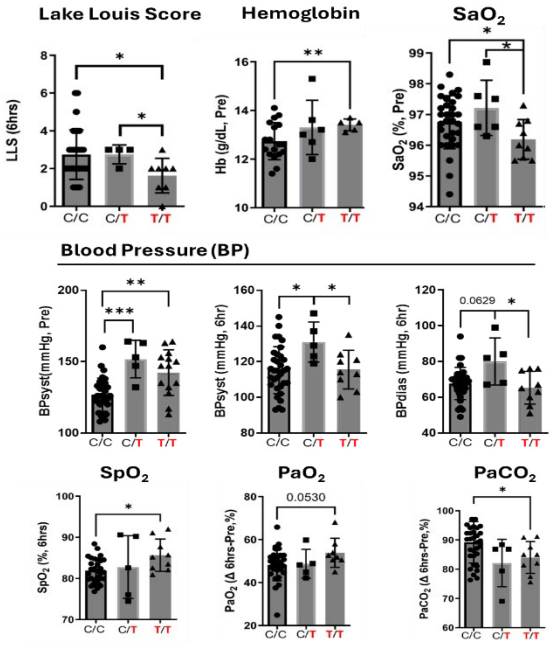


Figure. Association of *NFKB1* rs230511with physiological changes to acute hypoxia

Data is presented as the mean with standard deviation. Alleles bold and red represent variants enriched in the Aymara population. SaO_2 (arterial oxygen saturation); SpO_2 (peripheral oxygen saturation); PaO_2 (arterial oxygen tension); $PaCO_2$ (arterial carbon dioxide tension); systolic blood pressure (BPsyst); Diastolic blood pressure (BPdias)

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Development of Antibody-Immobilized Electrodes to Detect Osteocalcin for Racehorse Bone Health Monitoring

Daniel Sim[1,2], Tena Ursini[1], Sandro Colla[1]
[1]Department of Large Animal Clinical Sciences, The University of Tennessee College of Veterinary Medicine, Knoxville, Tennessee
[2]Department of Animal Science, The University of Tennessee AgResearch, Knoxville, Tennessee

I. SUMMARY

This paper presents the development of biosensors capable of detecting osteocalcin from non-invasive body fluids. While accessible, rapid methods for the early diagnosis of bone injury are required, current immunoassay methods are not suitable for individual-level detection. We develop electrical sensors in which the anti-osteocalcin antibody is immobilized on the electrode surfaces. When the binding event between the anti-osteocalcin antibody and osteocalcin occurs, the resulting changes in electrical resistance trigger an electrical signal. This biosensor enables early, easy detection of bone turnover biomarker accessibility, which is useful for racehorse management, especially for injury prevention.

II. BACKGROUND

While Thoroughbred racehorses have a significant risk of bone fracture injuries during racing or training, these horses do not show obvious outward signs of bone weakness until injury occurs. Detecting at-risk horses is challenging due to the difficulty of clinically identifying bone weakness in the early stages [1]. The use of bone turnover biomarkers has been useful for tracking horses' bone health. Although most of this research has used radioimmunoassay and/or radiological techniques to detect these biomarkers, these technologies are not well-suited for individual-level detection and are expensive. Identification of faster, more affordable methods for early diagnosis is required to prevent the progression of bone fractures before they are detected and to enable earlier, more effective treatment.

We present developing point-of-care biosensors capable of rapidly and quantitatively detecting osteocalcin from possibly sweat. Among several biomarkers, we select osteocalcin as the target molecule because it is a representative indicator of bone deterioration and is associated with an increased risk of fractures and decreased bone mineral density[2].

III. METHODOLOGY & PROTOCOL

The methods consist of device platform preparation, antibody immobilization to the device platform, and characterization of sensing performance. We chemically modify the surface of the device platforms with interdigitated electrodes (IDEs) to immobilize the anti-osteocalcin antibody. The specific methods include aminosilane-nanomaterials, assembling the functionalized nanomaterial on the IDE, and antibody drop-casting. Anti-osteocalcin antibody immobilization on the IDE is monitored by measuring changes in current after introducing the biomolecule onto the electrode surface. The sensor operates on the dual-probe station with the current voltage supply. The operating conditions are maintained at room temperature and kept wet throughout the experiments with phosphate-buffered saline.

IV. SIGNIFICANCE & PLANNED OUTCOMES

The development of biosensors that measure calcium-dependent biomarkers (e.g., osteocalcin) in body fluid samples benefits the management of racehorses by enabling early, accessible detection of bone turnover indicators, thereby helping prevent severe musculoskeletal injury. The osteocalcin sensor characterizes the IDE's response to target and reference proteins to evaluate sensitivity, limit of detection, and selectivity.

ACKNOWLEDGEMENTS

All authors acknowledge support from the University of Tennessee College of Veterinary Medicine.

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Artificial Intelligence for Comparative Oncology: Modeling Rare Cancers Using Naturally Occurring Canine Cancers

Jong Hyuk Kim[1,2,3]

[1]Dept. of Small Animal Clinical Sciences, College of Veterinary Medicine, Univ. of Florida; [2]UF Health Cancer Center; [3]AI² Center, University of Florida, Gainesville, FL

I. SUMMARY

Naturally occurring cancers commonly occur in companion animals offering translational models to advance understanding of human malignancies. Our research program focuses on comparative oncology with a particular focus on canine sarcomas such as hemangiosarcoma (HSA) and osteosarcoma, employing genomics, molecular biology, and artificial intelligence (AI) to reveal shared oncogenic mechanisms and therapeutic vulnerabilities applicable to both species.

II. COMPARATIVE GENOMICS AND MOLECULAR BIOLOGY

Canine HSA mirrors the clinical aggressiveness and poor prognosis of human angiosarcoma. Genome-wide expression profiling identified three molecular subtypes, challenging the endothelial cell-of-origin paradigm [1]. Comparative whole exome- and RNA-seq established convergent mutational landscapes with recurrent alterations in *TP53* (59.6%), *PIK3CA* (29.8%), and *PIK3R1* (8.5%) [2]. Novel protein-coding gene fusions co-occurring with *TP53* mutations activated convergent angiogenic transcriptional programs in both species [3]. HSA cells also elaborate hematopoietic cytokines that expand host-derived progenitors, implicating these tumors in stromal-immune niche remodeling [4]. Engineered *PIK3CA* H1047R-mutant HSA cell lines, coupled with multi-omic profiling further demonstrated that this hotspot drives immune cytokine enrichment (IL-6, IL-8, MCP-1), metabolic reprogramming, and alpelisib resistance, while identifying MAPK activation as a synthetic vulnerability for combination therapy [5].

III. AI FOR COMPARATIVE PATHOLOGY

Machine learning models (extra trees, random forest) trained on RNA-seq data from 76 canine HSAs achieved high classification accuracy in distinguishing malignant from non-malignant tissue and identified novel gene signatures as diagnostic biomarkers [6]. Deep learning CNN models demonstrated a strong potential for disease classification and for inferring mutational status and immune phenotype using H&E-stained histological images of canine HSA. Also, explainable AI (Grad-CAM) confirmed that model decisions aligned with pathologically relevant malignant features [7]. Expanding to whole-slide image (WSI) analysis, AI-driven digital pathology techniques decoded the spatial organization of canine HSA tissues that portray complex vascular structures [8].

IV. ONGOING WORK

Building on this prior work, our current project leverages naturally occurring canine HSA as a translational model for rare human angiosarcoma. First, we are building a comprehensive biorepository of canine HSA cell lines, alongside the development of ex vivo tumoroids and in vivo xenograft models derived from client-owned dogs, supported by multi-omics profiling. Second, we are evaluating the cross-species efficacy of RMC-7977, a tri-complex RAS(ON) multi-selective inhibitor, in human angiosarcoma and canine HSA xenograft models. Third, we are constructing multimodal, AI-driven frameworks that integrate genomic, transcriptomic, and veterinary clinical data to predict RAS pathway activation and assess the translational relevance of canine models for human disease.

ACKNOWLEDGEMENTS

This work was supported by the UF Health Cancer Institute and the AI² Center at the University of Florida, as well as the Morris Animal Foundation, the AKC Canine Health Foundation, the Department of Defense PRCRP and RCRP programs, and the NVIDIA–UF AI partnership.

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Nociceptive Nerve Remodeling in Osteoarthritic Mouse Knee Joints

Paromita Kundu, Brian Wise, Emma Norris, Mark James, Yaxin Zhang, Jennifer Jonason, Mark Buckley, Whasil Lee University of Rochester, Rochester NY 14560

Osteoarthritis is a progressive joint disease affecting hundreds of millions of people globally, with persistent pain representing its most disabling feature. Although structural changes such as cartilage loss and bone remodeling are well documented, the extent to which joint-innervating nerves are spatially reorganized during aging, and how this reorganization contributes to pain, remains an open question. To address this, thirty-eight C57BL/6 mice were divided by age and sex into four cohorts: young male, aged male, young female, and aged female. Mechanical pain sensitivity was measured by applying graded force to the knee joint, and cartilage integrity was scored histologically. For three-dimensional nerve mapping, whole knee joints underwent iDISCO+ optical clearing, a solvent-based method that renders dense musculoskeletal tissue transparent, followed by light sheet fluorescence microscopy. Volumetric imaging captured the distribution of total (PGP9.5$^+$), pain-transmitting (CGRP$^+$), and autonomic sympathetic (TH$^+$) nerve fibers across the anterior joint compartment. Custom MATLAB algorithms then quantified fiber length, branching complexity, and spatial distribution across medial and lateral regions. Complementary molecular analyses of dorsal root ganglia — the peripheral sensory neuron clusters relaying joint signals to the spinal cord — assessed expression of pain-associated proteins CGRP and PIEZO2, a mechanosensitive ion channel linked to pain signaling.

Aged male mice displayed the most severe joint degeneration and the greatest reduction in mechanical pain thresholds, reflecting heightened sensitivity with age. Three-dimensional imaging revealed striking nerve network expansion in this group, with roughly twice the total fiber length and more than three times the branching density relative to young males. This growth was specific to pain-transmitting fibers; autonomic sympathetic fiber density was unaffected by age or sex across all groups. Molecularly, aged males carried a greater proportion of pain-associated sensory neurons and markedly elevated mechanosensory protein expression in dorsal root ganglia. Notably, female mice showed no meaningful age-related shifts in pain behavior, cartilage integrity, nerve architecture, or molecular pain markers, revealing a pronounced sex divergence in how aging shapes OA pathophysiology.

Together, these findings demonstrate that selective expansion of nociceptive — rather than autonomic — nerve networks in the aging knee closely tracks with worsening joint damage and increased pain sensitivity, at least in male animals. This work positions three-dimensional volume imaging paired with computational nerve analysis as a powerful platform for studying neural contributions to joint disease and for evaluating potential nerve-targeted therapeutic strategies in osteoarthritis.

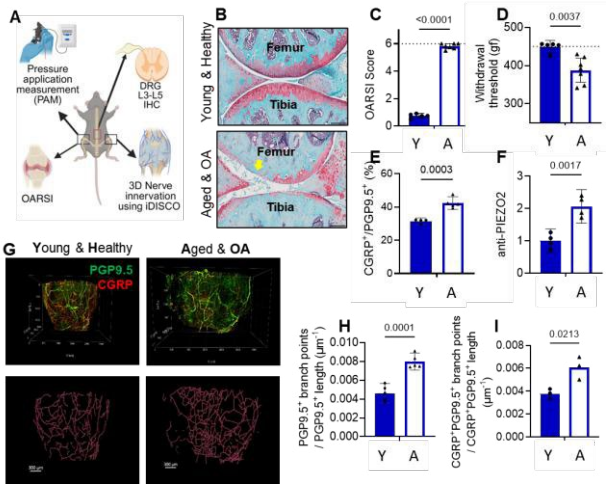


Figure 1: Fig. 1. Mice with aging-OA exhibit enhanced cartilage degeneration, joint pain, and knee-innervated CGRP+ nociceptive nerve branches compared to young&healthy controls. (A) Schematic of experimental design. (B-C) Representative Saf-O/FG and OARSI scores (D) Knee hyperalgesia by PAM. (E-F) Augmented CGRP+ and Piezo2 expression in DRG soma (L3-L5). (n = 5–7 mice/group). (G) 3D Light-Sheet Micrographs of knee-innervating nerve filaments stained with anti-PGP9.5 (green) and anti-CGRP (red) in M_y, M_a. (H-I) Total number of branches of CGRP$^+$/ PGP9.5$^+$ nociceptive nerve innervation in the aging OA knee joints (n = 3 mice/group).

ACKNOWLEDGEMENTS

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Altered translation elongation contributes to key hallmarks of aging

Jae Ho Lee[1,2*], Domenico Di Fraia[3*], Antonio Marino[3*], Erika Kelmer Sacramento[3], Mario Baumgart[3], Sara Bagnoli[4], Till Balla[5,6], Felix Schalk[3], Stephan Kamrad[7], Rui Guan[7], Cinzia Caterino[3], Chiara Giannuzzi[3,4], Pedro Tomaz da Silva[8,9], Amit Kumar Sahu[3], Hanna Gut[3], Giacomo Siano[4], Max Tiessen[3], Eva Terzibasi-Tozzini[4], Eugenio F. Fornasiero[10,11], Julien Gagneur[8,12,13], Christoph Englert[3,14], Kiran R. Patil[7], Clara Correia-Melo[3], Danny D. Nedialkova[5,6], Judith Frydman[2], Alessandro Cellerino[3,4], Alessandro Ori[3]

[1]Stony Brook University, USA, [2]Stanford University, USA, [3]Leibniz Institute on Aging - Fritz Lipmann Institute, Germany, [4]Scuola Normale Superiore, Italy, [5]Max Planck Institute of Biochemistry, Germany, [6]School of Natural Sciences, Technical University of Munich, Germany, [7]University of Cambridge, UK, [8]School of Computation, Information and Technology, Technical University of Munich, Germany, [9]Munich Center for Machine Learning, Germany, [10]University Medical Center Göttingen, Germany, [11]University of Trieste, Italy, [12]Helmholtz Center Munich, Germany, [13]Institute of Human Genetics, Technical University of Munich, Germany, [14]Friedrich Schiller University Jena, Germany. *Equal contribution

I. SUMMARY

Aging is associated with a decline in protein homeostasis, which leads to progressive accumulation of protein aggregates, organelle dysfunction, and global decline in cellular processes. These impairments manifest in various hallmarks of aging that include 'decoupling' between changes at transcription and proteome levels. In other words, increased transcription does not necessarily lead to increased protein levels and vice versa. To understand the origins of decoupling and how different proteins are affected, we carried out an integrative analysis of transcriptome, translatome, and proteome changes during aging in killifish brain. We find that aging causes widespread reduction of proteins enriched in basic amino acids that is independent of mRNA regulation, and it is not due to impaired proteasome activity. Instead, we identified sites of aberrant translation pausing that occur in an age-dependent manner particularly around basic amino acids. Moreover, further analysis in comparison to other datasets revealed that aberrant translation pausing is correlated with protein aggregation and protein loss, which partially explains the origin of transcriptome-proteome decoupling during aging. These events ultimately lead to reduced ribosome availability resulting in proteome remodeling independently of transcriptional regulation. Together, our results emphasize the fundamental role of translation speed in protein biogenesis and how it becomes vulnerable in the aging brain. Moreover, our work uncovers a vulnerable point in the aging brain's biology – the biogenesis of basic DNA/RNA binding proteins. This vulnerability may represent a unifying principle that connects various aging hallmarks, encompassing genome integrity and the biosynthesis of macromolecules.

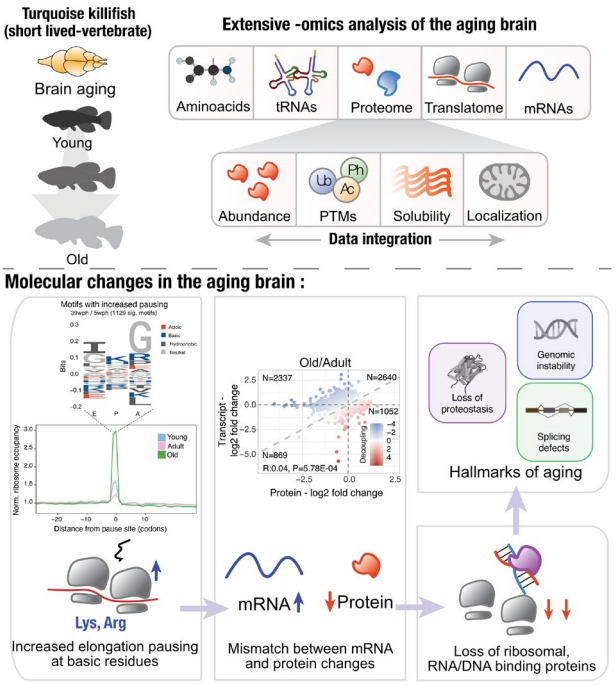


Figure 1. Summary of approach and results. We analyzed brains from aging killifish and performed extensive omics analysis. Through data integration, we show that aberrant pausing around basic residues leads to transcript-protein decoupling, which may be one of the underlying cause of hallmarks of aging.

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Can Cone Beam Computed Tomography Assess Oral Bone Density?

Do-Gyoon Kim[1]
[1]Orthodontics, Ohio State University

I. SUMMARY

Objectives: Dental cone-beam computed tomography (CBCT) is widely used to delineate dentoskeletal morphology [1]. However, its use for assessing BMD was previously limited, as its reliability in obtaining consistent CT attenuation values (gray values) had not been fully evaluated [1]. The objective of the current study was to determine whether clinical cone-beam computed tomography (CBCT) can assess the effects of orthodontic treatment on the alveolar bone (AB) surrounding the mandibular first molar serving as an anchorage unit.

Methods: Following IRB approval, CBCT images of 40 patients (28 females, 12 males; mean age: 14.42 ± 1.34 years) were retrospectively analyzed before and after treatment (mean duration: 20.50 ± 4.03 months) with full fixed appliances. Dentofacial morphology was assessed at the mandibular first molar. The alveolar bone (AB) surrounding the mandibular first molars and the basal cortical bone (CB) at corresponding locations were digitally isolated using ITK-SNAP. Bone mineral density (BMD) was assessed via gray value frequency plots to determine the mean, standard deviation (SD), and 5th (Low5) and 95th (High5) percentile values.
Results: Facial morphological parameters increased significantly ($p < 0.001$), while dental morphological parameters remained unchanged ($p > 0.09$) after treatment. Most gray values significantly increased in both the AB and CB ($p < 0.003$), except for the Low5 value in the CB ($p = 0.66$). High5 values in the CB, representing maturation-related mineralization during mandibular growth, showed strong linear relationships with those in the AB.

Conclusions: CBCT-based BMD analysis effectively assesses the biological consequences of orthodontic treatment in a clinical setting. The current findings suggest that new bone formation and mineralization are enhanced by both physiological growth and active bone turnover during adolescent orthodontic treatment, leading to increased BMD in the AB surrounding the mandibular first molar.

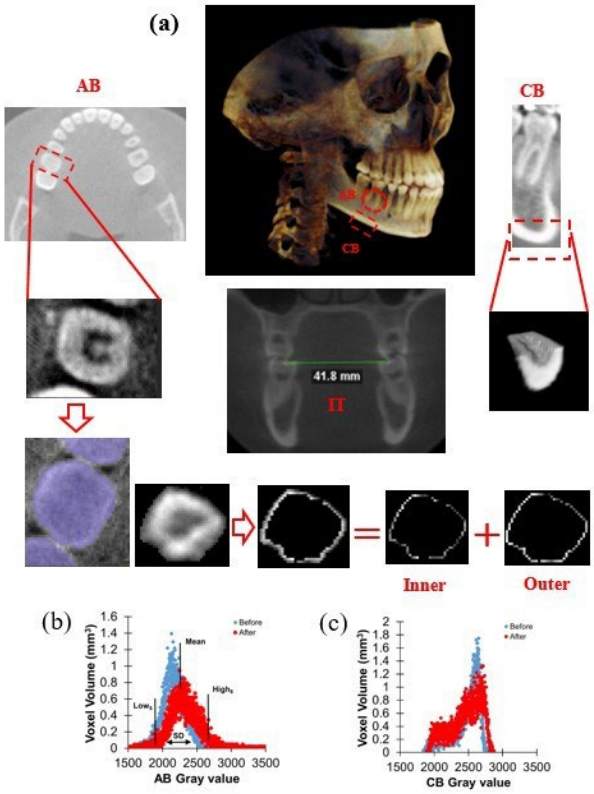


Figure 1 (a) A 3D CBCT image of a patient's both sides of the mandibular first molar were digitally isolated using ITK-SNAP software to segment the tooth. Alveolar bone (AB) layers were also isolated. The basal [6]cortical bone (CB) was isolated at the mandibular first molar site. Each image was also analyzed for buccal bone height (BBH), buccal bone thickness (BBT), intermolar distance (IT), molar angulation (MA) of the first molars before and after orthodontic treatment. Gray value parameters are shown in frequency plots for (b) the AB and (c) the CB.

ACKNOWLEDGEMENTS

The project described here was partly supported by Student Research Program (SRP) from the College of Dentistry, The Ohio State University.

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Differentially methylated genes in aggressive prostate cancer

Jong Park, PhD[1],
[1]Moffitt Cancer Center, Tampa FL

I. SUMMARY

Prostate cancer (PCa) remains a major cause of cancer-related death among men in the United States, with persistent racial disparities. African Americans (AA) experience higher incidence and mortality than European American (EA) men.

To address these disparities, we focus on DNA methylation, an epigenetic mechanism that regulates gene expression, and tumor progression. Aberrant methylation plays a central role in PCa pathogenesis, including the silencing of tumor suppressors and activation of oncogenic pathways. Because methylation changes arise early, they serve as powerful biomarkers for cancer detection and disease monitoring. We investigate differentially methylated genes associated in aggressive PCa in different racial groups.

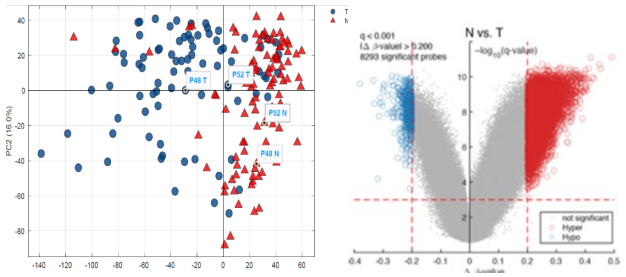
II. Methods

A. Epigenome-wide profiling using Illumina EPIC methylation array

The Illumina Methylation EPIC V1 BeadChip was used for methylation levels using genomic DNA samples from FFPE. β-values were estimated using the intensity of the methylated signal divided by the sum of both methylated and unmethylated signals, β = Mech/(Meth + Unmeth). We compared methylation level of CpG probe between tumor vs. normal tissues, indolent vs. aggressive, EA vs. AA PCa patients.

III. Results and conclusion

Tumor and normal tissues were analyzed (Figure 1). The 2 first principal components in a PCA model using tumor and normal pair samples separates normal and tumor from each other. Volcano plot comparing tumor vs. normal with Δβ-value (x-axis) and FDR corrected p-value, --log10(q) (y-axis).



Additional comparisons were performed between the results obtained with our cohort of AA with an EA cohort. The results based on Δβ-value and score (combining Δβ-value and −log10(p-value)) demonstrated an overall similarity in methylation changes between AA and EA cohorts. However, 261 differentially methylated genes were identified only in tumors from AA patients. Among these genes, several AA-specific methylated genes have been investigated for their potential roles in PCa.

The average age at diagnosis for the 3 racial groups with PCa included in this study was 58.6 years. We did not observe statistically significant differences among the 3 racial groups in terms of mean age at diagnosis, mean body mass index (BMI), tobacco use, marital status, and mean prostate-specific antigen (PSA) level (Table 1).

Table 1: Selected characteristics of prostate cancer patients

	White	Black	Hispanic
N	121	123	89
Age	59±8.2	56±7.1	59±7.6
smoke	40%	34%	28%
Marital	69%	65%	70%
BMI	28±6.2	30±6.4	31±6.1
PSA	7.7±10.8	8.7±13.0	8.2±12.9

In summary, numerous differentially methylated CpG sites were identified between tumors vs. normal, AA vs EA and aggressive vs. indolent PCa. Our results suggested the DNA methylation landscapes of PCa are different among different racial groups. We also identified genes that influence multiple biological pathways in cancers, including the immune process. Our results suggested potential mechanisms underlying aggressive tumor phenotypes and aid in the prognostic evaluation of patients with PCa.

Identification of unique DNA methylation patterns at diagnosis may introduce molecular biomarkers for physicians to select appropriate treatment strategies, especially for men with an aggressive type of PCa. Finally, our study paves the way for providing molecular tools to enable physicians to reduce racial disparities.

Activated Transient Receptor Potential Vanilloid Type 1 (TRPV1) endures global hypoperfusion following subarachnoid Hemorrhage (SAH)

Sungha Hong
Center for Translational Neuromedicine, University of Rochester Medical Center

Subarachnoid Hemorrhage (SAH) is a lethal neurovascular disorder which is mainly caused by aneurysmal rupture. SAH-injured brain remained hypoperfusion in the whole brain which is defined “global hypoperfusion”. Despite strong correlation between hypoperfusion and worsened SAH outcomes, pathological mechanism of post-SAH global hypoperfusion is barely studied. Transient Receptor Potential Vanilloid Type 1 (TRPV1) is a Ca^{2+} permeable channel that affects vascular functions in various vascular diseases. Therefore, current study investigated the role of TRPV1 on lasting global hypoperfusion following SAH.

Young *Trpv1*$^{-/-}$ and WT (C57BL6) mice (4 months old) and aged WT mice (15-16 months old, C57BL6) were subjected to the studies. Aged WT mice received TRPV1 antagonist (AMG9810) or vehicle (veh) at 30 min before SAH. Experimental SAH was induced by intraluminal perforation. Cerebral blood flow (CBF) in the whole brain was measured before and up to 2 h after SAH using customized inverted Laser Speckle Contrast Imaging (LSCI) system. Neurobehavioral deficits will be scored daily by a composite score system. Penetrating arteriolar reactivity in fresh *in vitro* brain slices from WT mice was tested with application of AMG9810 or veh under Differential Interference Contrast (DIC) microscopy. Lastly, intracellular Ca^{2+} concentration in hemoglobin (Hb)-exposed aged primary brain vascular smooth muscle cells (pbVSMCs) were measured with treatment of AMG9810 or veh.

Trpv1$^{-/-}$ mice enhanced CBF in ipsi- and contra-lateral hemispheres than WT for 2 h of SAH. Moreover, raised CBF in *Trpv1*$^{-/-}$ mice were maintained for 3 days after SAH. Neurodeficits in *Trpv1*$^{-/-}$ mice were significantly improved compared to WT on day 1 after SAH. AMG9810-received aged mice increased CBF compared to veh-received mice following SAH. Restored CBF in AMG9810-treated aged mice maintained for 7 days after SAH. AMG9810 treatment potentiated to improve the neurodeficits than veh-treatment following SAH in aged mice.
In *in vitro* brain slice experiment, constricted arterioles with pre-exposure of TRPV1 agonist (Dihydrocapsaicin) were relaxed by serial concentration of AMG9810. Our Ca^{2+} assay showed that treatment of AMG9810 decreased intracellular Ca^{2+} level in Hb -exposed pbVSMCs.

In conclusion, the results demonstrate that activated TRPV1 in vascular smooth muscle cells lowered CBF through arteriolar constriction following SAH. Most importantly, benefit of AMG9810 in SAH-injured aged mice highlights the potential of TRPV1 antagonist as a novel SAH treatment option for elderly SAH patients who are predominant population of SAH incidence.

ACKNOWLDEGEMNT

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Cytoprotective Effect of Kartogenin-Loaded Nanosomes on Arthritic Chondrocytes

Ryan Qiu[1], Shona Gordon[1], R. Northcutt[1], *Hongsik Cho[1,2]
University of Tennessee Health Science Center, Department of Orthopaedic Surgery & Biomedical Engineering, University of Tennessee-Campbell Clinic, Veterans Affairs Medical Center, Memphis, TN
*Corresponding author: hcho4@uthsc.edu

DISCLOSURES: R. Qiu (None), S. Gordon (None), R.Nothcutt (None), H. Cho (None)

INTRODUCTION: Osteoarthritis (OA) is a chronic degenerative joint disease that affects over 527 million individuals worldwide. It is characterized by progressive cartilage degradation and fibrosis of the joint tissue. As cartilage tissue is avascular and relies on diffusion within the synovial fluid space to receive metabolic support, it has a limited capacity to heal itself through cellular repair mechanisms. Current OA therapies include NSAIDs, corticosteroids, and hyaluronic acid injections, but these only provide symptomatic relief rather than targeting the underlying pathology of OA. Kartogenin (KGN) is a small hydrophobic molecule that acts through the CBFβ–RUNX1 pathway. It has been shown to promote chondrogenic gene expression (COL2A1, ACAN) and suppress catabolic enzymes (MMP13, ADAMTS5). However, KGN faces three major limitations: poor solubility, lack of tissue specificity, and risk of dose-dependent toxicity. We hypothesized that encapsulating KGN into lipid nanosomes would overcome these limitations by enhancing solubility, improving uptake in inflamed chondrocytes, and reducing the required therapeutic dose.

METHODS*: Culture of Primary Chondrocytes:* Articular cartilage was harvested from the femorotibial joints of 3 month old porcine. Cartilage slices were digested with Pronase followed by Collagenase under gentle agitation. Isolated chondrocytes were filtered, washed, and cultured in DMEM supplemented with 10% fetal bovine serum (FBS), streptomycin, penicillin G, L-glutamine, and L-ascorbic acid. Cells were incubated at 37°C and used at passage 3 for all experiments. *Establishment of In Vitro OA Model:* To model an OA catabolic phenotype, chondrocytes were seeded at 2.5×10^5 cells/well in 6-well plates and treated with 10 ng/mL of TNF-α for 24 hours. *Preparation of KGN-Nanosomes:* Lipids consisting of 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC), cholesterol, DSPE-PEG, and DSPE-PEG-maleimide were combined in a glass tube and dissolved in chloroform. The solvent was evaporated under a stream of air for 45 minutes to form a thin lipid film. It was vacuum dried for 15 minutes to remove residual solvent. The dried lipid film was rehydrated with PBS containing 500 µM Kartogenin. The suspension was then extruded through 200 nm polycarbonate membranes to obtain uniform nanosomes. Unencapsulated KGN was removed by size-exclusion chromatography. Dynamic light scattering confirmed a mean diameter of 178.7 nm and a polydispersity index of 0.023. Encapsulation efficiency was around 10%. The final external concentration was 40 nM/mL after 1:1000 dilution for cell treatment. *Experimental Design:* Chondrocytes were divided into five groups (n = 3 wells per group): (a) untreated control, (b) TNF-α only, (c) TNF-α + free KGN (1 µM), (d) TNF-α + free KGN (100 µM), and (e) TNF-α + KGN-loaded nanosomes (40 nM external concentration). Treatments were administered at the same time as TNF-α stimulation, and the cells were incubated at 37°C for 24 hours. *Gene Expression Analysis (RT-qPCR):* Total RNA was extracted using TRIzol reagent and quantified with a NanoDrop spectrophotometer. cDNA synthesis was performed. Quantitative PCR was conducted and targeted anabolic genes (COL2A1, ACAN) and the catabolic marker (MMP13). GAPDH was used as the internal reference housekeeping gene. Relative gene expression was calculated. *Statistical Analysis:* Data is expressed as mean ± standard deviation (SD). Statistical comparisons were made using one-way ANOVA. A p-value < 0.05 was considered statistically significant.

RESULTS: *Establishment of an In Vitro OA Model:* Upon exposure to TNF-α (10 ng/mL) for 24 hours, the chondrocytes transitioned towards an increased inflammatory and catabolic state. RT-qPCR analysis revealed a statistically significant upregulation of MMP13 of a 100-fold increase compared to untreated controls. Additionally, expression of the key anabolic markers COL2A1 and ACAN was significantly downregulated (Fig. X). These results confirm that TNF-α treatment reliably induces OA-like conditions in vitro. *Effect of KGN on Healthy Chondrocytes:* To assess potential off-target effects, KGN was applied to unstimulated, healthy chondrocytes. RT-qPCR demonstrated that COL2A1 and ACAN levels remained unchanged compared to control, and MMP13 expression did not increase (Fig. 1). This suggests that KGN does not disrupt baseline anabolic or catabolic signaling in non-inflamed cartilage cells. The absence of a catabolic response by KGN supports its safety profile for targeted therapeutic use. *KGN-Nanosome Characterization:* Dynamic light scattering measurements confirmed the successful formulation of KGN-loaded lipid nanosomes with a mean particle diameter of 178.7 nm and a polydispersity index (PDI) of 0.023 (Fig. 2). The particle size distribution fell within the optimal range for endocytosis-mediated uptake and reduced the likelihood of rapid clearance or macrophage recognition of the nanosome particles. After dilution to a 1:1000 ratio, the final external treatment concentration of the KGN-nanosomes was only 40 nM/mL, enabling delivery of a high local dose intracellularly while minimizing systemic exposure. *Impact of Free KGN and KGN-Loaded Nanosomes on Inflamed Chondrocytes:* Treatment of TNF-α–stimulated chondrocytes with free KGN at 1 µM produced negligible changes in gene expression. Increasing the dosage to 100 µM restored cartilage anabolism, as evidenced by a significant increase in COL2A1 expression, and suppressed MMP13 (Fig. 3). In comparison, KGN-loaded nanosomes administered at only 40 nM/mL achieved markedly similar outcomes of the 100 µM treatment group. RT-qPCR demonstrated significant upregulation of COL2A1 and significant suppression of MMP13. These results indicate that nanosome-mediated delivery not only enhances the bioactivity of KGN but also enables potent therapeutic effects at a concentration of 2,500 times less of the free KGN dose.

DISCUSSION: This study shows that delivering Kartogenin through lipid nanosomes improves its effectiveness in an in vitro model of osteoarthritis. TNF-α treatment reliably induced an OA-like phenotype in chondrocytes: high MMP13 expression and reduced COL2A1 and ACAN. Free KGN at high concentrations partially improved this imbalance, but only at 100 µM. In contrast, KGN-loaded nanosomes achieved similar anabolic and anti-catabolic effects at 2,500 times less concentration of just 40 nM/mL. Encapsulating KGN in nanosomes overcame key limitations to its use: poor solubility, lack of tissue specificity, and the risk of dosage-dependent systemic toxicity. The nanosomes allowed KGN to be delivered directly into inflamed chondrocytes at a high local drug concentration while keeping overall systemic exposure low, which reduces the risk of toxicity. Despite the nanomolar external dose, we saw a clear increase in COL2A1 and strong suppression of MMP13. The consistent size (~179 nm) and low polydispersity of our nanosomes indicate they are well-suited for cellular uptake and could be retained within the joint if tested in vivo. Future studies will need to evaluate their performance in murine models of OA and assess long-term effects, but these results provide a strong foundation for further development.

SIGNIFICANCE: KGN-loaded nanosomes represent a promising approach for OA treatment by delivering a potent regenerative molecule directly to inflamed cartilage cells. Our results achieved robust therapeutic effects at low doses. This strategy may pave the way for developing clinically viable disease-modifying osteoarthritis drugs that can halt or reverse disease progression.

ACKNOWLEDGEMENTS: VA Merit Award (1I01RX004283-01A1), UT Research Foundation 2025, and the Medical Student Research Fellowship (MSRF) Program

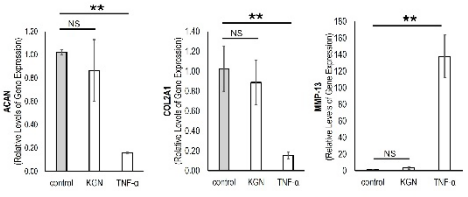


Fig 1. Gene expression by rt-PCR. Control vs KGN (10uM KGN) vs TNF-α (10ng/m); Aggrecan (ACAN), Col 2 (COL2A1), and MMP-13. (n=5, **p <0.01)

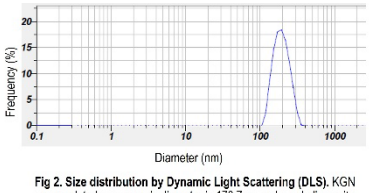


Fig 2. Size distribution by Dynamic Light Scattering (DLS). KGN encapsulated nanosome's diameter is 178.7nm and a polydispersity index (PDI) is 0.023

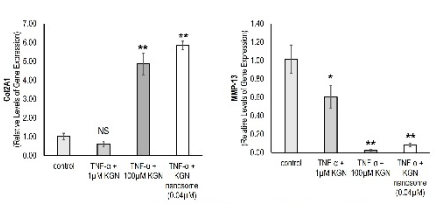


Fig 3. Gene expression by rt-PCR. Control vs 1uM KGN vs 100uM KGN vs 0.04 uM KGN-Nanosomes. All groups were treated with TNF-α (10ng/ml) except normal control group. Gene expression of the Co 2 (COL2A1), and MMP 13, all groups are comparison to control group (n=5. NS: no statistically difference. *p <0.05, **p <0.01)

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Human Amygdala-like Telencephalic Organoids Capture Developmental Program of Human Amygdala

Woo sub Yang[1], Mu Seog Choe[1],In-Hyun Park[1]

[1]Department of Genetics, Neuroscience, Stem Cell Center, Yale School of Medicine.

I. SUMMARY

Human emotional and stress responses are orchestrated by subcortical limbic circuits, with the amygdala playing a central role in integrating affective, sensory, and endocrine signals. Despite the urgent need to understand how these circuits develop and contribute to anxiety and stress-related disorders, progress has been hindered by lack of ex vivo human models. Here, we generated human amygdala-like telencephalic organoids (hATOs) that recapitulate cellular composition, region-specific development and key features of the amygdala. These findings highlight the potential of hATOs to understand molecular features of affective circuitry underlying emotion and the stress response, and neuropsychiatric disorders.

II. RESULTS

A. Differentiation of lateral and ventral pallial fate in human stem cells: Human embryonic stem cells (hESCs) were differentiated by modulating the WNT, FGF7, TGFalpha, SHH, and RA pathways to specify the ventral, lateral and subpallial regions of telencephalon. The expression of the markers for nuclei for amygdala was determined by performing RT-qPCR and immunostaining. Markers include amygdala-associated transcription factors (e.g., MEIS1, DLX2, FOXP2, LHX9), neuropeptides (e.g., CRH, TAC1, SST, PDYN), and EMX1/2.

B. Neural lineage and developmental trajectory analysis: To understand the developmental program of the hATOs, scRNA-seq were performed. UMAP analysis identified 31 distinct clusters, revealing clusters corresponding to neuronal progenitors, glutamatergic neurons, GABAergic neurons, astrocyte, and oligodendrocyte progenitor cells. To assess regional identity within hATOs, we compared hATO scRNA-seq profiles against human fetal brain atlas data (Post Conception Week, PCW 5-14). hATO clusters closely overlapped with subcortical areas. Further, VoxHunt analysis showed that all hATO clusters, including glutamatergic and GABAergic populations, closely matched the amygdala in both the Developing Human BrainSpan dataset (PCW 10-24). We further identifiied hATO clusters expressing key transcriptional markers associated with amygdala development and specific nuclei. Feature plot analysis in hATOs identified ventral and lateral pallial populations (SFRP2, ETV1, VEPH1, EVA1C, FEZF1), and distinct subpallial populations, including LGE (ZNF503, TLE4), CGE (PROX1, SP8), and MGE progenitors (NKX2-1, LHX6). Notably, GSX2 a marker of PSB42 was broadly expressed across pallial clusters, indicating PSB-like regionalization in hATOs.

C. Stress response in hATOs by cortisol treatment: The developing amygdala is vulnerable to prenatal glucocorticoid exposure due to early expression of glucocorticoid (GR, NR3C1) and mineralocorticoid (MR, NR3C2) receptors. We applied cortisol into hATOs to examine the acute response, and found that expression of CRH that represents a major stress response factor was highly upregulated, suggesting the utility of hATOs as an important platform to investigate the stress response in amygdala.

III. CONCLUSION

In this study, we generated hATOs that recapitulate key aspects of the regional identity, molecular signatures, and stress-relevant neurophysiological features of the developing human amygdala. By integrating developmental patterning cues, hATOs reproducibly generated diverse neuronal populations corresponding to major amygdala nuclei and captured key molecular and cellular features of the developing human amygdala.

ACKNOWLEDGEMENTS

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Functional Specialization of Craniofacial Bone Marrow Vasculature

Leah Willner[1], Aydan Lee[1], Bong-Ihn Koh[1]
[1]Yale Stem Cell Center, Department of Comparative Medicine, Yale School of Medicine

I. SUMMARY

Neuroinflammation drives Alzheimer's disease, multiple sclerosis, and neurodegeneration. Skull bone marrow (BM) supplies immune cells to the brain's borders through dedicated vascular channels, but the field treats the skull as a single uniform source. We show that each craniofacial BM compartment harbors a structurally and functionally distinct vascular niche for hematopoietic stem cells (HSCs) that produces a distinct immune repertoire. We demonstrate that calvarial BM undergoes lifelong vascular expansion, remains resilient against aging, and responds to pathophysiological challenges in ways fundamentally distinct from long bone BM. We further show that this heterogeneity extends across individual craniofacial compartments, establishing vascular niche heterogeneity as the structural basis for non-uniform immune contributions to the brain — and a new target for controlling neurodegeneration at its source.

II. RESULTS

A. Skull BM undergoes lifelong expansion driven by VEGFA–VEGFR2 signaling: Skull bone marrow vasculature increased substantially in frontal and parietal bones between young and geriatric mice, accompanied by a 13.1-fold increase in total hematopoietic cells. Human CT scans confirmed age-related diploic space expansion. Skull hematopoietic stem and progenitor cells (HSPCs) express high levels of VEGFA, which increases 2.2-fold in aging calvarial BM while decreases 40.2% in femur. VEGFA overexpression expanded skull BM 2.5-fold; VEGFR2 blockade profoundly inhibited this expansion, establishing VEGFA–VEGFR2 as the mechanistic driver of calvarial BM niche growth.

B. Skull BM is resilient to aging and responds distinctly to pathophysiological challenge: Adipogenesis was minimal in aging skull versus a 5.9-fold increase in femur, and only 1 of 12 pro-inflammatory cytokines was elevated in old skull versus 7 of 12 in old femur. scRNA-seq confirmed that skull HSCs and endothelial cells maintain a younger, pro-niche molecular profile relative to femur. In pathophysiological contexts, pregnancy, stroke, CML, and PTH treatment each drove substantial skull BM expansion, while femoral BM showed no change or vascular loss under the same conditions.

C. Craniofacial BM vascular niche heterogeneity is the structural basis for non-uniform immune contributions to the brain: Three calvarial segments display distinct vascular architectures, stromal populations, and BM–dura channel densities. The skull base harbors higher HSC concentration than the calvarium and undergoes early vascular regression rather than lifelong expansion. BM–dura channels decline with aging due to osteoclast loss, degrading bone–brain immune dialogue when the brain needs it most. Together, these findings establish that individual craniofacial BM compartments differ fundamentally in niche properties — and by extension, in the immune repertoires they deliver to distinct brain regions.

III. CONCLUSION

Individual craniofacial BM compartments differ fundamentally in vascular architecture, hematopoietic output, and niche resilience — and by extension, in the immune repertoires they deliver to distinct brain regions. The vascular niche mosaic of the skull may explain the regional selectivity of neurodegeneration, and represents an entirely new therapeutic target: reprogramming individual BM niches to amplify neuroprotective and suppress neurotoxic immune output at its source.

ACKNOWLEDGEMENTS

We thank the Max Planck Society and Yale School of Medicine.

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Flow-Induced Reprogramming of Endothelial Cells (FIRE) in Atherosclerosis:

Hanjoong Jo, PhD
Professor and Wallace H. Coulter Distinguished Faculty Chair Professor
Wallace H. Coulter Department of Biomedical Engineering
Emory University and Georgia Institute of Technology

Introduction: Atherosclerosis is the major underlying cause of heart attack and ischemic stroke. It occurs preferentially in arterial regions exposed to disturbed flow (d-flow), whereas stable-flow regions remain protected even under hypercholesterolemic conditions, through mechanisms involving broad changes in endothelial gene expression and function.

Hypothesis: We hypothesized that d-flow is an initial instigator of partial flow-induced reprogramming of endothelial cells (FIRE), but requires hypercholesterolemia as a second hit to induce full-blown FIRE and atherosclerotic plaque development.

Methods and Approaches: C57BL/6 mice were treated with AAV-PCSK9 and a Western diet to induce hypercholesterolemia and/or partial carotid ligation (PCL) to expose the left carotid artery to d-flow. scRNA-seq was performed on 98,553 single cells from 95 mice at 2 and 4 weeks post-PCL. EC-specific lineage-tracing (EC-Confetti) mice, reanalysis of human plaque scRNA-seq datasets, human coronary artery immunostaining, and human aortic endothelial cell (HAEC) studies were used for validation.

Results:

scRNA-seq in the PCL-hypercholesterolemia mouse model: generation of the FIRE hypothesis: scRNA-seq revealed 25 cell clusters and 1,291 flow-sensitive genes across five EC subpopulations. D-flow alone initiated partial FIRE, including inflammation and EndMT. Under hypercholesterolemia, d-flow fully reprogrammed ECs to immune-like (EndIT) and foam-like cells (EndFT).

In vivo validation of FIRE in EC-Confetti lineage-tracing mice: Comprehensive immunohistochemical staining of EC-Confetti mice confirmed that genetically labeled ECs co-expressed canonical markers of inflammation, EndMT, EndIT, and EndFT specifically under d-flow and hypercholesterolemic conditions, providing direct in vivo evidence supporting the FIRE hypothesis.

Validation in human atherosclerotic plaques: Reanalysis of two independent human plaque scRNA-seq datasets demonstrated the presence of EndIT and EndFT ECs in human atherosclerosis. Immunostaining of human coronary arteries confirmed significantly elevated expression of endothelial inflammation, EndMT, and most importantly, EndIT and EndFT markers in ECs of advanced plaques compared to early lesions.

In vitro FIRE induction in HAECs: HAECs subjected to oscillatory shear stress mimicking d-flow using an orbital shaker, combined with 27-hydroxycholesterol and a proinflammatory cytokine cocktail identified from our mouse scRNA-seq data, robustly induced FIRE (as determined by markers of inflammation, EndMT, EndIT and EndFT) at the transcript, protein, and functional levels, demonstrating that ECs alone are sufficient to undergo FIRE under proatherogenic conditions.

Conclusion: These findings validate the two-hit hypothesis and establish a comprehensive single-cell atlas of atherosclerotic plaques. The flow-sensitive genes and FIRE programs identified provide a crucial roadmap for novel mechanistic understanding and therapeutic targeting of atherosclerosis.

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Skeletal Stem Cell Heterogeneity and Regulatory Mechanism in Aging

Dongsu Park
[1] Department of Molecular Human Genetics, Baylor College of Medicine, Houston, TX, 77030, USA

I. SUMMARY

Adult skeletal stem cells (SSCs) are critical for life-long maintenance and regeneration of bone and bone marrow where they control physical activity, body protection, and blood formation. If these cells are dysregulated, it can cause developmental deformities, bone diseases, and aged bone defects. However, the heterogeneity and wide tissue distribution of SSC population in adult bone makes challenging to identify and characterize rare SSCs in vivo. In particular, functional roles and distinct molecular signatures of SSC subpopulation within their tissue compartments remain unknown.

In recent years, we have developed new imaging methods and animal models enabling in vivo stem cell tracking in living animals. Using these innovative techniques, we have defined the lifespan and short-term recycling of osteoblasts, adult SSC heterogeneity, and a long-term repopulating SSC subset present in periosteum (outer layer of bone) in vivo. We also identified that periosteal skeletal stem cells (P-SSCs) are a long-term repopulating, functionally distinct SSC subset with unique migratory mechanisms for injury repair. Further, by using comparative single cell analysis of human and mouse periosteal cells and bone marrow cells, we found unexpected heterogeneity in human periosteal cells with unique transcriptome profiles compared to bone marrow clusters. Among these periosteal cell clusters, we identified human P-SSC subsets expressing novel LRP1 and CD13 markers and a preferential expression of LRP1 in Prx1+ mouse P-SSCs. These LRP1+CD13+ human and mouse P-SSCs are perivascular cells with high osteo-chondrogenic but little adipogenic potentials. They can maintain themselves in vitro and repopulate in vivo upon transplantation into injury sites in mice. In addition, our single cell analysis of aged periosteal cells revealed the aged periosteal tissues decrease the expression of LRP1 and LRP1 activators but increase the expression of the LRP1-shedding enzyme. Notably, the local treatment with a LRP1 agonist to mouse bone injuries induced P-SSC expansion and improved bone healing in vivo.

These data demonstrate that the human and mouse periosteum contain unique osteo-chondrogenic stem cell subsets expressing specific markers, LRP1 and CD13, that are necessary for P-SSC function and bone repair in aging.

ACKNOWLEDGEMENTS

This work was supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases and National Institute of Dental and Craniofacial Research of the National Institutes of Health under award numbers 1R01AR072018, R01DE031288, R01DE031162.

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Engineered 3D Microphysiological Systems for Identification of Therapeutic Myokines

Mirae Kim[1], Yuseon Kang Lee[1], Yunki Lee[1], and **Young C. Jang[1,2,3,4]**,

[1] Department of Orthopaedics, Emory Musculoskeletal Institute
[2] Wallace H. Coulter Department of Biomedical Engineering,
Emory University School of Medicine, Atlanta, GA
[3] Parker H. Petit Institute of Bioengineering and Bioscience,
[4] Georgia Institute of Technology, Atlanta, GA

ABSTRACT

Skeletal muscle is increasingly recognized as a major endocrine organ that regulates whole-body physiology through the secretion of bioactive proteins, peptides, and cytokines collectively termed myokines. These muscle-derived factors mediate communication with distant organs, including the heart, brain, liver, adipose tissue, and immune system, and are believed to contribute to many of the systemic health benefits associated with exercise. Despite their tremendous therapeutic potential, the discovery of physiologically relevant myokines remains challenging due to the dynamic nature of circulating factors, their low abundance in blood, and the inability to distinguish muscle-derived proteins from those secreted by other tissues.

To address these limitations, we have developed an advanced three-dimensional (3D) microphysiological skeletal muscle platform that recapitulates key structural and functional features of native muscle tissue while enabling precise control of biochemical and mechanical stimuli. To directly identify muscle-derived secreted proteins, we integrated a cell-type-specific protein labeling strategy using the $MetRS^{L274G}$ transgene, allowing selective metabolic labeling and tracking of proteins synthesized by skeletal muscle cells. Furthermore, we engineered an optogenetically controlled exercise-mimetic system by co-expressing channelrhodopsin with $MetRS^{L274G}$, enabling noninvasive induction of muscle contractions and real-time interrogation of contraction-dependent secretory responses.

Using this integrated platform, we seek to define the molecular landscape of exercise-induced myokines and identify previously unrecognized factors that mediate beneficial systemic adaptations. We will further investigate how muscle-derived proteins influence muscle–heart communication, with a particular focus on mechanisms underlying ischemic preconditioning and cardio-protection. By combining tissue engineering, optogenetics, metabolic protein labeling, and quantitative proteomics, this work establishes a powerful framework for dissecting interorgan communication with unprecedented specificity and temporal resolution.

The proposed studies will generate fundamental insights into skeletal muscle endocrine biology and provide a scalable platform for identifying therapeutic myokines that can be leveraged to treat cardiovascular disease, metabolic dysfunction, frailty, and other age-related disorders. More broadly, this technology offers a versatile strategy for studying tissue-specific secretomes and systemic signaling networks across diverse physiological and pathological conditions.

ACKNOWLEDGEMENTS

Funding acknowledgements: NIH R01AR072088-01 (YCJ), NIH R01AG063928 (YCJ)

Plasma-based single extracellular vesicle analysis for diagnosis of cholangiocarcinoma

Mi Ho Jeong[1], Sang Gyu Lee[1], Jung Hyun Jo[2], Hyungsoon Im[1]
[1]Center for Systems Biology, Massachusetts General Hospital
[2]Department of Internal Medicine, Gangnam Severance Hospital

I. SUMMARY

Cholangiocarcinoma (CCA) is an aggressive biliary tract cancer that remains difficult to diagnose using current blood-based markers. In our previous study **(1)**, we demonstrated that single extracellular vesicle (EV) analysis of bile juice could detect CCA with high diagnostic accuracy. However, bile collection requires endoscopic procedures, limiting its use for broader non-invasive screening or longitudinal monitoring. To address this limitation, we developed a plasma-based single EV analysis approach for CCA diagnosis.

Plasma EVs were isolated using dual-mode chromatography and analyzed at the single-vesicle level using a plasmon-enhanced fluorescence assay (**Fig. 1A**). We profiled CCA-associated EV markers, including EGFR, EpCAM, MUC1, DKK1, LAMC2, and CLDN4, in plasma samples from patients with CCA and benign biliary disease. Total EV counts were comparable between groups (**Fig. 1B**). However, marker profiling in single EV identified distinct tumor-associated EV signatures in CCA plasma (**Fig. 1C**).

Because CA19-9 is the most widely used clinical biomarker for CCA but has limited sensitivity and specificity, we evaluated whether EV markers could complement CA19-9 rather than replace it (**Fig. 1D**). Among EV marker combinations, EpCAM, MUC1, LAMC2, and CLDN4 showed strong diagnostic performance as an EV-only panel. When integrated with CA19-9, the three-marker EV panel consisting of EGFR, LAMC2, and CLDN4 showed the best overall performance, achieving an AUC of 0.926 with 90.9% accuracy (**Fig. 1E-F**).

Importantly, the plasma EV-based score combined with CA19-9 showed clear diagnostic value in early-stage CCA (stage I-II). The combined EV panel significantly distinguished CCA from benign biliary disease, whereas CA19-9 alone showed limited separation without reaching statistical significance (**Fig. 1G**). These findings suggest that plasma single-EV profiling can capture tumor molecular changes at earlier disease stages.

Together, this study extends our previous bile-based EV work and demonstrates that plasma-based single EV analysis can sensitively detect CCA-associated EV populations. Plasma EV profiling may therefore complement CA19-9 for non-invasive CCA diagnosis, with potential value for early-stage disease detection.

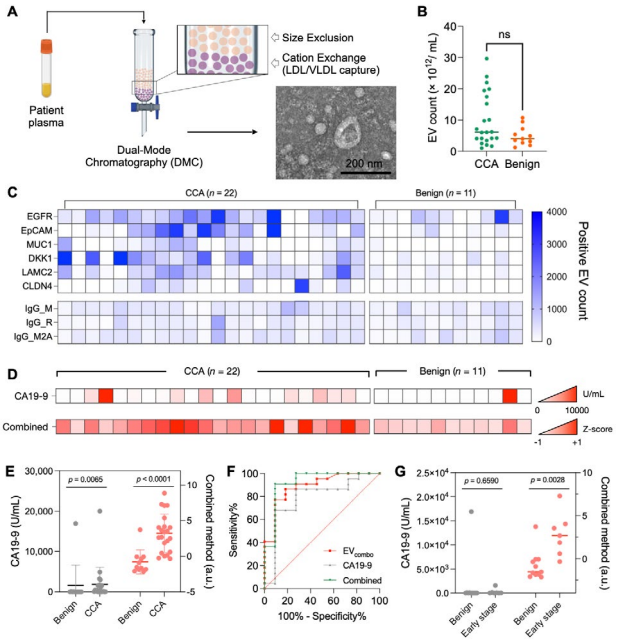


Figure 1: Plasma-based single EV analysis for CCA diagnosis. (A) Scheme for plasma EV isolation and single EV profiling. **(B)** Total EV counts in CCA and benign plasma. **(C)** Heatmap of CCA EV markers. **(D)** Comparison of CA19-9 and EV-based combined score. **(E)** CA19-9 and EV-based combined score in benign and CCA patients. **(F)** Receiver operating characteristic curves comparing CA19-9, the EV-only panel, and the combined CA19-9/EV score. **(G)** CA19-9 and EV-based combined score in benign and early-stage patients.

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Biology / Biotechnology / Health 2

Multiscale Biointerfaces for Neuromodulation: Access, Targeting, Modeling, and Sensing

Eunji Hong[1], Qianbin Wang[*,1], Siyuan Rao[*,1]
[1] Department of Biomedical Engineering, Binghamton University, Binghamton, NY, USA 13902

I. SUMMARY

Neural dysfunction in neurodegenerative diseases arises from coupled failures across molecular, cellular, and circuit scales. However, current neuromodulation approaches typically intervene at a single level, limiting functional predictability and therapeutic translation.

This work introduces multiscale biointerface engineering to bridge this gap by integrating nanoscale delivery systems, microscale models of pathophysiological mechanics, and circuit-level functional readouts.

Engineered nanoplatforms enable precise, cell-type-selective modulation across biological barriers, while microscale systems reconstruct disease-relevant mechanical microenvironments.

Coupled opto-electrophysiological platforms provide real-time monitoring of circuit responses, forming a unified framework for adaptive neuromodulation across hierarchical neural scales.

II. MAIN TEXT

We present a multiscale biointerface platform for neuromodulation that establishes a continuous pipeline spanning biological barrier access, neuronal targeting, disease modeling, and functional sensing across hierarchical neural scales. This integrated framework begins with carbon quantum dot-viral hybrid systems, which provide a platform for imaging biological barriers and guiding the development of next-generation therapeutic delivery systems. Delivered constructs are further directed to specific neuronal populations using extracellular vesicle-liposome hybrid nanovesicles designed for selective central nervous system targeting. The system is then coupled to a pressure-driven microfluidic platform that recapitulates glaucoma-associated mechanical pathophysiology, enabling controlled modeling of disease-relevant microenvironments. Finally, optogenetics-informed electroretinography provides cell-type-specific functional readouts of retinal ganglion cell activity, enabling high-resolution assessment of neural circuit integrity and system-level functional output.

III. ILLUSTRATIONS

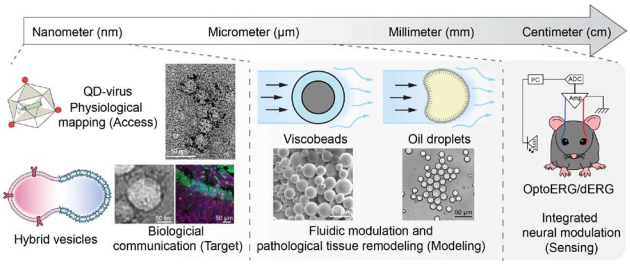


Figure 1: Multiscale Biointerfaces for Neuromodulation

ACKNOWLEDGEMENTS

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A Minimally Invasive Magnetically Actuated Intravesical Occlusion Device for Urinary Incontinence

Youngjae Chun[1,2], Hassan Beheshti Seresht[1], Roger D. Klein[3], Paul Rusilko[3]

[1]Department of Industrial Engineering, University of Pittsburgh, PA 15261, [2]Department of Bioengineering, University of Pittsburgh, PA 15213, [3]Department of Urology, University of Pittsburgh Medical Center

I. SUMMARY

Urinary incontinence (UI) affects over 50% of women in the United States and significantly impacts quality of life. Although surgical interventions provide high cure rates, many patients seek less invasive alternatives due to surgical risks or personal preference. This study introduces a minimally invasive controllable intravesical bladder outlet occlusion (CIBOO) device designed to improve continence through magnetic actuation and buoyancy-driven control. The device is deployed transurethrally near the bladder neck, where an external magnet attracts the internal magnetic device to increase bladder outlet resistance and prevent urine leakage. When the external magnet is removed, the device floats toward the bladder dome, restoring unobstructed voiding. Preliminary in vitro studies demonstrated reliable magnetic association and dissociation within physiologically relevant distances, suggesting the potential of the proposed device as a reversible and patient-controlled alternative for urinary incontinence management.

II. DEVICE DESIGN AND METHODS

The prototype consists of a hollow egg-shaped silicone structure containing a cylindrical neodymium magnet stabilized within a compressible porous foam matrix. Device density was calibrated to approximately 0.9–1.0 g/cm³ to achieve controlled buoyancy. Three prototypes were fabricated with an average volume of 15 mL and mass of 13.5 g. Magnetic attraction testing was performed in phosphate-buffered saline using an external neodymium magnet positioned 5–15 cm away to simulate anatomical conditions. Association and dissociation distances were measured using a motorized translation stage and load cell system.

III. RESULTS AND DISCUSSION

Magnetic force testing was performed on three device prototypes across physiologically relevant distances between the bladder neck and external perineal region. Experimental measurements showed that approximately 0.02 N of magnetic force was sufficient to overcome buoyancy and initiate device movement toward the magnetic source (Fig. 1). Device density significantly influenced magnetic association and dissociation behavior. Prototypes with densities near water (~1.0 g/cm³) enabled stable positioning at the simulated bladder outlet while maintaining sufficient buoyancy for rapid release when the external magnetic field was removed. In vitro testing demonstrated that the device associated with the magnetic source at approximately 14 cm and dissociated at approximately 10 cm. These results suggest reliable magnetic control and positioning within clinically relevant anatomical ranges for urinary continence management.

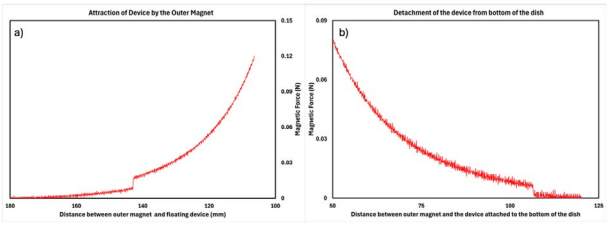


Figure 1: Trends of a) association and b) dissociation of the device, representing the average magnetic force values obtained from three tests, each conducted with different prototypes.

IV. CONCLUTIONS

The device introduced in this study presents a minimally invasive approach for managing urinary incontinence using magnetic and buoyancy-driven bladder outlet control. In vitro testing demonstrated reliable urine flow occlusion and safe release for normal voiding. Future studies will focus on device optimization and clinical translation.

ACKNOWLEDGEMENTS

This work was supported by the University of Pittsburgh Center for Medical Innovation (CMI) under grant number F_356-2024. Additionally, the project was supported by the National Institutes of Health through Grant Number UL1TR001857.

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Microfluidic and Machine Learning–Guided Fabrication of Sub-5 µm PLGA Microparticles with Adhesive Integration for Vascular Drug Delivery

Youngjae Chun[1,2], Mohamed S. Ibrahim[1], Hassan Beheshti Seresht[1], Chang Hun Kum[3], Jae Hwa Cho[3], Sang Hyun An[4], Sangho Ye[2]

[1]Department of Industrial Engineering, University of Pittsburgh, Pittsburgh, PA, USA; [2]Department of Bioengineering, University of Pittsburgh, PA, USA; [3]OSSTEMVASCULAR Co. Ltd., Seoul, Republic of Korea; [3]Daegu-Gyeongbuk Medical Innovation Foundation Laboratory Animal Center, Daegu, Republic of Korea

I. SUMMARY

This study aims to develop an integrated microfluidic–machine learning platform for the controlled fabrication of uniform sub-5 µm PLGA microparticles and their stable adhesive integration onto catheter surfaces. By combining computational fluid dynamics, experimental validation, and thermoresponsive adhesive design, the work seeks to enable scalable, biocompatible, and durable drug-carrier polymeric coatings for targeted vascular therapy and long-term restenosis prevention.

II. METHODS

A 4% (w/v) PLGA in DCM was used as the dispersed phase, and 2% (w/v) PVA in water as the continuous phase. A microfluidic chip with integrated generation and breakup zones was fabricated via soft lithography (SU-8 3050/PDMS 10:1, 70 °C, 2 h), producing 100 µm-thick and 50 µm-wide channels. The plasma-bonded PDMS–glass device was PVA-coated for DCM compatibility. CFD (ANSYS Fluent) and machine-learning optimization were used to determine conditions for monodisperse sub-5 µm particle formation. PLGA microparticles were characterized by SEM and integrated with a thermoresponsive PESBU-COOH adhesive activated at 37 °C for stable attachment under physiological flow.

III. RESULTS

The integrated experimental–computational platform enabled controlled particle generation and breakup within the redesigned cross-junction microfluidic chip featuring a shear-modulating barrier. As shown in Figures 1A(i–ii), synchronized flow of 4 % PLGA in DCM and 2 % PVA in DI-water produced stable particle formation with reproducible pinch-off events. Numerical simulations confirmed localized shear amplification near the barrier, promoting smaller particle formation under moderate flow-rate ratios (Qc/Qd = 10–20). Particle size decreased from 7.9 ± 1.0 µm to 4.6 ± 0.5 µm with increasing Capillary number, maintaining CV < 9 % (Fig. B). However, while the barrier improved breakup efficiency, consistent production of uniform ~5 µm particles was not always achieved, indicating sensitivity to slight variations in flow stability and channel wetting. Experimental and computational data correlated strongly (R^2 = 0.93). Machine-learning models trained on 120 datasets achieved >92 % prediction accuracy, identifying design and flow combinations that enhanced size uniformity (Fig.1C). SEM analysis (Fig.1D) confirmed smooth, spherical PLGA particles, while the thermoresponsive PESBU-COOH adhesive ensured stable attachment at 37 °C under simulated physiological flow.

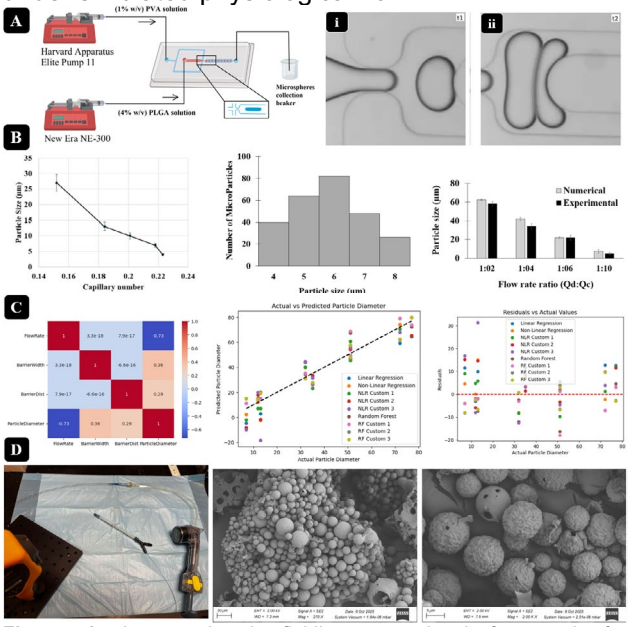


Figure 1. Integrated microfluidic–computational framework for generating sub-5 µm PLGA microparticles. (A) Experimental setup and optical visualization of particle formation within the shear-modulating cross-junction. (B) Particle size decreased from 7.9 ± 1.0 µm to 4.6 ± 0.5 µm with increasing Capillary number (CV < 9%). (C) Machine-learning models achieved >92% prediction accuracy. (D) SEM images confirm uniform, spherical particles and stable adhesion using thermoresponsive PESBU-COOH at 37 °C.

IV. CONCLUSIONS

The redesigned barrier-integrated microfluidic chip successfully generated sub-5 µm PLGA microparticles with improved size control and monodispersity. However, consistent 5 µm production remained challenging due to flow instability and surface wetting variations. Machine-learning optimization demonstrated strong predictive potential, suggesting that further refinement of channel geometry and flow parameters could enhance reproducibility and scalability for next-generation microfluidic drug delivery platforms.

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Soft Wearable NIRS for Monitoring Cardiac, Respiratory, and Slow-Oscillation Rhythms during Sleep

Junwoo Kwon[1,2], Seunghyeb Ban[2], W. Hong Yeo, PhD[2,*]
[1] School of Electrical and Computer Engineering, Cornell University, Ithaca, NY,
[2] Wearable Intelligent Systems and Healthcare Center at the Institute for Matter and Systems, Georgia Institute of Technology, Atlanta, GA
*Corresponding author: whyeo@gatech.edu

I. SUMMARY

Sleep involves changes in cardiac, respiratory, and neural activity, but continuous at-home monitoring of these signals remains challenging. Here, we present a soft wireless near-infrared spectroscopy (NIRS) system capable of capturing multiple physiological signals during natural sleep. Analysis of the optical signals resolves respiratory (RS), cardiac-cycle (CC), and slow-oscillation-linked NIRS oscillation (SONO) components that vary across sleep stages. NREM sleep shows steadier, higher-power respiratory and cardiac rhythms with stronger slow oscillations, while REM sleep shows weaker, higher-variance signals. These changes align with EEG-defined sleep-stage transitions with near-zero temporal lag, demonstrating the feasibility of wearable NIRS for monitoring of physiological rhythms during sleep.

II. METHODS

The soft NIRS device uses two LEDs and a single photodetector to measure three wavelength bands (640, 680, and 950 nm) on a flexible, forehead-conformal PCB with wireless streaming. Overnight recordings were collected from healthy subjects (N = 4; 16 nights) with simultaneous EEG/EOG for reference sleep staging (Wake, NREM, REM). Raw optical intensities were converted to brain-water–sensitive signals using the modified Beer–Lambert law (MBLL). Then the relevant physiological signals were extracted by multitaper spectrograms and Welch power spectral density (PSD), with Hilbert-based instantaneous power computed within predefined bands: RS (0.2-0.4 Hz), SONO (0.6-0.7 Hz), and CC (0.8-1.2 Hz). The extracted RS, SONO, and CC power was then aligned to the resulting hypnogram and compared across Wake, NREM, and REM, as well as across stage transitions, to characterize sleep-stage–dependent changes.

II. RESULTS

Respiration (RS). During NREM, the RS peak narrowed and shifted to 0.25 Hz with increased power, reflecting steady, regular breathing; during REM, it broadened toward 0.35 Hz with reduced power, indicating irregular respiration.

Cardiac cycle (CC). A narrow, high-power CC peak near ~0.9 Hz characterized NREM, indicating regular cardiac-frequency dynamics, whereas REM produced a broadened, lower-power peak reflecting greater variability (1).

Slow oscillation (SONO). Mean SONO power was lowest during wakefulness, increased slightly in REM, and was highest in NREM, consistent with the slow neural activity of deep sleep (2).

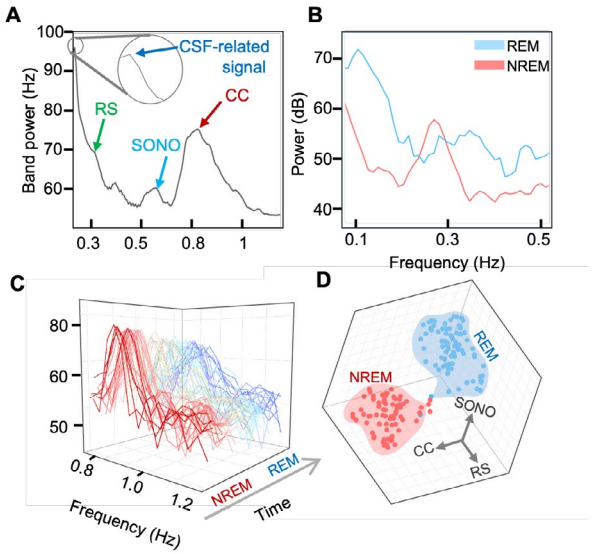


Figure 1: (A) NIRS power spectrum with RS, SONO, and CC peaks. (B) Respiratory-band spectra: a narrow ~0.25 Hz peak in NREM versus a broader ~0.35 Hz peak in REM. (C) Cardiac-band spectra across the sleep transition. (D) SONO-RS-CC feature space showing separable NREM and REM.

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Biophysical control of cell density promotes stem cell retention and tissue healing

Gwang-Bum Im[1,2], Hyun Su Park[3], Jong Wook Bae[3], Suk Ho Bhang[3]

[1]Department of Cardiac Surgery, Boston Children's Hospital, Boston, MA, USA

[2]Department of Surgery, Harvard Medical School, Boston, MA, USA, [3]School of Chemical Engineering, Sungkyunkwan University, Suwon, Republic of Korea

I. SUMMARY

Low retention of transplanted stem cells at target sites remains a major barrier to the clinical translation of regenerative therapies. Existing approaches to improve cell retention, including genetic engineering, chemical functionalization, and biomaterial encapsulation, often face challenges related to safety, regulatory complexity, and translational feasibility. Here, we present a nanoparticle-enabled biophysical strategy that enhances stem cell retention by modulating cellular density rather than directly altering cellular signaling pathways. We developed cell-settling nanoparticles (CN) composed of clinically relevant materials that are rapidly internalized by mesenchymal stem cells (MSCs), increasing cellular mass and density. This density increase accelerates gravitational settling, enhances cell adhesion, and improves local retention and survival following transplantation. Building on this platform, we engineered copper-chaperone-activatable cell-settling nanoparticles (CCN), which combine biophysical enhancement of cell retention with copper-mediated activation of regenerative signaling. CCN treatment significantly increased fibroblast growth factor 2 (FGF2) expression through activation of a copper-responsive CCS–MEK–ERK signaling axis and established a previously unrecognized FGF2–ERK positive feedback loop. In vitro, CCN enhanced cell aggregation, adhesion, migration, and pro-regenerative cytokine secretion. In a mouse skin wound model, CCN-engineered MSCs demonstrated superior therapeutic efficacy, characterized by enhanced vascularization, accelerated wound closure, improved tissue regeneration, and reduced fibrosis compared with untreated or CN-treated cells. Transcriptomic analyses further revealed activation of angiogenic, wound-healing, MAPK, PI3K-Akt, Rap1, and mTOR signaling pathways. Together, these findings establish cellular density tuning as a novel and translationally relevant strategy for improving stem cell engraftment and therapeutic performance. More broadly, this work expands the role of nanoparticles beyond conventional delivery vehicles and introduces physical regulation of cell behavior as a new paradigm for regenerative medicine and cell-based therapy.

II. ILLUSTRATIONS

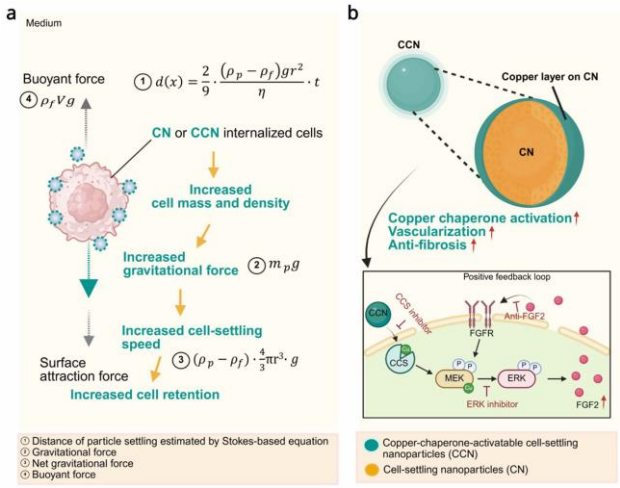


Figure 1: Cell-settling nanoparticles are designed to improve cell adhesion and retention via increased gravitational force, while enhancing the therapeutic effects through copper-driven FGF2 expression.

ACKNOWLEDGEMENTS

Add appropriate acknowledgements as needed.

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Reactive Oxygen Species, Electrode Potential and pH Affect CoCrMo Alloy Corrosion and Semiconducting Behavior in Simulated Inflammatory Environments

Hwaran Lee[1,2], Jeremy L. Gilbert[1,2]
[1]Department of Bioengineering, Clemson University, Charleston, SC, US
[2]Clemson University – Medical University of South Carolina Bioengineering Program, Charleston, SC, US

I. INTRODUCTION

Crevice corrosion in modular taper junctions of hip or knee replacements using cobalt-chrome-molybdenum (CoCrMo) alloys remains a clinical concern. The environments of around orthopedic implants may contain low pH and reactive oxygen species (ROS) from biomaterial oxidation or local inflammatory responses, experience voltage changes due to tribocorrosion (wear) and accelerated oxidation reactions leading greater corrosion susceptibility. The aim of this study was to identify the effect of the simulated inflammatory environment with hydrogen peroxide (H_2O_2) on the electrochemical behavior of CoCrMo in the range of voltage affected by tribology and inflammation. We investigated how resistance and capacitance of the CoCrMo oxide film (i.e., corrosion resistance) are modified in simulated *in vivo* crevice environments of modular taper junctions.

II. METHODS

Six solutions were evaluated (two pH levels: 1 and 7.4 and four hydrogen peroxide (H_2O_2) concentrations: 0, 0.001, 0.01 and 0.1 M). Electrochemical impedance spectroscopy (EIS) was run from -1 V to 1 V with 0.1 V increments. Corrosion resistance (R_p), and capacitance (C^{-2}) were measured and compared using symmetry-based electrochemical impedance spectroscopy (sbEIS). Mott-Schottky analysis was performed.

III. RESULTS and DISCUSSION

This study showed that the corrosion resistance and capacitance corrosion characteristics of low carbon CoCrMo alloy varied over a range of solutions and electrode potentials meant to approximate the crevice environment within modular taper junctions of hip replacements. The semiconductor type alters from n-type to p-type while anodic potentials are applied to the CoCrMo alloy at all solution types. The semiconducting behavior depends on the pH level. The flat band potential at pH 1 was higher than the pH 7.4 group, indicating a shift in the Fermi energy level of the oxide due to the acidic environment because of the ionic species (more cations) giving rise to structural and electronic defects. The greater concentration of H_2O_2 (0.1 M) has a major impact on the oxide film by generating the highest donor density (lower slope of Mott–Schottky plot) ($p = 0.0006$) and lower oxide resistance (R_p). The oxide film is less stable and protective in higher concentrations of H_2O_2, compared to other solutions. Electrode potential also has a significant effect on the polarization resistance of the alloy with cathodic potentials, resulting in large decreases in R_p ($p = 0.0005$). The concentration of H_2O_2 is a significant factor determining the oxide resistance of CoCrMo alloy.

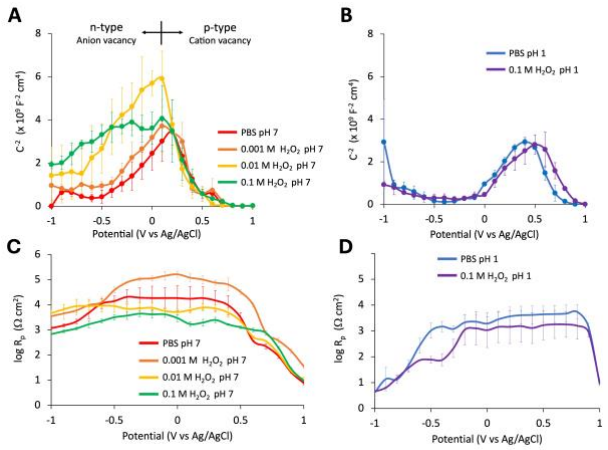


Figure 1: (A-B) Mott-Schottky plots, (C-D) Corrosion resistance (oxide resistance, R_p) from -1 V to 1 V.

Large Language Model and Human Performance on a Motor Sequence Learning Task

Hakjoo Kim[1,2]
[1]Brain Stimulation Mechanisms Lab, Division of Depression and Anxiety Disorders, McLean Hospital
[2]Department of Psychiatry, Harvard Medical School

I. INTRODUCTION

Recent large language models (LLMs) have advanced beyond conversational interaction with users to the autonomous execution of user-requested tasks. The present study aimed to have an LLM perform a motor sequence learning task and to characterize how its performance diverges from that of humans.

II. METHODS

A. Serial Reaction Time Task (SRTT)

The task used in this study was implemented as an HTML file designed to be performed by human participants [1]. During each 15-second rest period, the sequence to be typed was masked by a black box. When the rest period ended, the sequence to be typed was displayed on screen for 30 seconds. This cycle was repeated a total of 20 times. The trials comprised an intermixed set of training sequences and random sequences (see [1]).

B. Large Language Model (LLM)

The LLM used in this study was Claude Opus 4.8 (Anthropic). The model performed the task by directly controlling a web browser (i.e., Google Chrome). Through the prompt, the model was informed that the task consisted of alternating periods of 30 seconds of typing and 15 seconds of rest, repeated over a total duration of approximately 15 minutes. However, no information was provided regarding the presence of an underlying sequence or its composition. The model was further instructed to perform the task without analyzing the file structure of the task itself.

III. RESULTS

In human participants, when the same sequence is typed repeatedly, the number of correctly typed sequences within the 30-second typing periods tend to increase until the onset of fatigue. In contrast, the LLM required some initial time to comprehend the task, but once it had determined how to perform the task, it produced correct sequences at a consistent rate throughout the remainder of the session. Furthermore, human participants show a transient decline in performance when a repeatedly practiced sequence is abruptly replaced by a different one, whereas the LLM showed no such deterioration when random sequences appeared.

IV. DISCUSSION

The LLM and humans differed in the way they comprehended and performed the given task and are likely to differ in the memory consolidation of previously performed tasks as well.

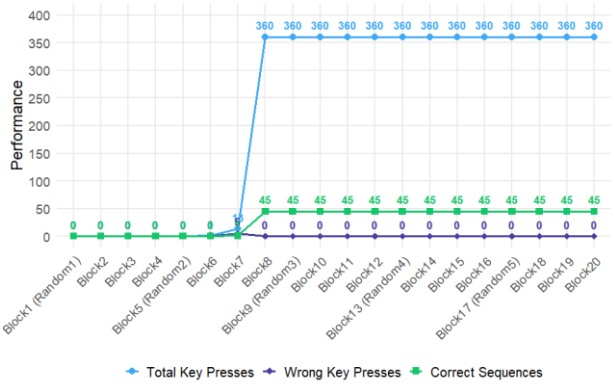


Figure 1: Task performance of the LLM. The LLM refrained from responding during the period in which it was establishing a strategy for performing the task; following the completion of this process (i.e., from Block 6 onward), it sustained consistently high performance.

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Comparative Analysis of Flexible Electrode Designs

Jong-Hoon Kim[1]
[1]School of Engineering and Computer Science, Washington State University, Vancouver, WA 98686

I. SUMMARY

Flexible wearable electronics are promising platforms for continuous physiological monitoring, especially for electromyography (EMG) applications [1]. In these systems, electrode geometry strongly influences mechanical durability, electrical stability, and signal quality [2,3]. This study compares three commonly used flexible electrode geometries, open-mesh, closed-mesh, and island-bridge, fabricated using identical materials and processing conditions to isolate the effect of design structure on wearable device performance (Fig. 1). Gold-coated polyimide (PI) electrodes with chromium adhesion layers were patterned using laser cutting and transferred onto flexible silicone substrates.

The open-mesh design provides high flexibility through serpentine conductive traces with large open spaces, while the closed-mesh design uses a dense interconnected network to improve electrical stability. The island-bridge design consists of rigid conductive islands connected by stretchable bridges to localize strain away from sensing regions. Mechanical characterization showed that the open-mesh structure experienced the largest resistance variation under stretching (up to ±6.2%), indicating reduced electrical stability during deformation. In contrast, the closed-mesh and island-bridge designs demonstrated significantly improved electromechanical stability, with resistance variations below ±3% under most stretching conditions (Table 1). The island-bridge design also exhibited the best bending durability during cyclic bending tests.

Real-time EMG measurements were performed during folding and twisting motions using a custom Bluetooth Low Energy (BLE)-based wireless acquisition system. Among the three designs, the closed-mesh electrode consistently achieved the highest signal-to-noise ratio (SNR), reaching 14.83 ± 1.94 dB during clockwise twisting motion. Its dense conductive network enabled stable skin contact and reduced motion artifacts during dynamic movement. The open-mesh design showed lower but consistent signal quality due to its high flexibility, while the island-bridge structure provided intermediate performance with larger variability caused by strain concentration at the bridge regions.

Overall, the results demonstrate that electrode geometry plays a critical role in flexible wearable electronics. The closed-mesh design achieved the best balance between mechanical reliability and EMG signal fidelity, making it the most suitable candidate for motion-intensive wearable bioelectronics applications.



Figure 1: CAD designs of the open-mesh (A), closed-mesh (B), and island-bridge (C) patterns.

Table 1: Relative resistance changes ($\Delta R/R_0$) under stretching

Design	Longitudinal	Transverse
Open-mesh	± 6.20%	± 4.70%
Closed-mesh	± 2.30%	± 1.21%
Island-bridge	± 1.32%	± 2.56%

ACKNOWLEDGEMENTS

We acknowledge the support of the WSU Commercialization Gap Fund.

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Capacitive Sensors for Non-invasive Monitoring of Vital Signs in Small Animals

Ethan Reyes[1], Shawn Kim[2], Rebekah Muldoon[1], Alison Clark[3], Bodhi Tran[4], Piper Deleon[5], Timothy Harris[6], Kennett Radford[7], Jae-Hyun Chung[2], and Kwang Choi[3,5,8]

[1]The Geneva Foundation, Bethesda, MD, [2]University of Washington, Mechanical Engineering, Seattle, WA, [3]Center for the Study of Traumatic Stress, Department of Psychiatry, Uniformed Services University, Bethesda, MD, [4]Bethesda-Chevy Chase High School, Bethesda, MD, [5]Neuroscience Graduate Program, Uniformed Services University, Bethesda, MD, [6]School of Medicine, Uniformed Services University, Bethesda, MD, [7]Naval Health Clinic Patuxent River, MD, [8]Department of Psychiatry, Uniformed Services University, Bethesda, MD (Contact: Kwang.choi@usuhs.edu)

I. Background: Non-invasive and continuous vital sign monitoring is crucial for *in vivo* preclinical research. However, currently available technologies may face some challenges including frequent signal dropouts and limited body parts for the sensor attachment in small animals. To address this issue, we developed a non-invasive capacitive sensing system for monitoring vital signs from the head region[1], validating their data against concurrent pulse oximetry signals obtained from the animals.

II. Methods: Adult male Sprague-Dawley rats (8-10 weeks old) were monitored under isoflurane inhalation anesthesia (1-3% mixed with 100% oxygen) for vital signs. Non-invasive vital signs were simultaneously measured using a pulse oximetry sensor and miniaturized brain capacitive sensors. Isoflurane concentration (1%, 2%, and 3%) was systematically varied to modulate cardiorespiratory function of the animals.

III. Results: Isoflurane variation produced robust effects on vital signs, including heartbeat rate (beats per minute), breath rate (breath rate per minute), and pulse distention (μm), while blood oxygen saturation (SpO2) and core body temperature remained stable. Specifically, increasing isoflurane concentration reduced heart rate and breath rate while increasing pulse distention; these changes were reversed upon decreasing the concentration. Brain capacitance monitoring yielded pulse waveforms containing both respiratory (0-4 Hz) and heartbeat (4-10 Hz) signals. Isoflurane produced dose-dependent effects on capacitance waveform frequency, amplitude, and morphology. The heartbeat (bpm) and breath rate (brpm) were successfully derived from the brain capacitance using signal processing methods including band-pass filtering, smoothing, and fast-Fourier transform (FFT). Correlation analyses between brain capacitance and peripheral pulse oximetry data indicated statistically significant effects on respiratory and heartbeat signals.

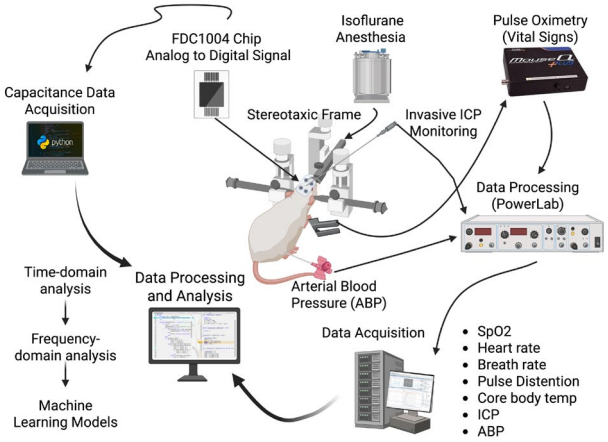


Figure 1: Overall Study Design

IV. Conclusions: The current results demonstrate that single-electrode capacitive sensors made of carbon nanotube composites can monitor continuous cardiorespiratory signals from the head region of animals. Further research is in progress to monitor invasive signals such as intracranial pressure (ICP) and arterial blood pressure (ABP) for comprehensive analyses of intracranial and hemodynamic indices. This cross-modal validation approach provides a foundation for high fidelity signal acquisition and data processing/analysis for non-invasive vital sign monitoring in small animals.

ACKNOWLEDGEMENTS

The opinions and assertions expressed herein are those of the authors and do not reflect the official policy or position of the Uniformed Services University or the Department of War. The authors declare no financial conflicts of interest. Funded by the TriService Nursing Research Program and CSTS.

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Assessing the Role of GAN-Based Synthetic Data in Cell Microscopy Classification under Limited Data Conditions

So-yun Park[1], Soon-Do Yoon[2], Se-woon Choe[1,3]
[1]Department of Biomedical Engineering, Kumoh National Institute of Technology, Republic of Korea
[2]Department of Chemical and Biomolecular Engineering, Chonnam National University, Republic of Korea
[3]High-tech Medical Equipment Research Institute, Kumoh National Institute of Technology, Republic of Korea

I. ABSTRACT
This study investigates the effectiveness of Generative Adversarial Network (GAN)-based synthetic data for improving microscopy-based cancer cell classification under data-limited conditions. Multiple GAN models were systematically compared, and their outputs were integrated with real data at controlled ratios. Results demonstrate that a 75% real and 25% synthetic data composition consistently yields the best performance across CNN models. These findings underscore the importance of balanced data integration and establish synthetic data as a complementary resource rather than a replacement.

II. INTRODUCTION
Deep learning-based image analysis critically depends on large and diverse datasets, which are often difficult to obtain in cell microscopy. Conventional augmentation methods provide limited variability and fail to capture complex morphological characteristics. GANs offer a promising alternative by generating realistic and diverse synthetic images. This study systematically investigates the effectiveness and optimal composition of GAN-based synthetic data for classification tasks.

III. MATERIALS AND METHODS
Microscopy images from five cancer cell lines were collected and preprocessed to extract standardized single-cell patches. All images were resized to a uniform resolution to ensure consistency across experiments. Four GAN architectures—DCGAN, LSGAN, WGAN, and WGAN-GP—were trained to generate class-specific synthetic images under controlled settings. The quality of generated images was evaluated using multiple quantitative metrics capturing distributional similarity, perceptual fidelity, and generative diversity. In addition, dimensionality reduction techniques were employed to analyze distributional alignment between real and synthetic data.

To evaluate practical effectiveness, synthetic images were combined with real datasets at controlled ratios (0%, 25%, 50%, 75%, and 100%), enabling systematic comparison across data compositions. Five CNN-based classifiers (ResNet50, DenseNet121, InceptionV3, MobileNetV2, and EfficientNetB2) were trained from scratch under consistent experimental conditions. Model performance was evaluated using accuracy, precision, recall, and F1-score. This framework enables a comprehensive assessment of both generative quality and downstream classification performance under data-limited conditions.

IV. RESULTS
GAN-generated synthetic data led to consistent improvements in classification performance, with effectiveness strongly dependent on the real-to-synthetic data ratio. The configuration combining 75% real and 25% synthetic data consistently achieved the highest performance across all CNN models, improving accuracy, recall, and F1-score compared to the real-only baseline. GAN performance varied across cell types, with WGAN-GP generally exhibiting the most stable balance between image quality and diversity. Overall, these results demonstrate that synthetic data is most effective when used in a balanced and complementary manner.

ACKNOWLEDGEMENTS
This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (RS-2023-00240521) and Ministry of Science and ICT (RS-2025-16068429).

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The Effects of Copper Availability on Ethane Oxidation by Obligate Methanotrophs

Jaeho Choi[1] and Jaewook Myung[1*]
[1]Department of Civil and Environmental Engineering, KAIST, Daejeon, Republic of Korea

ABSTRACT

Copper is a key regulator of methanotrophic metabolism, governing the differential expression of methane monooxygenases (MMOs). In natural gas seep environments, facultative methanotrophs harboring only soluble MMO (sMMO) are often more prevalent than methanotrophs expressing particulate MMO (pMMO), suggesting that the broader substrate range of sMMO may contribute to niche selection. Here, we hypothesize that sMMO expression states confer a physiological advantage in co-metabolic ethane oxidation. We used the copper-switch model obligate methanotroph *Methylosinus trichosporium* OB3b under copper-sufficient vs. copper-deficient conditions, each with or without ethane supplied as a non-growth substrate. Contrary to our hypothesis, methane oxidation stoichiometry remained invariant across treatments. The only significant difference in ethane oxidation ran counter to our hypothesis, with higher rates under copper-sufficient conditions. Together, these results indicate that pMMO- and sMMO-associated states do not exhibit clear physiological differences under the tested conditions. Consequently, this work demonstrates that ethane co-metabolism alone is insufficient to explain the ecological dominance of sMMO-only facultative methanotrophs in natural gas seep environments, suggesting that additional ecological or metabolic factors govern niche differentiation.

Table 1: Copper and ethane treatment conditions for *Methylosinus trichosporium* OB3b with 20% CH_4 and 30% O_2.

	Cu(+) (10 μM Cu)	Cu(-) (0 μM Cu)
NG(-) (0% C_2H_6)	Cu(+)/NG(-)	Cu(-)/NG(-)
NG(+) (3% C_2H_6)	Cu(+)/NG(+)	Cu(-)/NG(+)

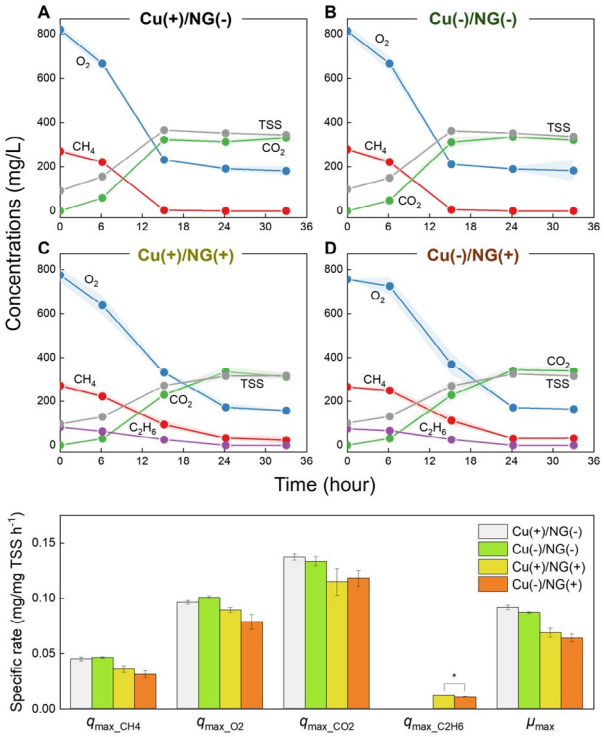


Figure 1: Growth and metabolic activity of *M. trichosporium* OB3b. (A–D) Time-course profiles of CH_4, O_2, C_2H_6, CO_2, and TSS. (E) μ_{max} and q_{max} values for substrate utilization and CO_2 production.

ACKNOWLEDGEMENTS

This research was supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Education (RS-2025-25423447), the Ministry of Land, Infrastructure and Transport (MOLIT) through the Innovative Talent Education Program for Smart City, and the Hyundai Motor Chung Mong-Koo Foundation.

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Coupling Mechanistic Lyophilization Models with a Multi-Agent AI Interrogation Engine for Autonomous Process Discovery

Saeyoung Kim[1], Jaeweon Lee[1], Kimia Babaei[1], Seongkyu Yoon[1,*]
[1]Department of Chemical Engineering, UMass Lowell, MA, *Corresponding Author

I. SUMMARY

Lyophilization development for mRNA-lipid nanoparticle (mRNA-LNP) products is a high-dimensional decision problem because recipe and formulation jointly govern critical quality attributes (CQAs). We present DAEMON (Discovery Agents Exploring Mechanistic ODE Networks), a framework that couples a first-principles freeze-drying model with a multi-agent AI interrogation engine. Five AI agents autonomously propose hypotheses, run simulations, interpret results, and converge on evidence-backed recipe recommendations, reducing weeks of manual iteration to an overnight run.

II. BACKGROUND AND MOTIVATION

Lyophilization development is a multi-variable decision problem. For mRNA-LNP products, both recipe and formulation affect final CQAs. In this study, the mechanistic model exposes a 20-input search space (13 recipe and 7 formulation variables). Useful discovery requires more than running simulations; it requires choosing informative next experiments. DAEMON combines mechanistic simulation with multi-agent reasoning to support and automate that process.

III. DAEMON SYSTEM OVERVIEW

DAEMON couples a 9-state ODE model (temperature, ice thickness, chamber pressure, moisture, cake resistance, encapsulation efficiency [EE], RNA integrity number [RIN], particle size, potency proxy) with five AI agents: MONITOR (orchestrator), SCOUT (exploration), REFINER (optimization), CONSERVATIVE (robustness), and AUDITOR (evidence review). The user defines a research question and constraints, then agents iterate through hypothesis, simulation, interpretation, and discussion until MONITOR declares convergence. Unlike classical DOE or black-box optimization, DAEMON provides physics-grounded adaptive search with interpretable hypotheses and a complete evidence trail.

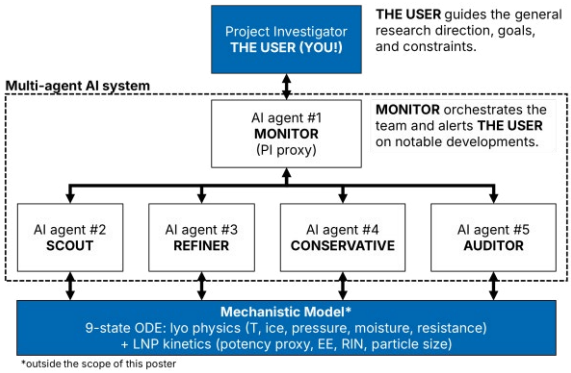


Figure 1: DAEMON system architecture.

IV. CASE STUDY AND HIGHLIGHTS

We tested DAEMON on the question: which factors drive residual moisture below 4% while maintaining EE above 90% and RIN above 7? In one converged session (5 cycles, 57 experiments, ~22 min wall time), DAEMON identified consistent operating windows: SD temperature 40–50 °C, PD pressure below 300 mTorr, and protectant concentration of at least 15%. Recommendations are directional pending experimental calibration. Next steps: LLM benchmarking, model calibration, and lab validation.

ACKNOWLEDGEMENTS

This work was supported by the Technology Innovation Program (or Industrial Strategic Technology Development Program-Materials and Components Technology Development Program) (RS-2024-00438660, Development of core components and system for online process monitoring in lyophilization of nucleic acid therapeutics) funded by the Ministry of Trade, Industry & Resources (MOTIR, Korea).

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Bio-inspired zwitterion-treated silicone catheters reduce device-related complications in chronically catheterized patients

Min Kyu Lee[1], Brian McVerry[1,2], Ethan Rao[1,2], Na He[1,2], Alexandra Polasko[1,3], Yi-Wei Chen[1], Suzy Matinyan[1], Ivy Kwok[1], Armando M. Marrufo[4], Marissa J. Andersen[4], Naomi Kobayashi[1], Meagan Pruner[1], Alyssa Sifuentes[1], Evgeniy Kreydin[5], Glenn Werneburg[6], Howard B. Goldman[6], Chris Elliott[3,8], Forrest Jellison[7], Daniel Jhang[7], Jacqueline Zillioux[9], Nhi Ha[5], Luis Ojeda[5], Stefania Arcila[5], Ana Flores-Mireles[1,4], Hung Ton-That[1], Shaily Mahendra[1], Richard Kaner[1,2*]

[1]UCLA [2]Silq Technologies, Corp. [3]Stanford University [4]University of Notre Dame [5]University of Southern California / Rancho Los Amigos Nat'l Rehab. Center [6]Cleveland Clinic [7]Loma Linda University [8]Santa Clara Valley Medical Center [9]University of Virginia Health

I. SUMMARY

The Foley catheter is associated with the most nosocomial infections of any medical implant, yet antimicrobial and silver-based strategies have shown poor clinical efficacy and contribute to antimicrobial resistance. We report a drug-free approach that applies a bio-inspired polyzwitterion surface treatment to silicone catheters to resist biofilm adhesion and the foreign body response. A scalable UV-based manufacturing system was built to covalently graft polysulfobetaine onto indwelling catheters, producing devices that received FDA 510(k) clearance and satisfy ISO 13485/GMP requirements. Zwitterion-treated silicone significantly reduced *S. aureus* adhesion *in vitro* and decreased fibrous capsule formation in a murine implant model. We also identified that commonly used latex catheters leach bacterial endotoxin well above the FDA limit for blood-contacting devices. Two randomized clinical studies in catheterized patients confirmed significant reductions in biofilm, catheter-associated urinary tract infections, and encrustation versus standard of care, with a strong patient preference for the treated device.

II. RESULTS & DISCUSSION

Manufacturing and preclinical data. A UV-coating apparatus (Fig. 1) enables >1M treated catheters/year under ISO 13485. Eight commercial latex catheters contained endotoxin >20× the FDA 20 EU/device limit (some >200×); latex extracts were cytotoxic to urinary epithelial and macrophage cells while zwitterion-treated silicone extracts were not. Per ASTM E3371, treated silicone showed a 99.9% (3-log) reduction in viable *S. aureus*. In a 12-week murine subcutaneous implant study, collagen density 90–100 μm from the interface was 80.9% lower ($p<0.001$) for treated implants, with markedly thinner fibrous capsules.

Clinical studies. An 8-site randomized study (NCT04841226, n=112) measured adhered biofilm on explanted catheters by microbial viability assay: treated catheters showed 75.6% less biofilm vs. silver-hydrogel latex ($p=0.013$) and 71.5% less vs. silicone-coated latex ($p=0.038$). A 5-site randomized crossover study in chronically catheterized patients (NCT05931887, n=115) compared treated catheters to each subject's standard of care over six months. The treated group had a 70% lower CAUTI rate (1.8 vs. 5.9 per 1000 catheter-days; incidence rate ratio 0.30, $p=8.1\times10^{-5}$) and 72.2% less encrustation mass (38.1 vs. 137.2 mg, $p=6.1\times10^{-15}$); 86.4% of subjects with a preference preferred the treated catheter. Applied to published CAUTI cost estimates (2025 USD), each use is projected to save $131–$1,534, depending on care setting.

III. ILLUSTRATIONS

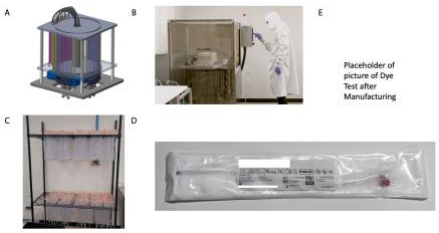


Fig 1. (**A**) Prototype zwitterion-treatment apparatus; (**B, C**) catheter production under GMP/ISO 13485 in a Class 7 cleanroom; (**D**) sterilization pouch; (**E**) dye staining confirms coating uniformity.

ACKNOWLEDGEMENTS

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Real-Time Optical Control and Quantitative Imaging of Cellular Responses

Seohee Ma[1,2], Bin Dong[1,2], Shivam Mahaptra[1,2], Chi Zhang[1,2,3]
[1] James Tarpo Jr. and Margaret Tarpo Department of Chemistry, Purdue University, 560 Oval Dr., West Lafayette, IN 47907, USA, [2] Purdue Center for Cancer Research, 201 S. University St., West Lafayette, IN 47907, USA. [3]Purdue Institute of Inflammation, Immunology, and Infectious Disease, 207 S. Martin Jischke Dr., West Lafayette, IN 47907, USA

I. Background

Understanding localized biochemical processes in living cells requires technologies capable of both observing and controlling molecular activities with high spatial and temporal precision. Existing optical perturbation methods rely on prior imaging and manual target selection, limiting their ability to manipulate dynamic intracellular structures in real time. To address these limitations, this work focuses on developing real-time precision opto-control (RPOC) platforms that integrate molecular detection with automated optical perturbation, enabling chemically selective and spatially precise control of subcellular processes without prior imaging or manual intervention.

II. Method

To overcome limitations of conventional optical perturbation methods, RPOC was developed for chemically selective live-cell manipulation during imaging. Fs-RPOC further improved spatial confinement and perturbation precision using femtosecond pulses and pulse-picking technology for highly localized sub-organelle control with reduced off-target effects.

III. Results and discussion

CW-RPOC enabled asymmetric mitochondrial perturbation during metaphase to investigate how localized mitochondrial dysfunction influences mitotic progression and daughter cell fate (**Figure 1A**). Although perturbation was spatially localized, intracellular mitochondrial dynamics rapidly homogenized the effects, resulting in largely symmetric cellular responses, including mitotic arrest and comparable daughter cell outcomes. Extracellular ATP partially rescued laser-induced mitochondrial damage, suggesting compensatory energy redistribution from unaffected mitochondria. Fs-RPOC significantly improved perturbation precision by confining laser interactions to the focal plane through nonlinear multiphoton absorption. The system enabled single- and sub-organelle microsurgery with reduced off-target photodamage (**Figure 1B**) and revealed site-specific reactive oxygen species formation, hydrogen peroxide diffusion, and low-density plasma generation following femtosecond laser interaction with mitochondria. Together, these studies establish RPOC as a versatile framework for real-time optical regulation of intracellular biochemical processes with high spatial precision.

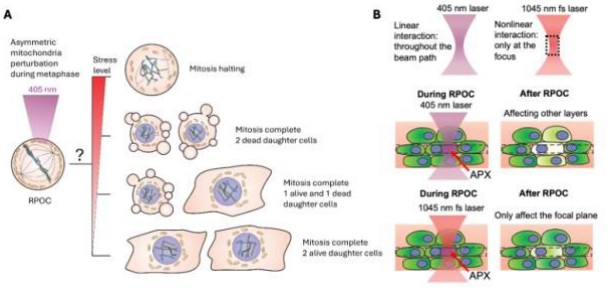


Figure 1: (A) CW-RPOC enables asymmetric mitochondrial perturbation during mitosis to investigate stress-dependent cellular responses and daughter cell fate. (B) Fs-RPOC improves axial confinement through nonlinear femtosecond laser interactions, enabling highly localized sub-organelle perturbation with reduced off-target effects.

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A study on early detection of mild cognitive impairment (MCI) in older Korean adults using daily speech and EEG data

Youngjin Park[1], Myeongki Cho[1], Kyunghwan Cho[1], Ji-Eun Kim[1], Kyeyoung Jeong[1] and Byung Ok Kang[2]
[1]Korea Electrotechnology Research Institute, Ansan, South-Korea
[2]Electronics and Telecommunications Research Institute, Daejeon, South-Korea

I. Abstract

This paper introduces a study on screening older adults at high risk of mild cognitive impairment (MCI) using daily-life speech and EEG data from older Korean adults. During app-based task performance, speech and EEG data are wirelessly collected through wearable devices developed and a multimodal AI analysis model is developed based on the data. Its applicability is validated through pilot tests at community senior care facilities and some analysis results are presented.

II. Introduction

Early detection of cognitive decline followed by timely and proactive intervention is considered one of the most effective strategies to delay or prevent progression to dementia.

Cognitive decline presents with heterogeneous clinical manifestations [1], and increasing research attention has focused on speech and electroencephalography (EEG) as objective and quantifiable biomarkers.

In this study, we propose a digital app–based paradigm for simultaneous speech and EEG acquisition implemented on a tablet platform. During task performance, speech and EEG are concurrently collected using custom-developed wearable devices and processed. The acquired multimodal data are analyzed to enable automated screening of cognitive decline in older adults.

III. Data collection, analysis, and pilot test

A. Task paradigm and wearable device for data

The data acquisition paradigm was previously reported in a study published last year [2]. It comprises four task types: picture description, conversational daily-life questions, procedural explanation, and storytelling. All task materials were implemented in a digital application format.

To ensure accurate task delivery and sustained attention in real-world daily noise environments, we developed a wearable speech acquisition device compatible with the digital app–based paradigm, as shown in Fig.1. The device is designed to facilitate clear auditory perception of task instructions and effective task performance under ambient noise conditions.

B. Test and results

Data from 300 participants consisting of cognitively normal individuals and patients with mild cognitive impairment (MCI) were used for AI training.

In the pilot test, a total of 90 participants were enrolled, including 29 individuals diagnosed with MCI. Participants were recruited from the Sangnok-gu Senior Welfare Center in Ansan (cognitively normal older adults) and the Gangseo-gu Dementia Care Center for MCI.

The test procedure is shown in Fig. 1. The output provided cognitive decline analysis results for each individual paradigm, as well as an overall integrated assessment outcome. From the analysis, the sensitivity of the method of 72% was obtained.

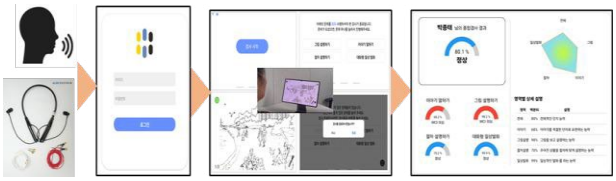


Figure 1: Test procedure, display of analysis results(right), and a wearable device (left)

IV. Conclusions

The proposed paradigms and method demonstrated effectiveness in screening for MCI. We plan to improve the sensitivity of the method. Furthermore, we aim to develop an interpretable system capable of providing individualized explanations.

ACKNOWLEDGEMENTS

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All-in-One Wearable Bioelectronics for a Continuous Assessment and Early Diagnosis of Acute Kidney Injury

Dr. Woon-Hong Yeo

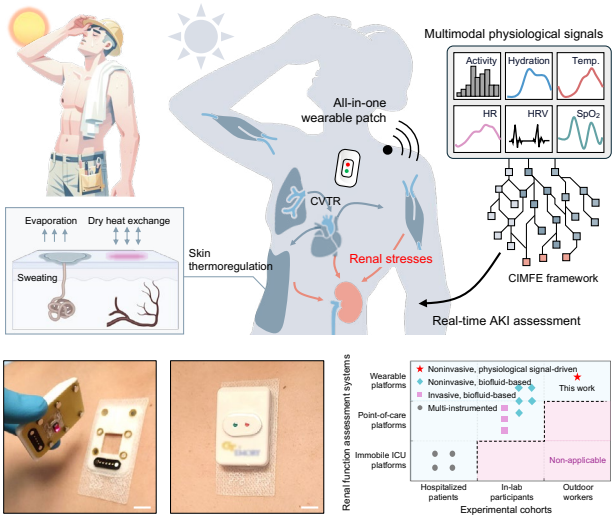
George W. Woodruff School of Mechanical Engineering, Wallace H. Coulter Department of Biomedical Engineering, Georgia Tech and Emory University School of Medicine, Atlanta, GA 30332, USA
Wearable Intelligent Systems and Healthcare Center, Georgia Tech, Atlanta, Georgia 30332, USA

I. INTRODUCTION

Outdoor workers are at a significantly higher risk of acute kidney injury (AKI). Efficient noninvasive monitoring of physiological changes plays a crucial role in the proactive assessment of AKI risk. Here, we introduce an all-in-one wearable platform that presents a class of translational technologies of multimodal sensors, multifunctional materials, snap-on modular electronics, and an AI-based predictive model for continuous renal function assessment and AKI risk. The wearable patch is designed to simultaneously measure temperature, skin hydration, cardiac activities, physical activities, and blood oxygen saturation, which detects continuous changes in serum creatinine, the clinical standard for diagnosing AKI. An in vivo study involving 110 outdoor workers demonstrates that the real-time collection of multiple physiological parameters combined with integrated AI can facilitate early diagnosis of AKI for prompt intervention.

II. RESUTLS AND DISCUSSION

This paper reports the development of an all-in-one wearable platform that integrates a wearable sensor for multimodal signal monitoring and an AI-based predictive model for continuous renal function assessment and AKI risk, specifically designed for outdoor workers. As shown in the figure, the all-in-one wearable patch is designed to simultaneously and noninvasively measure temperature, skin hydration, heart rate (HR), heart rate variability (HRV), physical activity, and blood oxygen saturation (SpO2), which facilitates continuous assessment of renal function and AKI risk. The all-in-one wearable patch comprises a multifunctional patch integrating flexible, low-profile sensors and a miniaturized smart sensor unit, which can be reversibly assembled via magnetic coupling. This integrated system offers high adhesion strength, sweat absorption, wireless connectivity, and reusability, enabling robust fixation, reliable data acquisition, and extremely user-oriented characteristics for outdoor workers. This work introduces a clinically-informed multi-level feature extraction (CIMFE) framework as a real-time, continuous renal function predictive model. This predictive model integrates a clinically-informed pretext task to learn deep-learning-derived features with statistical features, outperforming conventional AI-based predictive models that utilize raw multimodal time-series inputs to basic deep learning architectures.



III. CONCLUSIONS

The all-in-one wearable system presented here demonstrates a translational medical platform enhancing safety and saving lives in high-risk occupational environments. This robust signal monitoring system enables the deployment of a predictive ML framework for continuous renal function and AKI risk assessment, based on the in vivo test with an in-lab cohort of 29 participants and a real-world cohort of 110 outdoor workers. Remarkably, the CIMFE framework exhibits superior performance on this clinical task by learning physiology-informed deep representations through a novel PSI prediction task, which serves as a key indicator of physiological state, and by incorporating static features.

Cytoprotective Effect of Kartogenin-Loaded Nanosomes on Arthritic Chondrocytes

Ryan Qiu[1], Shona Gordon[1], R. Northcutt[1], *Hongsik Cho[1,2]
University of Tennessee Health Science Center, Department of Orthopaedic Surgery & Biomedical Engineering, University of Tennessee-Campbell Clinic, Veterans Affairs Medical Center, Memphis, TN
*Corresponding author: hcho4@uthsc.edu

DISCLOSURES: R. Qiu (None), S. Gordon (None), R.Nothcutt (None), H. Cho (None)

INTRODUCTION: Osteoarthritis (OA) is a chronic degenerative joint disease that affects over 527 million individuals worldwide. It is characterized by progressive cartilage degradation and fibrosis of the joint tissue. As cartilage tissue is avascular and relies on diffusion within the synovial fluid space to receive metabolic support, it has a limited capacity to heal itself through cellular repair mechanisms. Current OA therapies include NSAIDs, corticosteroids, and hyaluronic acid injections, but these only provide symptomatic relief rather than targeting the underlying pathology of OA. Kartogenin (KGN) is a small hydrophobic molecule that acts through the CBFβ–RUNX1 pathway. It has been shown to promote chondrogenic gene expression (COL2A1, ACAN) and suppress catabolic enzymes (MMP13, ADAMTS5). However, KGN faces three major limitations: poor solubility, lack of tissue specificity, and risk of dose-dependent toxicity. We hypothesized that encapsulating KGN into lipid nanosomes would overcome these limitations by enhancing solubility, improving uptake in inflamed chondrocytes, and reducing the required therapeutic dose.

METHODS*: Culture of Primary Chondrocytes:* Articular cartilage was harvested from the femorotibial joints of 3 month old porcine. Cartilage slices were digested with Pronase followed by Collagenase under gentle agitation. Isolated chondrocytes were filtered, washed, and cultured in DMEM supplemented with 10% fetal bovine serum (FBS), streptomycin, penicillin G, L-glutamine, and L-ascorbic acid. Cells were incubated at 37°C and used at passage 3 for all experiments. *Establishment of In Vitro OA Model:* To model an OA catabolic phenotype, chondrocytes were seeded at 2.5×10^5 cells/well in 6-well plates and treated with 10 ng/mL of TNF-α for 24 hours. *Preparation of KGN-Nanosomes:* Lipids consisting of 1,2-dioleoyl-sn-glycero-3-phosphocholine (DOPC), cholesterol, DSPE-PEG, and DSPE-PEG-maleimide were combined in a glass tube and dissolved in chloroform. The solvent was evaporated under a stream of air for 45 minutes to form a thin lipid film. It was vacuum dried for 15 minutes to remove residual solvent. The dried lipid film was rehydrated with PBS containing 500 μM Kartogenin. The suspension was then extruded through 200 nm polycarbonate membranes to obtain uniform nanosomes. Unencapsulated KGN was removed by size-exclusion chromatography. Dynamic light scattering confirmed a mean diameter of 178.7 nm and a polydispersity index of 0.023. Encapsulation efficiency was around 10%. The final external concentration was 40 nM/mL after 1:1000 dilution for cell treatment. *Experimental Design:* Chondrocytes were divided into five groups (n = 3 wells per group): (a) untreated control, (b) TNF-α only, (c) TNF-α + free KGN (1 μM), (d) TNF-α + free KGN (100 μM), and (e) TNF-α + KGN-loaded nanosomes (40 nM external concentration). Treatments were administered at the same time as TNF-α stimulation, and the cells were incubated at 37°C for 24 hours. *Gene Expression Analysis (RT-qPCR):* Total RNA was extracted using TRIzol reagent and quantified with a NanoDrop spectrophotometer. cDNA synthesis was performed. Quantitative PCR was conducted and targeted anabolic genes (COL2A1, ACAN) and the catabolic marker (MMP13). GAPDH was used as the internal reference housekeeping gene. Relative gene expression was calculated. *Statistical Analysis:* Data is expressed as mean ± standard deviation (SD). Statistical comparisons were made using one-way ANOVA. A p-value < 0.05 was considered statistically significant.

RESULTS: *Establishment of an In Vitro OA Model:* Upon exposure to TNF-α (10 ng/mL) for 24 hours, the chondrocytes transitioned towards an increased inflammatory and catabolic state. RT-qPCR analysis revealed a statistically significant upregulation of MMP13 of a 100-fold increase compared to untreated controls. Additionally, expression of the key anabolic markers COL2A1 and ACAN was significantly downregulated (Fig. X). These results confirm that TNF-α treatment reliably induces OA-like conditions in vitro. *Effect of KGN on Healthy Chondrocytes:* To assess potential off-target effects, KGN was applied to unstimulated, healthy chondrocytes. RT-qPCR demonstrated that COL2A1 and ACAN levels remained unchanged compared to control, and MMP13 expression did not increase (Fig. 1). This suggests that KGN does not disrupt baseline anabolic or catabolic signaling in non-inflamed cartilage cells. The absence of a catabolic response by KGN supports its safety profile for targeted therapeutic use. *KGN-Nanosome Characterization:* Dynamic light scattering measurements confirmed the successful formulation of KGN-loaded lipid nanosomes with a mean particle diameter of 178.7 nm and a polydispersity index (PDI) of 0.023 (Fig. 2). The particle size distribution fell within the optimal range for endocytosis-mediated uptake and reduced the likelihood of rapid clearance or macrophage recognition of the nanosome particles. After dilution to a 1:1000 ratio, the final external treatment concentration of the KGN-nanosomes was only 40 nM/mL, enabling delivery of a high local dose intracellularly while minimizing systemic exposure. *Impact of Free KGN and KGN-Loaded Nanosomes on Inflamed Chondrocytes:* Treatment of TNF-α–stimulated chondrocytes with free KGN at 1 μM produced negligible changes in gene expression. Increasing the dosage to 100 μM restored cartilage anabolism, as evidenced by a significant increase in COL2A1 expression, and suppressed MMP13 (Fig. 3). In comparison, KGN-loaded nanosomes administered at only 40 nM/mL achieved markedly similar outcomes of the 100 μM treatment group. RT-qPCR demonstrated significant upregulation of COL2A1 and significant suppression of MMP13. These results indicate that nanosome-mediated delivery not only enhances the bioactivity of KGN but also enables potent therapeutic effects at a concentration of 2,500 times less of the free KGN dose.

DISCUSSION: This study shows that delivering Kartogenin through lipid nanosomes improves its effectiveness in an in vitro model of osteoarthritis. TNF-α treatment reliably induced an OA-like phenotype in chondrocytes: high MMP13 expression and reduced COL2A1 and ACAN. Free KGN at high concentrations partially improved this imbalance, but only at 100 μM. In contrast, KGN-loaded nanosomes achieved similar anabolic and anti-catabolic effects at 2,500 times less concentration of just 40 nM/mL. Encapsulating KGN in nanosomes overcame key limitations to its use: poor solubility, lack of tissue specificity, and the risk of dosage-dependent systemic toxicity. The nanosomes allowed KGN to be delivered directly into inflamed chondrocytes at a high local drug concentration while keeping overall systemic exposure low, which reduces the risk of toxicity. Despite the nanomolar external dose, we saw a clear increase in COL2A1 and strong suppression of MMP13. The consistent size (~179 nm) and low polydispersity of our nanosomes indicate they are well-suited for cellular uptake and could be retained within the joint if tested in vivo. Future studies will need to evaluate their performance in murine models of OA and assess long-term effects, but these results provide a strong foundation for further development.

SIGNIFICANCE: KGN-loaded nanosomes represent a promising approach for OA treatment by delivering a potent regenerative molecule directly to inflamed cartilage cells. Our results achieved robust therapeutic effects at low doses. This strategy may pave the way for developing clinically viable disease-modifying osteoarthritis drugs that can halt or reverse disease progression.

ACKNOWLEDGEMENTS: VA Merit Award (1I01RX004283-01A1), UT Research Foundation 2025, and the Medical Student Research Fellowship (MSRF) Program

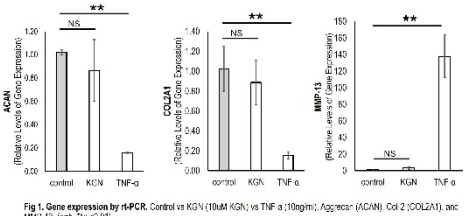


Fig 1. Gene expression by rt-PCR. Control vs KGN (10uM KGN) vs TNF-α (10ng/m); Aggrecan (ACAN), Col 2 (COL2A1), and MMP-13. (n=6, **p <0.01)

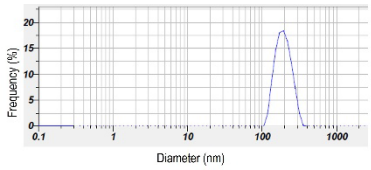


Fig 2. Size distribution by Dynamic Light Scattering (DLS). KGN encapsulated nanosome's diameter is 178.7nm and a polydispersity index (PDI) is 0.023

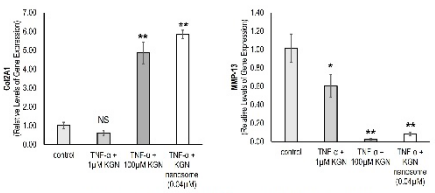


Fig 3. Gene expression by rt-PCR. Control vs 1μM KGN vs 100uM KGN vs 0.04 uM KGN-Nanosomes. All groups were treated with TNF-α (10ng/ml) except normal control group. Gene expression of the Col 2 (COL2A1), and MMP 13, all groups are comparison to control group (n=6, NS: no statistically difference, *p <0.05, **p <0.01)

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Computational modeling of durotactic cell migration

Donghyun Yim[1], Taeyoon Kim[1,*]
[1] Weldon School of Biomedical Engineering, Purdue University, West Lafayette, IN, USA

I. Background

Many types of cells on surfaces can navigate by protruding parts of their membranes in the form of lamellipodia or filopodia. Protrusions are driven mainly by the polymerization of actin filaments at the leading edge of the cell. After protrusion, actin filaments are anchored to the extracellular environment by forming focal adhesions (FAs). Myosin motors try to pull actin filaments toward the rear, resulting in the cell body advancing.

II. Methods

We developed a two-dimensional cell migration model that discretely simulates cell protrusions and FAs (Figure 1A). The protrusions were treated as an element of which equilibrium length increased over time. Note that the direction of new protrusion was restricted around the most extended membrane segment to reproduce cell polarization. Based on the FA displacement by V_{ret}, we calculated FA forces ($\overrightarrow{\boldsymbol{F}_{\mathbf{FA}}}$), which was distributed into a cell body node where a protrusion was attached, and a protrusion tip.

III. Results and Discussion

A. Quantification

We repeated 20 cases by varying the protrusion's maximum number, polarization angle, and lifetime and quantified the entire dataset using the α-value of mean squared displacement and half time at which directionality reduces to 0.5. As protrusions were 1) limited in number, 2) more restrictively polarized, and 3) more persistent, the α-value increased toward 2 and half time increased, which are indicators for ballistic and guided migrations than being random (Figure 1C-D).

B. Chemotaxis

During chemotaxis, a chemoattractant locally turns on its receptor, which in turn activates PI3K. Activated PI3K phosphorylates PIP2 into PIP3 and PIP3 eventually kicks off the WAVE pathway and initiates actin polymerization. As this level is known to be proportional to relative chemoattractant level raised to the third power[1] (Figure 1E), we assumed the protrusion elongation and appearance rates obey this relationship. We then placed cells on either positive, zero, or negative chemical gradients and observed that the sign of gradient determines the collective migratory directions (Figure 1F).

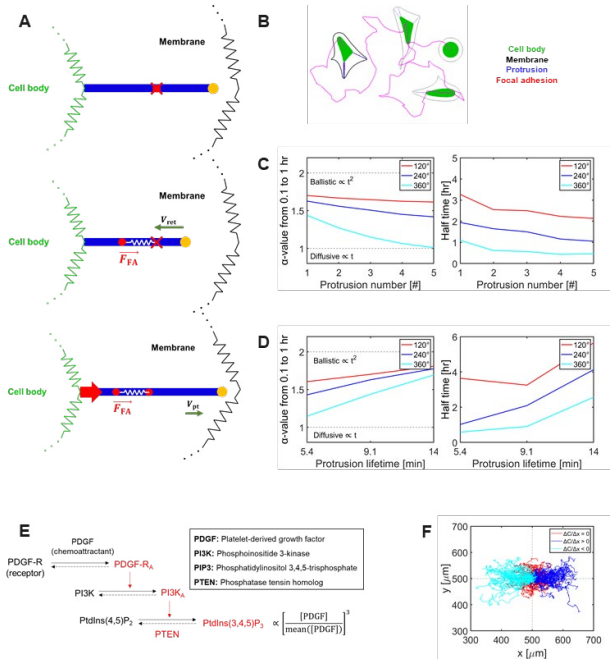


Figure 1. A) Schematics illustrating what enables the cell migration and B) sample run. α-value and half-time analyses in varying C) protrusion number and D) lifetime. E) Chemical reaction chain enabling chemotaxis and F) migratory patterns.

ACKNOWLEDGEMENTS

We gratefully acknowledge the financial support from National Institutes of General Medical Sciences, USA, and Asan Foundation, Republic of Korea.

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Beyond Adhesion: Stress-Dissipating Interface for Soft–Rigid Polymer Integration in Biomedical and Robotic Systems

Yurim Choi[1], Junmin Lee[1]

[1]*Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH)*

I. Introduction

Human-integrated systems increasingly combine compliant and rigid materials to achieve tissue compatibility and functional performance. However, the abrupt modulus mismatch at these interfaces remains a fundamental barrier to long-term reliability, as it localizes stress and drives delamination and fatigue under repeated deformation [1]. Conventional adhesives strengthen the interface but do not eliminate discontinuous stress transfer. Inspired by the graded architecture of natural soft-to-stiff tissue junctions, we developed a pseudo-integrated interphase that transforms a sharp boundary into a stress-dissipating transition zone.

II. Results and Discussion

A. In situ formation of a pseudo-integrated interphase

UV irradiation simultaneously increased the surface tension of the photocrosslinkable elastomer phase and enhanced chain mobility within the rigid polyester, thereby promoting precursor penetration, and three-dimensional interlocking. This pseudo-integrated interphase formed within 5 min under ambient conditions, without chemical pretreatment, toxic reagents, high temperature, or applied pressure.

B. Multiscale gradients across the interface

SEM revealed a continuous interphase without visible gaps, while Raman spectroscopy and nanoindentation confirmed gradual chemical and mechanical transitions. These gradients replaced the sharp soft–rigid boundary with a distributed stress-transfer zone.

C. Enhanced and durable interfacial performance

The integrated interface achieved an interfacial toughness of approximately 110 J m^{-2} and a shear strength of 0.55 MPa. More importantly, it preserved interfacial integrity across a mechanical mismatch exceeding 3,000-fold, after 100 compression cycles, and during bending up to 180° in both air and aqueous environments.

III. Conclusion

This study establishes a distinct interfacial design principle for soft–rigid polymer integration: durable bonding requires not only strong adhesion, but also spatially distributed stress transfer. By combining three-dimensional interlocking with multiscale gradients, the pseudo-integrated interphase overcomes the mechanical discontinuity that limits conventional adhesive interfaces. Its rapid, mild, and tunable formation offers a robust platform for mechanically reliable implantable devices, bioelectronics, engineered tissues, and soft robotic systems.

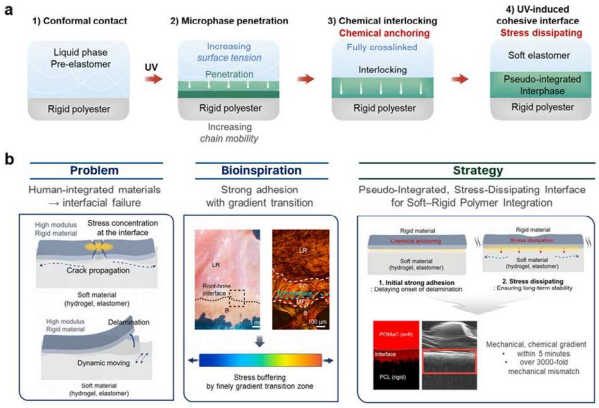


Figure 1: Bioinspired design of a pseudo-integrated, stress-dissipating interphase. a) Engineering mechanism of the interface formation. b) Design rationale of the interfacial strategy.

ACKNOWLEDGEMENTS

This work was supported by the Hyundai Motor Chung Mong-Koo Foundation.

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Gene–Diet Interactions in Alzheimer's Disease: APOE4 Rewires Astrocytic Ketone Metabolism to Drive Amyloid Pathology

Youbin Kim[1], Natalie Suhy[1], Dominic Haworth-Staines[1], Joel Blanchard[1]
[1]Department of Neuroscience and Stem Cell Biology and Regenerative Medicine, Icahn School of Medicine at Mount Sinai, New York, NY, USA

I. BACKGROUND

The apolipoprotein E4 (*APOE4*) allele is the strongest genetic risk factor for late-onset Alzheimer's disease (AD), yet many *APOE4* carriers do not develop the disease, highlighting the influence of additional environmental factors disease risk. Diet has long been recognized to modify AD risk and progression. The ketogenic diet, characterized by high fat and low carbohydrate intake, has shown promise in many neurological disorders. However, clinical data indicate that cognitive improvement occurs primarily in *APOE4* non-carriers, with limited or adverse responses in *APOE4* carriers. Here, we model ketogenic conditions in vitro to investigate the mechanisms underlying gene–diet interactions in AD.

II. METHODS

A. Modeling ketogenic conditions

To model ketogenic conditions in vitro, cells were cultured in 50% SILAC Advanced DMEM/F-12 Flex, 50% Neurobasal-A, 1x N-2, 1x B-27 minus vitamin A, 1x NEAA, and 1x GlutaMAX, supplemented with 20 mM D-glucose (Glucose medium, control) or β-Hydroxybutyrate (Ketogenic medium).

B. Measuring lysosomal proteolytic activity

Isogenic *APOE3/3* and *APOE4/4* astrocytes were differentiated from human iPSCs. Astrocytes were cultured in Glucose or Ketogenic medium for 2 weeks, incubated with 10 ng/ml DQ-BSA, and monitored for 24 h.

C. Inducing amyloid pathology in the iBBB

Isogenic *APOE3/3* and *APOE4/4* brain endothelial cells and pericytes were differentiated from human iPSCs. To assemble 10 ul of iBBB, $1x10^4$ astrocytes, $5x10^4$ brain endothelial cells, and $1x10^4$ pericytes were encapsuled in Geltrex. iBBBs were matured in astrocyte medium supplemented with 20 ng/ml VEGFA for 2 weeks, and in Glucose or Ketogenic medium for 2 weeks. $A\beta_{1-40}$ and $A\beta_{1-42}$ fibrils (20 nM each) were added to 4-week iBBBs for 96 h.

III. RESULTS

Lysosomal proteolysis was significantly reduced in *APOE4/4* astrocytes compared to *APOE3/3* astrocytes, and this impairment was further exacerbated under ketogenic conditions. In a 3D iBBB model, amyloid accumulation was unchanged in *APOE3/3* but increased in *APOE4/4* under ketogenic conditions, recapitulating allele-dependent human responses.

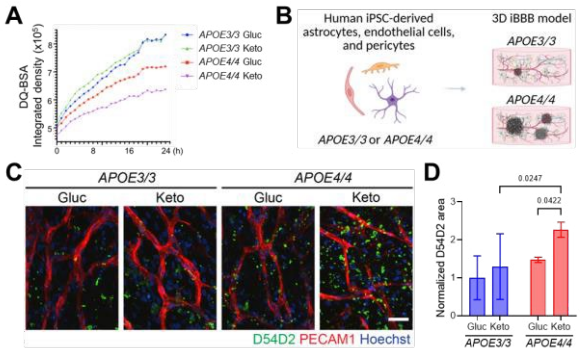


Figure 1: APOE4 alters responses to ketogenic diet.

IV. CONCLUSIONS

This work establishes a platform to model genetic risk and dietary metabolism in AD and supports a pathogenic interaction between *APOE* allele and ketone metabolism.

ACKNOWLEDGEMENTS

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Mitochondrial Dysfunction Induces Asparaginase Resistance in R-Spondin Fusion Colorectal Cancer

Su Hyun Lee[1], Yun-Cheol Chae[1], Alejandro Gutierrez[1]
[1]Department of Oncology, St. Jude Children's Research Hospital; Memphis, Tennessee

I. INTRODUCTION

Asparaginase is an amino acid-depleting therapy widely used in leukemia and increasingly explored for solid tumors such as colon cancer. However, the mechanisms by which colon cancer cells develop resistance to asparaginase remain poorly understood. We previously found that asparaginase has efficacy in R-spondin fusion CRCs because these fusions block upregulation of proteasomal protein degradation, a source of intracellular amino acids, when asparagine is lacking from the environment [1]. Mitochondria contain >1100 proteins, 99% of which are nuclear-encoded, cytoplasmically-synthesized, and then imported into mitochondria [2]. Here we show that mitochondrial protein import system impair enhances protein degradation in R-spondin fusion CRCs. Our findings provide a molecular understanding of how the failure of import of mitochondrial proteins may be an anticipated mechanism of resistance to asparaginase in patients.

II. MATERIALS AND METHODS

A.CRISPR screening

PTPRK-RSPO3 HCT-15 cells were transduced with Human CRISPR Knockout Pooled Library (Brunello) in biologic duplicates, split into treatment with vehicle or asparaginase (500 U/L), and guide RNA representation was assessed after 10 days of treatment.

B. Mitochondria/Cytoplasm fraction assay

Cells were resuspended in Mitochondrial Extraction Buffer and homogenized on ice using a Dounce homogenizer. The homogenate was centrifuged at 1,000 × g for 10 min at 4°C to remove nuclei and debris. The resulting supernatant was further centrifuged at 10,000 × g for 20–30 min at 4°C to separate cytoplasmic and mitochondrial fractions. The supernatant was collected as the cytoplasmic fraction, while the mitochondrial pellet was washed once with ice-cold Mitochondrial Extraction Buffer.

III. RESULS AND DISCUSSION

To anticipate mechanisms of treatment resistance that may emerge, we applied a CRISPR-based genetic screen to identify modifiers of asparaginase response in R-spondin fusion CRC. We found that guide RNAs targeting multiple mitochondria-localized proteins were enriched in asparaginase-treated cells, as these genes comprised 59% of the top 100 "hits" on the screen. This finding suggested that impairing mitochondrial function induces asparaginase resistance, which was surprising because mitochondrial function is required to produce intracellular aspartate, a key substrate for asparagine biosynthesis. Indeed, in R-spondin fusion CRC driven cells, we confirmed that shRNA knockdown of multiple mitochondrial factors, or a pharmacologic inhibitor of mitochondrial translation, each induced asparaginase resistance. We found that induction of mitochondrial dysfunction led to a marked increase in total K48-linked polyubiquitinated proteins, along with cytoplasmic accumulation of multiple nuclear-encoded mitochondria proteins. Our findings support the model that triggering mitochondrial dysfunction impairs mitochondrial import of nuclear-encoded mitochondrial proteins, which are then degraded via the ubiquitin proteasome system.

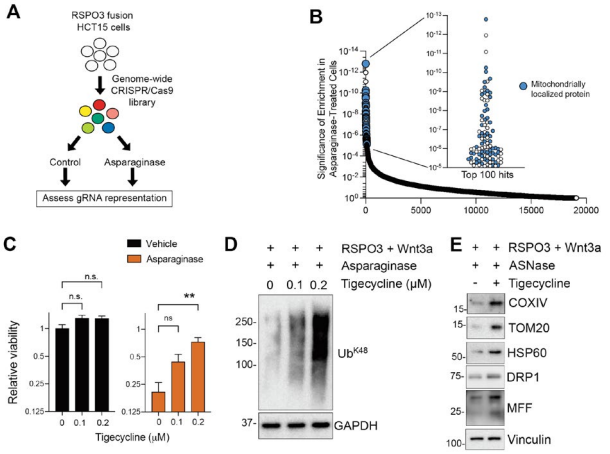


Figure 1 (A) Schematic of the CRISPR-Cas9 screening workflow. (B) Significantly enriched genes in asparaginase vs. vehicle-treated cells was assessed by MAGeCK analysis. (C) Relative viability showed that tigecycline induces asparaginase resistance (**$p < 0.01$) (D) Tigecycline induces polyubiquitination linkage (K48), suggesting that mitochondrial dysfunction leads to enhanced proteasomal degradation. (E) Mitochondrial proteins accumulated upon tigecycline treatment in the cytoplasm fraction

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A Rat Glioma Spheroid-Neural Cell Tri-Culture Model to Investigate Cellular Crosstalk in Glioma Pathology

Testaverde Sangwoo Kim[1], Erkin Şeker[2]
Departments of [1]Biomedical Engineering, [2]Electrical and Computer Engineering

Summary. Glioblastoma is one of the most lethal primary brain tumors in adults, characterized by diffuse cellular infiltration into the brain parenchyma and high recurrence rates. Although glioblastoma progression has traditionally been attributed to tumor-intrinsic mechanisms, increasing evidence highlights the critical role of crosstalk between tumor cells and surrounding neural and immune cells in driving disease pathology. However, most in vitro models fail to recapitulate this multicellular complexity due to the challenges of maintaining multiple interacting cell types under physiologically-relevant conditions. To address this gap, we developed cell culture models termed Glioma-Co-Culture and Glioma–Tri-Culture, in which a C6 rat glioma spheroid is integrated with primary rat neurons, astrocytes, with or without microglia under serum-free conditions (**Figure 1**). This platform enables the investigation of glioma pathology within a multicellular neural–immune tumor context. Using this model, we examined how tumor–microglia interactions regulate glioma spheroid growth and invasion, as well as microglial proliferation and morphological changes.

Materials & Methods. Tri-cultures were established from dissociated neonatal rat cortical cells maintained under the specific growth medium, consisting of IL-34, TGF-β, and cholesterol that are essential for microglial survival and function. GFP-expressing C6 glioma spheroids were generated using agarose-coated plates and integrated into mature tri-cultures at DIV7 to establish the glioma–tri-culture model. Tumor growth and invasion were monitored over 14 days. The cultures were then chemically fixed and immunostained to assess microglial proliferation and morphological evolution of cells.

Results. In the presence of microglia, glioma spheroids exhibited greater spreading toward the cortical area, whereas no significant difference was observed in the extent of spheroid growth. On the other hand, a higher number of microglia was observed in the Glioma–Tri-Culture than in the control without a glioma spheroid. Moreover, we observed that microglia numbers were higher in the vicinity of the glioma spheroid, and these cells exhibited more ramification compared to microglia distal to the spheroid. Altogether, these findings indicate the impacts of crosstalk among tumor and non-tumor cells.

Future directions. Beyond tumor–microglia interactions, this platform provides an additional unique opportunity to interrogate glioma–neuron signaling within a physiologically-relevant multicellular environment, thereby addressing the pathology in the context of the neuro-immune-tumor axis. Future work will investigate neuronal activity-dependent tumor modulation and tumor-induced neuronal remodeling to further define the integrated tumor–neural–immune axis.

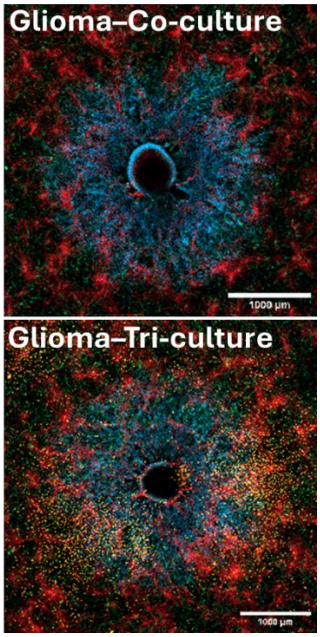


Figure 1. Representative fluorescent images of Rat Glioma–Co-Culture (top panel) which consists of three major cellular types, glioma cells, neuron and astrocytes and Glioma–Tri-Culture (bottom panel) which includes additional microglia. Immunostaining was conducted to specifically identify the cell types in the models where beta-tubulin III for neurons (red), GFAP for astrocytes (green) and glioma cells, Iba1 for microglia (yellow), and DAPI for nuclei (blue).

Rootin: A Mobile Symptom Tracking and Self-Care App for Women with Breast Cancer on Aromatase Inhibitors

Soyeon Lee, BFA[1], Heejoo Kim, MFA[1], Gee Su Yang, PhD[2]
[1]University of Connecticut School of Fine Arts, [2]University of Connecticut School of Nursing

I. SUMMARY

Breast cancer is a major public health burden in the U.S. With advances in treatment, the 5-year survival rate is 90%, resulting in over 4 million breast cancer survivors (BCS).[1] Over 70% of these women have hormone receptor-positive breast cancer that is treated with aromatase inhibitors (AIs), which prevent recurrence by lowering circulating estrogen levels. However, AI therapy is associated with persistent side effects, including musculoskeletal pain, hot flashes, and insomnia, which negatively impact quality of life and daily activities.[2] Up to 50% of survivors discontinue or demonstrate non-adherence due to these side effects, highlighting the need for improved long-term symptom management.

With the increasing use of web-enabled devices such as smartphones, the healthcare community can leverage these technologies to engage patients and improve health outcomes and care quality. Existing healthcare applications on AI therapy primarily focus on clinical functions and often lack emotionally supportive, user-centered design tailored to survivors receiving AIs.

II. METHODS

A. Objective

This study aims to (1) develop a prototype mobile symptom-tracking application with an emotionally supportive, user-centered design and (2) evaluate its usability, engagement, and emotional experience.

B. Procedure

The study consists of two components: prototype mobile application (*Rootin*) development and usability evaluation. The *Rootin* prototype was developed using React and Vite. It integrated validated questionnaires on insomnia, joint pain, cardiovascular disease risk, hot flashes, and physical activity, and demographic information (e.g., ISI, WOMAC, PHQ-4, Godin leisure time exercise questionnaire), educational contents, and self-management guidance. A plant-based growth metaphor was implemented as a core design strategy, representing each user as a growing plant (seed → sprout → bloom → thrive) to support emotional engagement and reflection. This approach differentiates *Rootin* from conventional healthcare applications by emphasizing growth, restoration, and daily awareness.

The prototype will be evaluated through remote usability testing with approximately 10 BCS taking AI therapy, assessing usability, engagement, and emotional response through guided tasks and semi-structured interviews.

C. Expected Outcomes

This study develops and evaluates a near-production mobile prototype, assessing usability, engagement, and emotionally supportive design. Findings will inform future development toward real-world implementation.

III. ILLUSTRATIONS

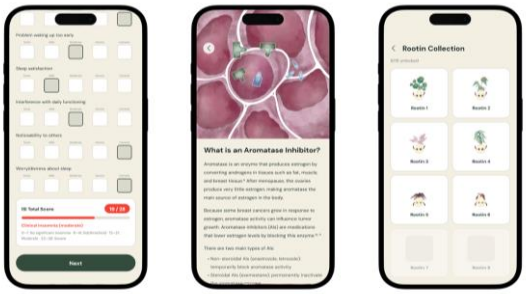


Figure 1. Screenshots of the Rootin prototype: (A) Symptom questionnaire, (B) Informational content page, (C) Plant-based symptom tracking.

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Dual-Responsive Gelatin Microspheres for Ultrasound-Regulated Enzyme-Mediated Drug Release in Cancer Therapy

Yuri Kang[1], Jinhee Yoo[2], Hyungham Kim[1]
[1]Pohang University of Science and Technology, [2]Bringham Women's Hospital, Harvard University

I. Abstract

Gelatin microspheres (GMSs) are widely used as drug carriers due to their biocompatibility, biodegradability, and high loading capacity [1]. However, drug release relies on slow enzymatic degradation, limiting temporal control [2]. To address this, we combined ultrasound with collagenase to enhance release and enable spatiotemporal regulation. We developed ultrasound-mediated doxorubicin-loaded GMSs (UD-GMSs) with stimulus-responsive release. Ultrasound increased enzyme-driven degradation by 37% and DOX release by 3.35-fold versus enzyme alone, indicating cavitation-driven acceleration. In 3D 4T1 spheroids, combined treatment reduced viability to 51.68%, demonstrating externally controlled drug delivery.

II. Method

UD-GMSs were prepared via water-in-oil emulsification, crosslinking, and doxorubicin loading. Collagenase was used to degrade the gelatin matrix. Samples were treated under four conditions: control (Ctrl), ultrasound (US), enzyme (Enz), and US+Enz. Gelatin degradation and drug release were quantified by monitoring changes in the absorbance of the supernatant. For efficacy, 4T1 spheroids were treated under identical conditions, and viability was assessed using Calcein-AM and EthD-1 fluorescence.

III. Result

Ultrasound and collagenase synergistically increased gelatin degradation and DOX release, while Ctrl and US alone showed minimal effects. Enz increased gelatin dissolution and DOX release, and US+Enz further enhanced degradation by 37% and DOX release by 3.35-fold (Fig. A, B). Increasing the duty factor from 10% to 50% reduced DOX release by 61%, supporting a cavitation-dominant mechanism (Fig.C). In 3D spheroids, UD-GMSs with collagenase reduced viability to 66.06%, and ultrasound further decreased it to 51.68%, with strong EthD-1 signals throughout the spheroid (Fig. D, E).

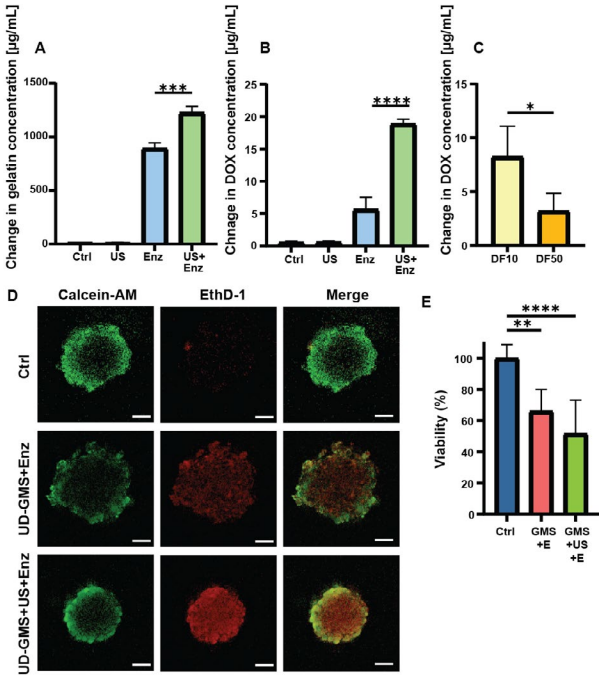


Figure. (A–B) Gelatin degradation and DOX release from UD-GMSs under Ctrl, US, Enz, and US+Enz conditions. (C) Effect of ultrasound duty factor (DF10 vs. DF50) on DOX release. (D) Confocal live/dead images of 4T1 spheroids (Calcein-AM, EthD-1). (E) Quantified spheroid viability. Scale bars: 50 μm. Data are mean ± S.D. (n = 3).

IV. Conclusion

We developed a dual-trigger UD-GMS platform enabling enzyme-primed, ultrasound-enhanced drug release. Cavitation-assisted degradation improved penetration and cytotoxicity in 3D tumors, providing a programmable strategy for controlled chemotherapy delivery with potential for in vivo translation.

ACKNOWLEDGEMENTS

This work was supported by Hyundai Motor Chung Mong-Koo Foundation.

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Flexible, Three-Dimensional Electronic Framework for Electromechanical Monitoring in Engineered Heart Tissues

Hayeon Yun[1, 2], Yong-Woo Kang[2], Sam Gauthier[2], Vittoria Sama[1, 2], Clara Asseily[1, 2], Ruhani Sachdeva[1, 2], Lydia Ding[1, 2], Ivana A. Chychula[5], Dominic E. Fullenkamp[5], John A. Rogers[1, 2, 3, 4]

[1] Department of Biomedical Engineering, Northwestern University, Evanston, IL 60208 USA
[2] Querrey Simpson Institute for Bioelectronics, Northwestern University, Evanston, IL 60208 USA
[3] Department of Materials Science and Engineering, Northwestern University, Evanston, IL, 60208, USA
[4] Department of Neurological Surgery, Northwestern University, Chicago, IL, 60611, USA
[5]Center for Genetic Medicine, Bluhm Cardiovascular Institute, Northwestern University Feinberg School of Medicine, Chicago, IL 60611, USA.

I. BACKGROUND

Cardiac research has relied on animal models, but species differences limit translation to human.[1] hiPSC-CM models address this limitation by using human cells to model disease and test drug responses.[2] The field has also moved towards 3D engineered heart tissues (EHTs), which better support tissue alignment, cardiomyocyte maturation, mechanical loading, and contractile function.[2] Recent work integrated flexible 3D electronics with EHTs for simultaneous electrical and mechanical monitoring.[3] Building on this platform, this project adds magnetic actuation to apply controlled mechanical stretch, which enables the system to better mimic cardiac mechanical loading and study disease-related responses to mechanical stress.

II. METHODS

Soft, mesoscale electronic devices were fabricated on 4-inch silicon wafers using microfabrication techniques and transformed into 3D structures by compressive buckling. Pt black was electroplated onto the electrodes, and electrode impedance was measured. After micromagnets were attached, ring-shaped EHTs were mounted onto the 3D framework. Voltage applied to the electromagnet actuated the micromagnets to apply controlled stretch to the tissue. Electrical and mechanical responses were then recorded under baseline and stretched conditions to assess stretch-induced changes in beating behavior, contraction, and arrhythmia susceptibility.

III. RESULTS AND DISCUSSION

Baseline recording showed time-aligned spikes and strain gauge signals, indicating synchronized electrophysiological and mechanical activity in healthy EHTs. Under stretch, both BPM and active contraction amplitude increased. Across five devices actuated from 0 to 15 V at 0.5 Hz, the tissue diameter increased from 9.70 $\pm$ 0.30 mm at 0V to 10.69 $\pm$ 0.57 mm at 15 V, corresponding to 10.19 $\pm$ 1.72% stretch. These results show that magnetic actuation can apply controlled stretch to EHTs and record stretch-induced electrical and mechanical responses in healthy cells. Future studies will test the platform using disease cell lines, such as FLNC and LMNA, to evaluate disease-related responses to mechanical stress and arrhythmia susceptibility.

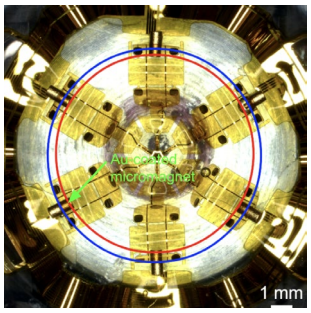


Figure 1: EHT device under electromagnetic actuation. (Red: tissue diameter at 0 V; blue: tissue diameter at 15 V.)

ACKNOWLEDGEMENTS

This work made use of the NUFAB facility of Northwestern University's NUANCE Center.

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Soft Wearable BW-NIRS for Monitoring Sleep-Dependent Brain Water Dynamics

Seunghyeb Ban[1], W. Hong Yeo, PhD[1]
[1] Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, USA

I. SUMMARY

Sleep plays a critical role in brain health and glymphatic function, but continuous monitoring of cerebrospinal fluid (CSF)-related brain water dynamics during natural sleep remains challenging. Here, we present a soft wireless brain-water near-infrared spectroscopy (BW-NIRS) system for long-term monitoring of sleep-stage–dependent brain water dynamics. Monte Carlo simulations validated sensitivity to deep brain regions, while overnight recordings showed increased $\Delta[H_2O]$ during NREM transitions and decreased $\Delta[H_2O]$ during REM transitions. These findings demonstrate the feasibility of wearable BW-NIRS for noninvasive monitoring of sleep-related brain fluid dynamics.

II. METHODS

The BW-NIRS system incorporates 640, 680, and 950 nm LEDs with a photodetector in a soft forehead-mounted platform. Brain water changes ($\Delta[H_2O]$) were estimated using the modified Beer–Lambert law (MBLL) with wavelength-dependent extinction coefficients for HbO, HbR, and H_2O. Monte Carlo photon transport simulations were performed using a five-layer head model consisting of skin, skull, CSF, gray matter, and white matter to evaluate photon sensitivity and optimize source–detector separation. Simulations confirmed sensitivity extending beneath superficial tissues into cortical regions below the CSF layer. Overnight sleep recordings were analyzed using multitaper spectrogram methods and hybrid EEG/EOG-based sleep staging algorithms to evaluate sleep-stage–dependent brain water dynamics (1).

III. RESULTS

Monte Carlo simulations demonstrated depth-dependent photon propagation capable of sampling cortical tissue beneath the CSF layer at a 30 mm source–detector separation. Physiological validation using exercise/rest and breath-holding paradigms showed stable and reproducible $\Delta[H_2O]$ responses associated with cerebrovascular and intracranial fluid redistribution. Overnight recordings revealed clear sleep-stage–dependent modulation of brain water dynamics. Specifically, cumulative $\Delta[H_2O]$ increased during transitions into NREM sleep and decreased during transitions into REM sleep across overnight recordings. Power spectral analysis additionally identified ultra-slow oscillatory components during NREM sleep with minimal HbO/HbR crosstalk, supporting signal specificity. These findings demonstrate the capability of BW-NIRS for continuous, noninvasive monitoring of sleep-related brain water dynamics in natural environments (2).

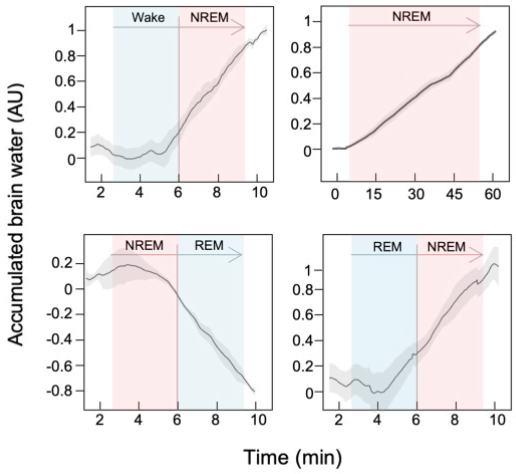


Figure 1: Transition-dependent accumulated brain water changes

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A 3D Brain Geometry Toolkit for Scalable Multisite Vertex-wise Brain Morphometry Analysis

Yanghee Im[1], Melody J.Y. Kang[1], Elizabeth Haddad[1], Neda Jahanshad[1], Paul M. Thompson[1], Christopher R.K. Ching[1]

[1]Imaging Genetics Center, Mark and Mary Stevens Neuroimaging & Informatics Institute, Keck School of Medicine, University of Southern California, Marina del Rey, CA 90292, USA

I. BACKGROUND

Bipolar disorder (BD) and major depressive disorder (MDD) are associated with subtle and partially overlapping alterations in brain structure, such as smaller hippocampal and amygdala volumes. Vertex-wise brain shape analysis can reveal detailed local morphometric variations associated with neurological and psychiatric disorders. Here we present a toolkit for 3D brain geometry analysis which addresses key challenges facing large-scale neuroimaging studies (Figure 1A). Our framework incorporates scalable methods for multisite data integration, site-specific confound correction, accelerated statistical modeling, interpretable machine learning, and interactive results visualization [1]. Here we focus on accelerated statistical analyses using data from UK Biobank (N=34,515).

II. METHODS

3D T1-weighted brain MRI scans from UK Biobank (ICD-10 diagnosis of MDD=1,448, BD=89, HC=32,978; ages 44.6 - 82.8, F 53%) were analyzed to derive (1) gross subcortical volumes (FreeSurfer v7.1.1.) [2] and (2) two vertex-wise shape features (local thickness and surface dilation/contraction) from 27,120 of vertices across 14 subcortical structures. Linear regression models were used to compare MDD, BD, BD+MDD (combined mood disorder), and healthy controls (HC), adjusting all results for multiple comparisons. The fast and efficient mixed-effects algorithm (FEMA) [3] was used to compare compute time to traditional linear models (*fitlm)*.

III. RESULTS

Shape analysis revealed complex differences between psychiatric groups, including differentially thicker/thinner and dilated/contracted subregions across all regions in those with BD or MDD. BD+MDD shape alterations were primarily driven by the larger MDD sample (Figure 1B). FEMA resulted in a 5 times acceleration in model fitting compared to the traditional approaches.

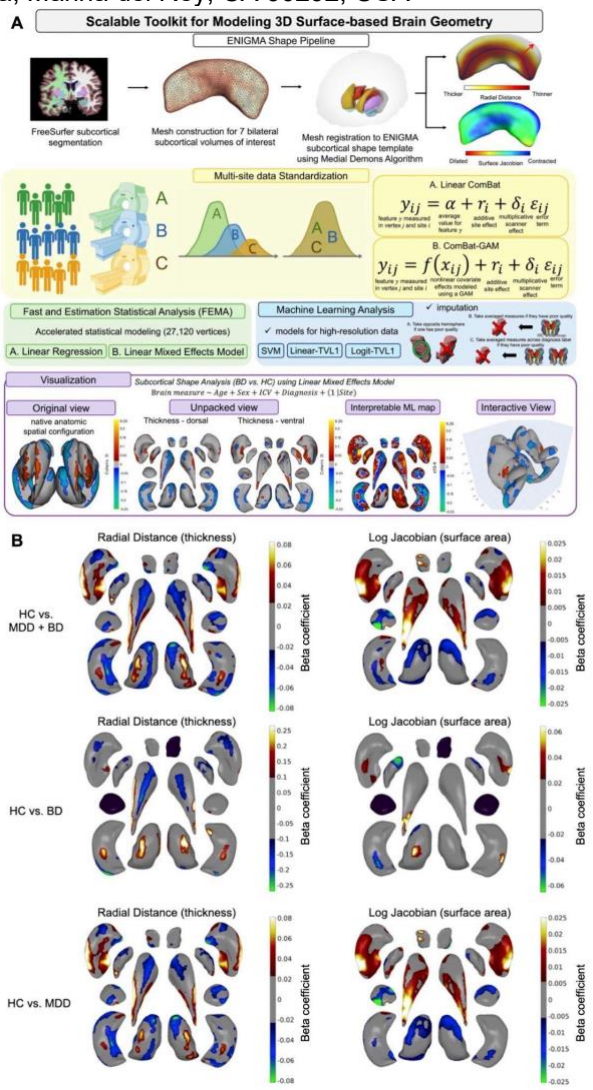


Figure 1A - Overview of Python-based 3D brain geometry toolkit. 1B - Beta coefficients from shape analysis adjusting for age, sex and ICV, plotted in regions passing FDR correction for multiple comparisons.

ACKNOWLEDGEMENTS

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A Nanoemulsion-Based TLR7/8 Adjuvant Platform for Coordinated Immune Activation Against Diverse Viral Threats

JuA Song[1], Yeon Jeong Yoo[1], Suhyeon Kim[1], Asha Wickramasinghe[2], Jaemoo Kim[3], Young-Il Kim[3], Juryeon Gil[3], Young-Woock Noh[4], Min-Ho Lee[4], Sang-Seok Oh[4], Myeong-Mi Lee[4], Yebin Seong[2], Jong-Soo Lee[2], Young Ki Choi[3], Yong Taik Lim[1]

[1]SKKU Advanced Institute of Nano Technology, Sungkyunkwan University, Suwon, Republic of Korea, [2]College of Veterinary Medicine, Chungnam National University, Daejeon, Republic of Korea, [3]Center for Study of Emerging and Re-emerging Viruses, Korea Virus Research Institute, Institute for Basic Science (IBS), Daejeon, Republic of Korea, [4]New Drug Development Center, Osong Medical Innovation Foundation, Cheongju, Republic of Korea

I. SUMMARY

SE(Trojan-TLR7/8a) is a nanoemulsion-based adjuvant platform that enables coordinated immune activation across multiple biological scales, leading to strong, durable, and cross-protective antiviral immunity with improved safety.

II. MULTISCALE IMMUNE ENGINEERING STRATEGY USING SE(Trojan-TLR7/8a)

A. Rationale and Design of SE(Trojan-TLR7/8a)

SE(Trojan-TLR7/8a) was designed to generate broad and long-lasting protection against rapidly evolving viruses. The system combines a squalene-based nanoemulsion for efficient antigen delivery with a modified TLR7/8 agonist that enables controlled immune activation. This design allows simultaneous regulation at the tissue and cellular levels, enhancing immune priming while minimizing excessive systemic inflammation.

B. Mechanism of Action and Immunological Programming

Following administration, the nanoemulsified SE(Trojan-TLR7/8a) facilitates efficient transport of antigen and adjuvant to lymph nodes. The Trojan-formulated TLR7/8 agonist promotes sustained activation of antigen-presenting cells while preventing premature exhaustion.

C. Preclinical Efficacy and Combinatorial Potential

The platform provided effective protection against diverse influenza strains and SARS-CoV-2 variants and maintained robust T cell immunity in aged animal models. Its consistent performance across different viral challenges highlights its potential as a versatile vaccine strategy for both pandemic and endemic diseases.

III. ILLUSTRATIONS

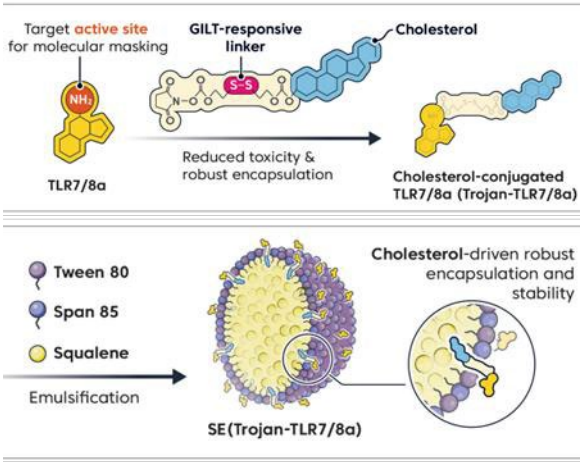


Figure 1: Synthesis process of SE(Trojan-TLR7/8a)

ACKNOWLEDGEMENTS

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This work was supported by Hyundai Motor Chung Mong-Koo Foundation.

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Integrated spatial multi-omics identifies TRPS1 as a regulator of joint cell fate linking cartilage development to osteoarthritis

Ji-Hye Yea[1*], Sharon Onggo[1*], Suhani Dewagan[1], Kaiwen Chen[1], Kaily Young[1], Patrick Cahan[1]
[1]Johns Hopkins University, Baltimore, MD, * indicates equal contribution.
Jyea2@jh.edu

INTRODUCTION

Synovial joints enable movement and are composed of multiple specialized tissues. During early limb development, chondroprogenitors (CPs) at the future joint site downregulate Col2a1 and Sox9 to form the interzone (IZ), a transient structure marked by Gdf5 at E12.5. These IZ cells give rise to joint components, but the molecular mechanisms regulating their fate remain unclear.

METHODS

To identify regulators of IZ formation, we performed scRNA-seq on mouse hindlimbs (E11.5–E14.5) after removing hematopoietic and erythroid cells. Spatial transcriptomics (Slide-seq) was used to map gene expression, and IZ-enriched genes at E12.5 were screened. Candidate gene expression was validated by in situ hybridization. Functional analysis was conducted using siRNA-mediated knockdown of Trps1 in E12.5 limb explants from Sox9-GFP mice, followed by assessment of joint formation, gene expression, and cartilage development.

RESULTS

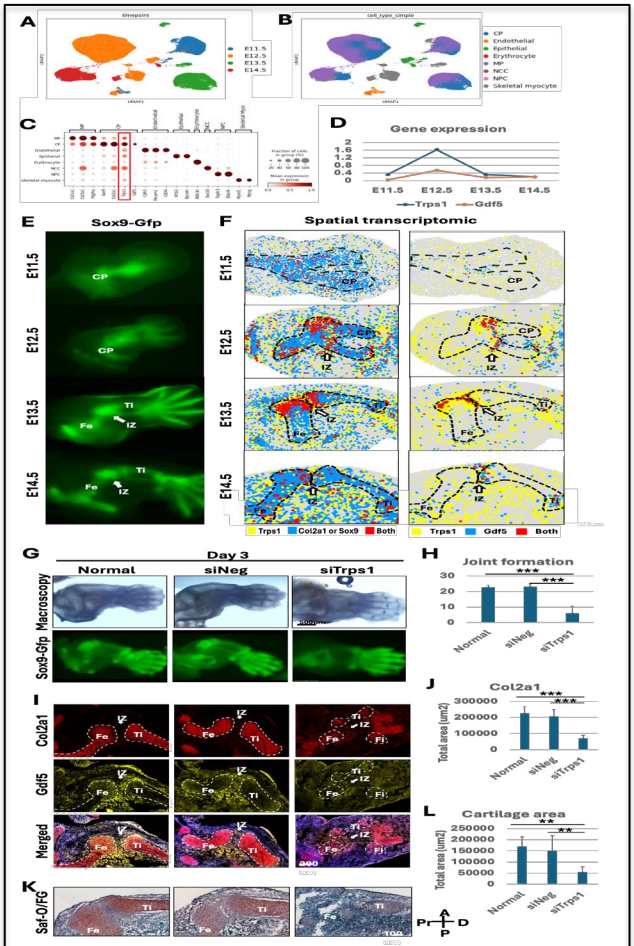
scRNA-seq showed that Trps1 is highly expressed in CPs, with peak expression at E12.5. Spatial analysis revealed that Trps1 localizes to the IZ and colocalizes with Sox9, Col2a1, and Gdf5, suggesting a role in early joint development. In explant cultures, siTrps1 effectively reduced Trps1 expression. By Day 3, control groups formed clear joint structures, whereas the siTrps1 group showed impaired joint formation, reduced Sox9-GFP signal, and disrupted cartilage patterning. Col2a1 expression and cartilage matrix formation were also significantly decreased.

DISCUSSION

These findings identify Trps1 as an IZ-enriched gene required for proper joint formation. A limitation is that functional validation was performed ex vivo, and in vivo studies are needed.

SIGNIFICANCE

Understanding regulators of IZ cell fate, such as Trps1, provides insight into joint development and may inform therapeutic strategies for degenerative joint diseases like osteoarthritis.



Trps1 controls interzone formation and joint development.
(A–F) Single-cell and spatial analyses showing Trps1 expression in the IZ during limb development.
(G–L) Trps1 knockdown impairs joint formation and cartilage development in explants.

ACKNOWLEDGEMENTS

N/A

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Energy / Materials / Resources

Atmospheric Pressure Plasma Deposition for High-Performance PVDF-Based Piezoelectric Nanogenerator

Choon-Sang Park[1], Eun-Young Jung[2], and Heung-Sik Tae[2]
[1]Department of Electrical Engineering, Milligan University, USA
[2]Shcool of Electronic and Electrical Engineering, Kyungpook National University, South Korea,

I. SUMMARY

This work investigates the structrure and dielectric properties of poly(vinylidene fluoride) (PVDF) films for piezoelectric nanogenerators (PENGs) that is grown by atmospheric pressure plasma (APP) process. The fabricated PENGs exhibit an open-circuit voltage that increases from 4.92 to 10.3 V_{pp} with plasma processing time under periodic mechanical impact.

II. METHODS

Figure 1 shows the schematic diagram, a photo of the fabricated APP reactor, and the complete experimental setup used in this study. The APP reactor is a dielectric barrier discharge (DBD) configuration operated with floating ground. The discharge region consisted of a cylindrical glass guide tube (length 80 mm, outer diameter 34 mm) that housed a copper high-voltage electrode covered by a glass dielectric. The counter-electrode (the sample/copper substrate) was electrically floating. The substrate rested on a polytetrafluoroethylene (bluff-body) stand mounted on an electronic rotator to promote uniform exposure. The electrode–substrate separation defined the discharge gap and was adjusted within the reactor chamber to generate an intense, broadened glow-like discharge suitable for precursor fragmentation and film growth. Two argon streams were used and controlled independently. Main Ar flow (ranging from 1000 to 2500 sccm) was used to sustain the plasma discharge, setting the residence time, ambient entrainment, and discharge length. In parallel, a separate Ar stream of 500 sccm was bubbled through the PVDF/DMF solution to introduce vapor into the discharge/near-substrate region. The two streams were mixed at the gas-feeding tube, which feeds into the discharge zone; decoupling them allowed independent tuning of hydrodynamics and precursor supply during deposition

III. RESULTS

Currently, the developments tendency of piezoelectric nanogenerator, will be portable and stretchable electronic devices with light weight [1]. From this point of view, the PVDF and its copolymers have good attractive attention in field of piezoelectric nanogenerator device due to their advantages such as mechanical flexibility, lightweight, piezoelectricity, dielectric property, thermal stability, and high chemical resistance, and good biocompatibility [1,2]. Accordingly, we investigated the structure and dielectric properties of the deposited PVDF thin film by APP process. In summary, we examined the structural and dielectric characteristics of PVDF films by APP process. After plasma deposition, in FT-IR result, the plasma-deposited films show mostly two crystalline phases (α and β phases), which represents the peaks at 1288 and 1400 cm^{-1} for β-phase and the peaks at 765 and 975 cm^{-1} for α-phase, respectively. Based on the experimental results, these two peaks contributed to the enhancement in the dielectric coefficient of PVDF thin film.

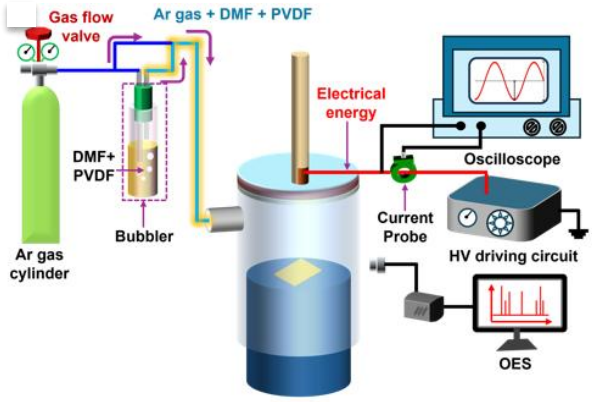


Figure 1: Schematic of the APP reactor and experimental setup.

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Highly Efficient Triboelectric Nanogenerator Based on Low Impedance and High Charge Density through Multi-Layer Design

Jin-Kyeom Kim[1]

[1]Department of Materials Science and Engineering, University of Wisconsin-Madison, Madison, WI, 53706, USA

I. SUMMARY

This presents an overview of triboelectric nanogenerators (TENGs), highlighting development, significance, and potential applications. It explains the triboelectric effect and various charge transfer mechanisms essential for understanding contact electrification processes.

I introduced a new cationic material structure and assembly of multi-layered TENGs in improving output performance and stability. The resulting TENG with MoS_2/SiO_2/Ni-mesh produced 13 times higher output power and lower impedance compared to a control Ni-mesh-based TENGs. The enhanced output power is attributed to a high charge density (1,072 μC/m^2) created through contact electrification. This high charge density is due to efficient charge transfer by the low work function of MoS2, charge migration facilitated by an electric field, and high charge storage capability of SiO_2. Synchrotron radiation photoemission spectroscopy indicated that the energy band at the MoS_2–SiO_2 surface was bent upward, creating an electric field that drives charge migration. Our TENGs demonstrated excellent charge retention and produced an average output power of about 14.75 W/m^2 in gear-cam mode.

I introduced the development of highly dispersible core-shell hybrids (P2VP@$BaTiO_3$) for use in triboelectric nanogenerators (TENGs), form high-quality uniform films that maximize dielectric constants. It exhibits excellent device stability, maintaining nearly 100% of maximum output voltage for 54,000 cycles and 68.7% voltage retention at 99% humidity. Additionally, incorporating a MoS_2/SiO_2/Ni-mesh layer into the double-layer TENG achieves an ultrahigh charge density of up to 1,228 μC/m^2, the highest reported for TENGs. I also demonstrated a near-field communication-based sensing system for CO_2 monitoring using the developed self-powered generator with enhanced output and robustness.

These advancements contribute to the development of sustainable energy technologies capable of supporting the global transition to carbon neutrality.

II. ILLUSTRATIONS

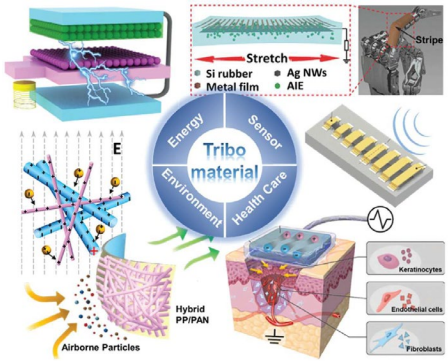


Figure 1: Future energy harvesting and self-powered sensors with advanced materials.

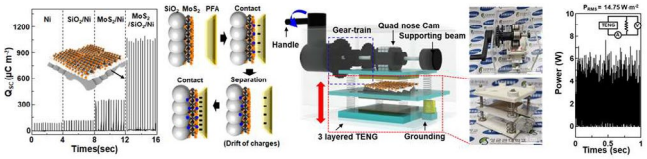


Figure 2: Improving Charge Transport Efficiency through Material Synthesis and Development.

ACKNOWLEDGEMENTS

I was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (RS-2024-00354872).

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Entanglements in Polymer Networks: A New Pathway for Soft Material Design

Junsoo Kim
Department of Mechanical Engineering, Northwestern University

I. Summary

The fracture resistance of soft materials is tightly coupled to the topology of polymer networks (**Figure 1**) [1, 2]. Achieving control over this topology is therefore central to advancing the design of soft materials. In this talk, I will present two approaches for designing the topology and discuss their effects on the mechanical properties of the networks [3].

II. Approach

A. Initiation rate

We tune the initiation rate during polymerization to control the entanglement formation. By lowering UV intensity, polymer chains grow more gradually in the presence of existing chains, promoting the formation of trapped entanglements. To study this effect, we use a polyacrylamide hydrogel system as a model material, and fix precursor stoichiometry to ensure that chain length and total entanglement density remain constant. The initiation rate is controlled via UV intensity and validated through heat-flux measurements. We measure the equilibrium swelling ratio to distinguish trapped from transient entanglements. The role of entanglements in mechanical properties is studied using rheology, uniaxial tension, and pure shear tests.

B. Ultrasound

We apply focused ultrasound during polymerization to induce stable acoustic cavitation and control the entanglement formation. Under controlled acoustic conditions, microscopic bubbles oscillate without collapsing, generating localized micro-acoustic streaming flows in the surrounding solution. These flows kinetically agitate polymer chains, promoting entanglement formation. As polymer chains crosslink, the enhanced chain entanglements become trapped within the network.

III. Results

Our study demonstrates that polymerization kinetics, specifically the initiation rate and ultrasound, can control the fraction of trapped entanglements in polymer networks without altering precursor stoichiometry. Slower initiation promotes the formation of more trapped entanglements, leading to reduced swelling and enhanced mechanical properties such as stiffness, strength, and toughness. Ultrasound from entanglement beyond thermodynamic equilibrium, overcoming the thermodynamic limit in entanglement density. This work establishes a new kinetic pathway for tailoring network topology and expanding the design space of polymer materials for improved performance.

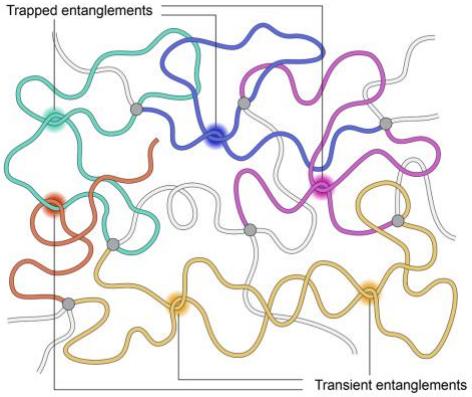


Figure 1: Trapped and transient entanglements in a polymer network.

Acknowledgements

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Vapor Pressure Suppression of Hydrocarbons under Nanoconfinement Revealed by Differential Scanning Calorimetry

Hyeyoung Cho[1], Taylor Jordan[2], Michael Bartl[3], Milind Deo[2]
[1]Department of Biology, Chemistry, and Chemical Engineering, Florida Polytechnic University
[2]Department of Chemical Engineering, University of Utah
[3]Department of Chemistry, University of Utah

I. INTRODUCTION

Hydrocarbons confined in nanoporous materials can behave quite differently from bulk fluids, especially in terms of phase transitions [1,2]. This becomes important in systems such as tight-oil reservoirs, where a large fraction of fluids exists within nanoscale pores. However, experimental data directly probing these effects are still limited.

In this work, we use differential scanning calorimetry (DSC) to look at how confinement influences the boiling behavior of simple hydrocarbons.

II. METHODS

Mesoporous silica (SBA-15, ~4 nm pore size) was used as a model system to represent nanoscale confinement. Heptane and toluene were introduced into the pores, and bulk samples were also prepared for comparison.

DSC measurements were carried out at 101, 700, and 1300 kPa. The same experimental conditions were used for both bulk and confined systems.

III. RESULTS AND DISCUSSION

The DSC results show noticeable differences between bulk and confined hydrocarbons. In particular, the phase transition peaks shift to higher temperatures when the fluids are confined, which suggests a suppression of vapor pressure.

This trend is observed across all pressures tested. While the magnitude of the shift varies, the overall behavior remains consistent. These results indicate that confinement effects are not negligible, even under elevated pressure conditions.

Rather than following bulk thermodynamic expectations, the confined systems show systematic deviations, which could have implications for understanding fluid behavior in nanoporous environments.

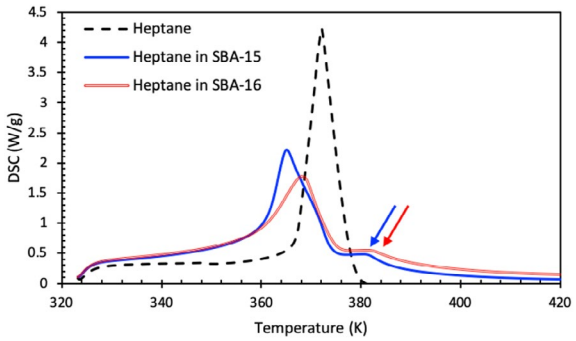


Figure 1: DSC curves of bulk and confined heptane

IV. CONCLUSION

The DSC measurements presented here show that nanoscale confinement affects hydrocarbon phase behavior in a measurable way. Even in relatively simple systems, the differences from bulk behavior are clear.

Further work will focus on expanding the dataset and exploring different pore structures and fluid systems.

ACKNOWLEDGEMENTS

This work was supported by the EFRC-MUSE, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Basic Energy Sciences under Award #DE-SC0019285. The author acknowledges Florida Polytechnic University for conference travel support.

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Thermal Management Technologies for High-Thermal-Load Systems: Applications in Data Centers and Re-Entry Spacecraft

Tae Young Kim, Taeho Choi, Junhyeon Bae, Chanwoo Park, Hae Chan Lim, Hae Min Choi
Dept. of Mechanical Engineering, Seoul National Univ. of Science and Technology, Seoul, Korea

I. Thermal challenges in engineering applications

Thermal management has emerged as a critical engineering challenge in modern high-thermal-load systems, where conventional cooling approaches are inadequate to ensure stable and reliable operation in systems such as data centers and aerospace applications. In data centers, high-power-density AI accelerators generate significant thermal loads due to concentrated chip-level power density, necessitating advanced cooling technologies to suppress hotspot formation and maintain device reliability. In aerospace applications, reusable spacecraft experience severe thermal loading near the stagnation region during atmospheric reentry, requiring active thermal protection to regulate wall temperature and ensure structural durability under repeated thermal cycling.

II. Advanced thermal management strategies

A. Hybrid cooling technology for AI accelerators

Targeting the persistent bottleneck of spatially non-uniform heat generation in high-power electronics, we present a hybrid cold plate integrating jet impingement and parallel-flow cooling within a unified architecture to enhance heat transfer performance as well as flow uniformity. The proposed design features a two-floor architecture including jet holes, sweep slots, and an optimized-fin structure, which collectively enable localized high-intensity cooling at the central high-heat-flux region while facilitating uniform parallel-flow heat removal across peripheral areas.

B. Transpiration cooling for active thermal protection

Transpiration cooling protects surfaces by driving coolant through a porous wall, during which the coolant absorbs heat within the porous matrix and is discharged at the surface to form a protective thermal barrier. Integrated experimental and numerical studies were conducted to identify the key parameters and underlying mechanisms that control cooling effectiveness under reentry-like stagnation heat flux. We present the key phenomena governing cooling performance, including flow regime transitions, phase-change characteristics, and coupled thermo-fluid behavior within the porous structure. The results offer mechanistic insight and actionable guidance for designing more durable and efficient transpiration cooling systems.

III. Future directions and perspectives

For future data centers, it will be critical to manage increasing thermal loads while meeting rigorous energy and water efficiency requirements. To address these challenges, integrated system-level optimization—combining advanced cooling, energy-efficient design, and data-driven controls—are necessary to reduce key metrics such as Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE).

For aerospace applications, developing fully reusable spacecraft requires a shift from component-level design to multiphysics, multidisciplinary frameworks. Active cooling systems should be developed in conjunction with aerodynamic heating, boundary-layer behavior, and trajectory-dependent reentry conditions, requiring integrated approaches that couple fluid dynamics, heat transfer, materials science, control and optimization.

ACKNOWLEDGEMENTS

This work was supported by the “A nature-inspired high-efficiency solar energy collector mimicking energy metabolic mechanism of plants” funded by the National Research Foundation (NRF, 2022R1C1C1005922), Republic of Korea, and this work was supported by Korea Research Institute for defense Technology planning and advancement (KRIT) grant funded by the Korea government (DAPA(Defense Acquisition Program Administration)) (No.KRIT-CT-22-030, Reusable Unmanned Space Vehicle Research Center, 2026).

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Optimization of Surfactant-Imbibition In-situ DNAPL Remediation with Horizontal Wells

BETTY CEPEDA-SALGADO, GYU SANG LEE, SEUNG IHL KAM*

*Professor, Craft & Hawkins Department of Petroleum Engineering, Louisiana State University, Baton Rouge, LA

(ph) 1-225-578-5216, (fax) 1-225-578-6039, (email) kam@lsu.edu

I. SUMMARY

Dense non-aqueous phase liquids (DNAPLs), when leaked, have been a serious threat to subsurface environments and human health. Such a negative impact amplifies due to the long-term nature of the pollutants associated with capillary trapping of the oleic phase [1].

Following our recent innovative horizontal well technology to remediate DNAPL contaminants [2], this study investigates how to optimize the process in order to improve the in-situ recovery efficiency through a field case study.

II. INTRODUCTION

A typical in-situ NAPL remediation technology, using vertical injection and horizontal wells, shows a limited success as the process intrinsically deals with difficulties involving unfavorable mobility ratio, underground heterogeneity, gravitational effect, and sweep efficiency [1].

III. METHODOLOGY

Fluid extraction from the bottom horizontal production wells (Figure 1), allowing surfactant solution to be imbibed from the top, has a unique advantage over the conventional vertical well remediation. This study conducts three-dimensional simulation work to evaluate a wide range of spill and remediation scenarios (Figure 2). These outcomes form a basis to come up with an optimal design of the field operations.

IV. RESULTS AND DISCUSSIONS

The major findings of this study include that (i) screening of surfactant chemicals is an important step to reduce the level of capillary trapping, (ii) the location of the extraction wells and their spacing should be fully considered during the construction phase, and (iii) the treatment facilities and pumping units in the field are likely to set the upper limit of the overall remediation efficiency.

An expansion from 2D to 3D simulation effort requires additional understanding of subsurface geological setting and groundwater movement to obtain realistic simulation outcomes

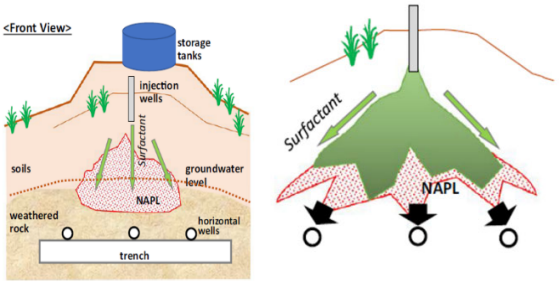


Figure 1: Horizontal well technology (3 extraction wells) with surfactant imbibition (1 injection well); modified from Ref. 2

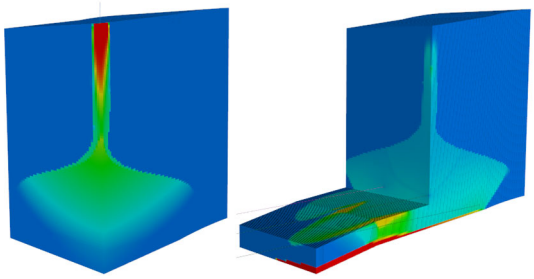


Figure 2: 3D simulation of field-scenario evaluation for optimization efforts

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Novel Nanophotonic Devices based on Strong Light-Matter Interaction

Hong-Gyu Park[1]
[1]Department of Physics and Astronomy, Seoul National University, Republic of Korea

I. SUMMARY

I will talk about two topics: advancing nanolasers based on photonic topological cavities and strain-induced single-photon emitters in atomically thin semiconductors.

II. Advancing nanolasers based on photonic topological cavities[1]

Optical vector vortex beams provide additional degrees of freedom for spatially distinguishable channels in data transmission. Although several coherent light sources carrying a topological singularity have been reported, it remains challenging to develop a general strategy for designing ultra-small, high-quality photonic nanocavities that generate and support optical vortex modes. Here, we demonstrate wavelength-scale, low-threshold, vortex and anti-vortex nanolasers in a C_5 symmetric optical cavity formed by a topological disclination. Various photonic disclination cavities are designed and analyzed using the similarities between tight-binding models and optical simulations (Fig. 1). Unique resonant modes are strongly confined in these cavities, which exhibit wavelength-scale mode volumes and retain topological charges in the disclination geometries. In the experiment, the optical vortices of the lasing modes are clearly identified by measuring polarization-resolved images, Stokes parameters and self-interference patterns. Demonstration of vortex nanolasers using our facile design procedure will pave the way towards next-generation optical communication systems.

III. Strain-induced single-photon emitters in atomically thin semiconductors[2]

Single-photon emitters, the basic building blocks of quantum communication and information, have been developed using atomically thin transition metal dichalcogenides (TMDCs). Although the bandgap of TMDCs was spatially engineered in artificially created defects for single-photon emitters, it remains a challenge to precisely align the emitter's dipole moment to optical cavities for the Purcell enhancement. Here, I will present the demonstration of position- and polarization-controlled single-photon emitters in monolayer WSe_2 via optical pumping. We demonstrate single-photon emitters encoded with spin angular momentum in a strained WSe_2 monolayer coupled with chiral plasmonic gold nanoparticles. Single-photon emissions are observed at the nanoparticle position, exhibiting photon antibunching behavior with a $g^{(2)}$ value of ~0.3 and circular polarization properties (Fig. 2). We also demonstrate electrically driven single-photon emitters located at the positions where strains are induced by atomic-force-microscope indentation on a van der Waals heterostructure. Therefore, our approach is a unique way to develop next-generation, deterministic, controllable single-photon emitters based on TMDC materials.

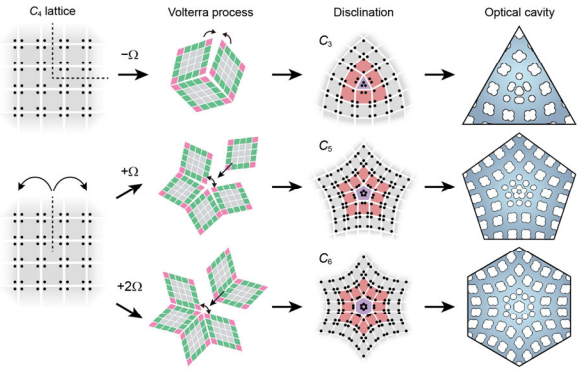


Figure 1

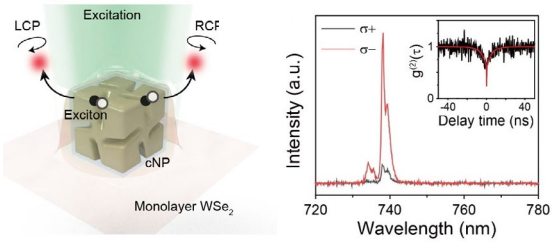


Figure 2

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Two-dimensional gas chromatography (GC×GC) Applications in Plastic Pyrolysis Research

Do Hyun Lee[1], Hilal Ezgi Toraman[1,2,3]
[1]Department of Energy and Mineral Engineering, Penn State University,16802, PA, [2]Department of Chemical Engineering, Penn State University,16802, PA, [3]Institute of Energy and Environment, Penn State University,16802, PA,

I. Abstract

Pyrolysis of plastic waste is emerging as a promising approach for recycling plastic waste, offering minimal pretreatment and producing marketable chemicals. To comprehensively elucidate complex chemical mixtures derived from plastic pyrolysis, a high-resolution technique is critical for precise identification and quantification. Two-dimensional gas chromatography (GC×GC) has emerged as a powerful analytical technique for resolving and identifying components in such complex systems. Previous studies have utilized GC×GC to profile product distributions from thermal and catalytic pyrolysis of mixed polyolefins[1] and oxygenated polymers[2], and a parametric study of polyethylene (PE)[3]. In summary, GC×GC could supply critical mechanistic insights into the pyrolysis of plastic.

II. Concept of GC×GC

A GC×GC system consists of two distinct columns, a modulator, and detectors. A column pair of GC×GC can be generally considered based on volatility and polarity. The modulator can be placed between the first- and second-dimensional columns. It enables the rapid transfer of analytes from the first-dimensional column to the second-dimensional column, thus enhancing separation performance. Detectors can be chosen depending on the analytical purposes.

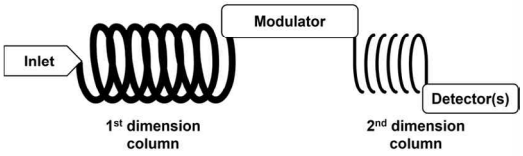


Figure 1: Overview of the GC×GC structure

III. Application of GC×GC in pyrolysis research of plastics

GC×GC has been used to analyze the products from the thermal pyrolysis of plastics, considering mixed polyolefins[1] and a parametric study of primary decomposition of PE[3], as well as the catalytic pyrolysis of plastics, which includes oxygenated polymer (PET)[2]. GC×GC drives precise product analysis and thereby provides critical insights into the pyrolysis of plastic waste, paving the way toward industrial implications.

ACKNOWLEDGEMENTS

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Plasticization-Driven Ionic Transport in $AlBr_3$–Based Solid Electrolytes

Kyunghyun Kim[1], Dongwook Lee[1*]
[1]Hongik University

I. INTRODUCTION

Solid-state electrolytes are promising alternatives to liquid electrolytes owing to their improved safety and thermal stability. However, their practical use remains limited by the rigidity of solid materials, which causes poor interparticle contact, high electrolyte-electrode interfacial resistance, and low ionic conductivity. External pressure is therefore often required, complicating cell design and scalability[1]. Here, we demonstrate an $AlBr_3$–based solid electrolyte formed via Lewis acid–base interactions. The electrolyte exhibits a room-temperature ionic conductivity of 1.2 mS cm^{-1} and an electrochemical stability window of 0.65–3.7 V vs. Li/Li^+. This plasticization-driven strategy offers a distinct solid-electrolyte design that improves ionic transport, electrochemical stability, and interfacial compatibility while addressing flammability concerns.

II. RESULTS AND DISCUSSION

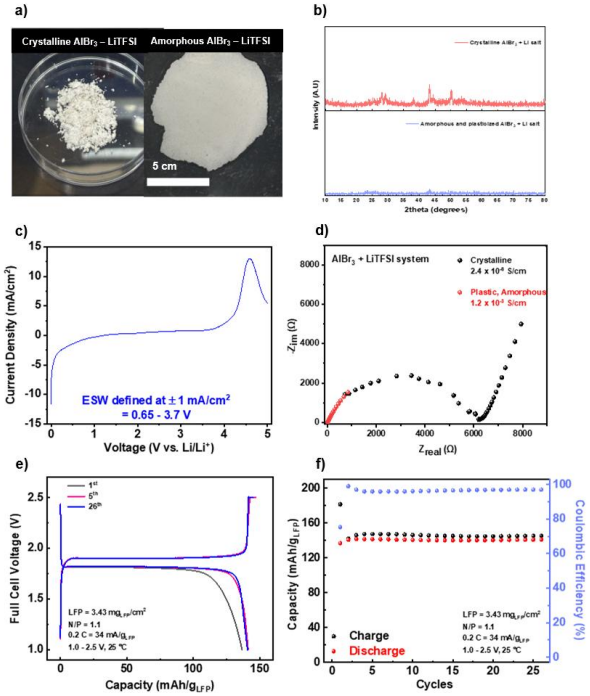


Figure 1. (a) Optical images of crystalline and plasticized samples. (b) XRD patterns. (c) LSV profile. (d) EIS spectra. e) Charge–discharge profiles of the LFP | LTO full cell. (f) Cycling performance.

A. Synthesis of plasticized amorphous electrolyte

As shown in Fig. 1a, simple hand grinding of $AlBr_3$–LiTFSI produces a uniform and pliable solid within 30 min at room temperature, indicating plasticization via Lewis acid–base interactions. Exposure to air leads to fume generation, confirming that the observed mechanical softness does not originate from moisture. XRD analysis (Fig. 1b) shows complete disappearance of crystalline peaks, confirming full amorphization. The resulting highly disordered structure provides more favorable Li^+ transport pathways than the rigid crystalline phase, as evidenced by the enhanced ionic conductivity.

B. Ionic transport and electrochemical stability

The amorphous electrolyte exhibits a conductivity of 1.2×10^{-3} S cm^{-1}, compared to 2.4×10^{-6} S cm^{-1} for the crystalline counterpart (Fig. 1d), corresponding to ~500-fold enhancement. LSV (Fig. 1c) shows a stability window of 0.65–3.7 V vs. Li/Li^+.

C. Full cell performance

An LFP | LTO full cell demonstrates stable charge–discharge behavior and cycling (Fig. 1e,f). A uniform and deformable solid electrolyte enables intimate electrode contact without external pressure, allowing stable operation after simple rolling.

III. CONCLUSION

A plasticized amorphous $AlBr_3$–LiTFSI electrolyte was developed via a simple room-temperature process. The system exhibits high ionic conductivity, good electrochemical stability, and pressure-free cell operation, highlighting plasticization as a promising strategy for solid-state battery design.

ACKNOWLEDGEMENTS

This work was supported by the Hyundai Motor Chung Mong-Koo Foundation.

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Coupling Mechanistic Lyophilization Models with a Multi-Agent AI Interrogation Engine for Autonomous Process Discovery

Saeyoung Kim[1], Jaeweon Lee[1], Kimia Babaei[1], Seongkyu Yoon[1,*]
[1]Department of Chemical Engineering, UMass Lowell, MA, *Corresponding Author

I. SUMMARY

Lyophilization development for mRNA-lipid nanoparticle (mRNA-LNP) products is a high-dimensional decision problem because recipe and formulation jointly govern critical quality attributes (CQAs). We present DAEMON (Discovery Agents Exploring Mechanistic ODE Networks), a framework that couples a first-principles freeze-drying model with a multi-agent AI interrogation engine. Five AI agents autonomously propose hypotheses, run simulations, interpret results, and converge on evidence-backed recipe recommendations, reducing weeks of manual iteration to an overnight run.

II. BACKGROUND AND MOTIVATION

Lyophilization development is a multi-variable decision problem. For mRNA-LNP products, both recipe and formulation affect final CQAs. In this study, the mechanistic model exposes a 20-input search space (13 recipe and 7 formulation variables). Useful discovery requires more than running simulations; it requires choosing informative next experiments. DAEMON combines mechanistic simulation with multi-agent reasoning to support and automate that process.

III. DAEMON SYSTEM OVERVIEW

DAEMON couples a 9-state ODE model (temperature, ice thickness, chamber pressure, moisture, cake resistance, encapsulation efficiency [EE], RNA integrity number [RIN], particle size, potency proxy) with five AI agents: MONITOR (orchestrator), SCOUT (exploration), REFINER (optimization), CONSERVATIVE (robustness), and AUDITOR (evidence review). The user defines a research question and constraints, then agents iterate through hypothesis, simulation, interpretation, and discussion until MONITOR declares convergence. Unlike classical DOE or black-box optimization, DAEMON provides physics-grounded adaptive search with interpretable hypotheses and a complete evidence trail.

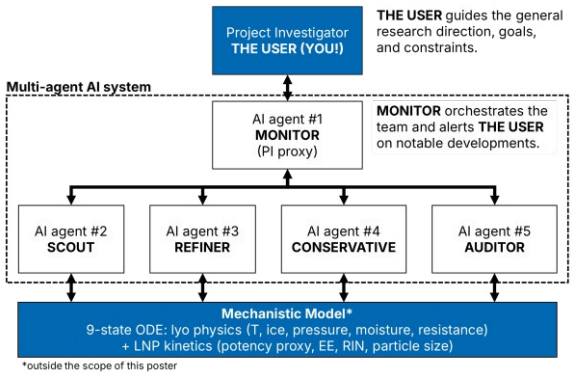


Figure 1: DAEMON system architecture.

IV. CASE STUDY AND HIGHLIGHTS

We tested DAEMON on the question: which factors drive residual moisture below 4% while maintaining EE above 90% and RIN above 7? In one converged session (5 cycles, 57 experiments, ~22 min wall time), DAEMON identified consistent operating windows: SD temperature 40–50 °C, PD pressure below 300 mTorr, and protectant concentration of at least 15%. Recommendations are directional pending experimental calibration. Next steps: LLM benchmarking, model calibration, and lab validation.

ACKNOWLEDGEMENTS

This work was supported by the Technology Innovation Program (or Industrial Strategic Technology Development Program-Materials and Components Technology Development Program) (RS-2024-00438660, Development of core components and system for online process monitoring in lyophilization of nucleic acid therapeutics) funded by the Ministry of Trade, Industry & Resources (MOTIR, Korea).

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From Classroom to Community: Preparing Next-Generation Engineering Through Municipal Water Quality Projects

Jun Kim[1,2], Jayden Ramey[1], Hailey Bauer[1], Nolan Nguyen[1], Aaron Medley[2]
[1]WATER Lab, Florida Polytechnic University
[2]Florida Industrial & Phosphate Research (FIPR) Institute

I. Summary

Communities across the Southwest Florida region face increasing droughts, water scarcity, and pressure on regional drinking water sources, while public understanding of water treatment remains limited. To address these challenges, Florida Polytechnic University (FPU) and the Florida Industrial and Phosphate Research (FIPR) Institute partnered with the City of Winter Haven, Tampa Bay Water, and Hillsborough Community Public Schools (HCPS), to advance municipal water treatment, workforce development, and community engagement.

The collaboration provided undergraduate students in environmental engineering with hands-on experience in water quality monitoring and analysis across nine water treatment plants (WTPs) in Winter Haven. Students conducted weekly samplings and developed practical skills in field measurements, sample handling, and physicochemical analysis. They also gained proficiency in analytical tools, including GIS, AutoCAD, and statistical platforms, as well as advanced instrumentation, such as ion chromatography (IC), total organic carbon (TOC), and inductively coupled plasma mass spectrometry (ICP-MS). The project generated over 1,000 water quality data points, supporting the development of data-driven decision tools to improve treatment processes and operational efficiency.

Project outcomes have been integrated into FPU's curriculum, enhancing courses such as Foundations of ENV 2003, ENV 4412, and ENV 4514. Plant tours and sampling activities were incorporated into lecture materials, quizzes, and term projects, improving student engagement and satisfaction rates, and increasing participation in both term projects and facility tours (Tampa Bay Water's seawater desalination plant and regional surface water treatment plant).

The K-12 outreach program, developed in partnership with HCPS, combines knowledge-building lessons, hands-on water treatment experiments, and guided lab tours. Through interactive demonstrations and real-world exposure to treatment technologies, the project translates complex water science into accessible, engaging experiences for young learners.

These efforts enhanced public understanding of regional water challenges, treatment processes, and long-term conservation needs, while equipping educators with sustainable teaching materials. It also contributed to the development of highly skilled, workforce-ready graduates prepared for careers in utilities and local governments, while establishing a scalable model for university-municipal-community partnerships that advance both educational and public resilience. Overall, the initiative strengthens community engagement, builds trust in local water infrastructure, and empowers diverse students to become informed stewards of regional water sources.



Figure 1: Course materials and facility tours.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the City of Winter Haven, Tampa Bay Water, and HCPS for their continued collaboration in this project.

Korea's Path to Fusion Energy: Progress and Strategic Vision

Yeongkook OH
Korea Institute of Fusion Energy (KFE), Daejeon, Korea

I. SUMMARY

Korea is advancing toward fusion energy realization through world-leading plasma research, strong international collaboration, and a strategic roadmap integrating AI-driven innovation and next-generation fusion reactor development.

II. FUSION AS A TRANSFORMATIVE ENERGY SOULUTION

Fusion is no longer a distant scientific aspiration but is rapidly emerging as a realistic and transformative energy solution. As global energy demand accelerates—particularly driven by AI and digital infrastructure—there is growing need for clean, stable, and scalable energy sources beyond conventional renewables.

Fusion offers a carbon-free, safe, and virtually limitless energy source, positioning it as a key enabler for sustainable growth in the AI-driven era.

III. THREE DECADES OF KOREA'S FUSION RESEARCH EXCELLENCE

Over the past three decades, Korea has established a strong foundation in fusion science and technology through sustained national investment. At the core of this effort is the Korea Superconducting Tokamak Advanced Research (KSTAR) device, a world-leading superconducting tokamak that has demonstrated high-performance, long-pulse plasma operation, sustaining plasmas for up to ~50 seconds while achieving ion temperatures exceeding 100 million degrees.

In parallel, Korea has contributed significantly to the ITER international project, supporting both construction and operational readiness. Through participation of over 180 domestic institutions, Korea has developed robust fusion supply chains and advanced engineering capabilities, strengthening its role as a key global partner in fusion research and development.

IV. STRATEGY FOR EARLY FUSION ENERGY COMMERCIALIZATION

In response to intensifying global competition toward fusion energy realization in the 2030s–2040s, Korea is pursuing a clear strategy for early commercialization. A central initiative is the development of the Compact Pilot Device (CPD), designed to demonstrate burning plasma ($Q > 5$) and generate approximately 100 MW of electricity in a compact, high-field tokamak.

The CPD integrates steady-state operation, closed tritium fuel cycle, and AI-assisted plasma control, serving as a critical bridge between experimental devices and commercial fusion power plants. This effort is supported by a phased roadmap linking KSTAR, ITER participation, and future demonstration reactors.

V. ECOSYSTEM AND GLOBAL COLLABORATION FOR FUSION ENERGY

Korea is building an integrated fusion ecosystem that connects government, research, industry, and global partnerships, supported by national acceleration strategies, public–private collaboration, and long-term roadmaps.

Through active participation in ITER and international cooperation, Korea is advancing key technologies—including materials, tritium fuel cycle, superconductors, and AI-based design—while contributing to joint research and workforce development. These efforts position Korea as both a technology leader and a key partner in the global transition from fusion science to practical energy.

ACKNOWLEDGEMENTS

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Analysis of Cutting Force Characteristics in Ultra-Precision Milling of Single Crystal Sapphire

Jin ho Park[1, 2], Suk bum Kwon[3], Sangkee Min[4], Hae-Sung Yoon[1, 2]
[1]Department of Smart Air Mobility, Korea Aerospace University,
[2]School of Aerospace and Mechanical Engineering, Korea Aerospace University,
[3]Department of Mechanical Engineering, University of New Haven,
[4]Department of Mechanical Engineering, University of Wisconsin-Madison

I. SUMMARY

Single-crystal sapphire is widely used for semiconductor substrates, precision components, and optical parts because of its high hardness and superior chemical and optical properties. However, its brittleness makes precision machining difficult. While previous studies have mainly focused on the ductile-to-brittle transition in scribing [1], the cutting force characteristics in milling remain less understood. In this study, ultra-precision milling experiments were conducted to investigate the orientation-dependent surface and cutting-force characteristics of single-crystal sapphire in the ductile-to-brittle transition region.

II. EXPERIMENTAL PROCEDURE

Ultra-precision milling experiments were performed on C-plane single-crystal sapphire using a single-flute ball end mill. The workpiece was machined along multiple feed directions relative to the crystal orientation, and the tool path was designed to examine cutting-force characteristics at different depths and feed directions. Three-axis cutting forces were measured during milling, and representative force values were extracted at the Fz peak, corresponding to the moment when the cutting edge reached the lowest point of engagement. The valid cutting interval was divided into entry and exit regions, and the force data were averaged within depth sections to compare feed-direction-dependent force characteristics. Surface morphology after machining was also examined to relate the measured forces to ductile and brittle material removal.

III. RESULTS

The cutting force characteristics of single-crystal sapphire varied with feed direction, showing anisotropic milling behavior. Brittle-mode removal was observed only at a specific feed direction, while the other directions did not show clear brittle behavior under the tested conditions. Accordingly, the magnitude and direction of the resultant force were analyzed to further examine the orientation-dependent milling behavior. These results indicate that the ductile-to-brittle transition in sapphire milling depends on crystallographic orientation.

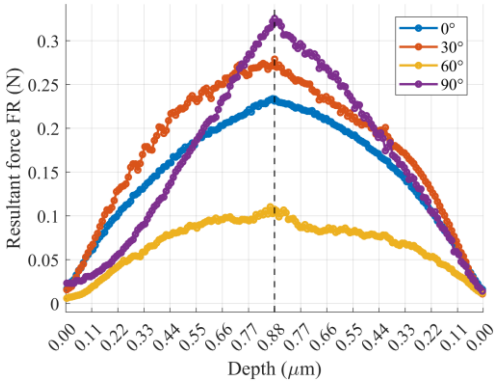


Figure 1: Representative depth-dependent resultant force at different feed directions

ACKNOWLEDGEMENTS

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Virus-Based Sustainable Recovery of Critical Minerals

Inseok Chae
Assistant Professor, Chemical Engineering, Texas Tech University

Rare earth elements (REEs) are essential for alternative energy, defense, and medical technologies, as advanced magnets, sensors, and energy storage systems rely on their unique physical properties. However, significant environmental concerns associated with conventional separation technologies have led the United States to rely heavily on overseas supply chains. Biomining has emerged as a promising alternative for critical mineral separation. Traditionally, efforts have focused on bioleaching, which uses organic acids produced through microbial fermentation to dissolve metal ions from natural ores, and this approach has been successfully implemented at the industrial scale. More recently, substantial progress has been made in utilizing naturally evolved biomolecules—including proteins, bacteria, and viruses—to selectively capture lanthanide ions. Compared to conventional organic extractants, these biomolecules exhibit superior selectivity due to their well-defined higher-order structures. As a result, biomaterial-based separation approaches have gained increasing attention for their ability to use selective binding motifs for critical minerals recovery.

Despite these advantages, two major challenges limit practical implementation. First, the production of protein-based biosorbents is typically limited to small scales in microbial systems, whereas industrial mineral recovery requires processing at the scale of thousands of tons. Second, effective separation strategies that fully exploit unique properties of biomolecules remain lacking. Addressing these challenges is critical for enabling large-scale, high-purity REE separation and advancing scalable bio-recovery technologies. Accordingly, the next phase of biomining research needs to focus on developing a sustainable and scalable bioseparation process that incorporates highly selective biosorbents.

In this presentation, we introduce an innovative strategy for REE separation based on stimuli-responsive coacervation of genetically engineered viruses, specifically F-specific filamentous bacteriophages (phages). They serve as a safe and versatile biotemplate that can be genetically programmed to display tailored binding motifs on their major coat proteins (**Fig. 1**). As a biosorbent, phage offers a high modularity across diverse aqueous environments, making them particularly suitable for critical mineral separations.

Through genetic engineering of phage DNA, we have demonstrated selective recovery of heavy REEs from complex sources such as allanite ore and acid mine drainage.[1] In addition, phages exhibit robust stability across a wide range of pH and temperature conditions, along with favorable handling characteristics. Compared to other biomaterials, such as isolated proteins, phages provide enhanced structural integrity and higher metal-binding capacity, supporting their use as a scalable and effective biosorbent for REE separation.

Also, by co-displaying a lanthanide-binding peptide and a thermo-responsive peptide on the major coat proteins of the phage, we engineered a bifunctional scaffold capable of selective REE binding and temperature-triggered coacervation in aqueous environments.[2] This system enables efficient REE separation through simple temperature modulation. Moreover, the process is recyclable and maintains high metal selectivity over multiple cycles. **Our work demonstrated significant potential of virus-based separation technology as eco-friendly and sustainable solution for next-generation critical mineral recovery.**

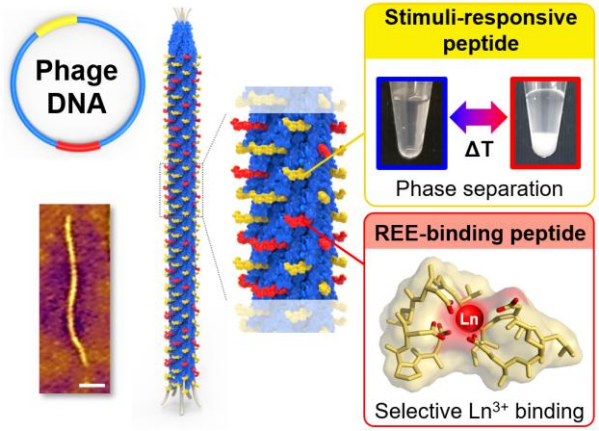


Figure 1: Schematics of engineered phage that can selectively bind Ln^{3+} ion and exhibit thermo-responsive coacervation upon heating. AFM image of the phage with 200 nm scale bar.[2]

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This work was supported by NSF (#2223730).

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Effectiveness of Low-Cost Window Fans for reducing Indoor Cooking Emissions Compared with Kitchen Hoods

Semi Park[1], Lucas Kim[2], Insung Kang[1]
[1]Department of Civil Engineering, University of Texas at Arlington, [2]Research Intern, BEH Lab, University of Texas at Arlington

I. SUMMARY

Cooking is one of the major sources of indoor air pollution, generating particulate matter (PM), volatile organic compounds (VOCs), and nitrogen dioxide (NO_2), which pose significant health risks [1,2]. However, many U.S. households lack adequate kitchen exhaust ventilation, particularly in low-income settings [3,4]. While kitchen hoods have been evaluated in prior studies, low-cost alternatives such as window fans remain understudied. This study experimentally compared $PM_{2.5}$, PM_{10}, and ultrafine particle (UFP) removal performance across kitchen hood, window fan, window fan with natural ventilation, and baseline (no ventilation) conditions. Results showed that kitchen hoods yielded significantly lower peak concentrations, while window fan strategies achieved decay rates comparable to those of kitchen hoods at a fraction of the cost ($30–50 vs. $2,000+).

II. METHODODGY

Experiments were conducted in a residential kitchen equipped with a gas stove and a ducted range hood. Four ventilation conditions were tested: (1) baseline (no ventilation), (2) kitchen hood (low/medium/high), (3) window fan in exhaust mode (low/high), and (4) window fan combined with natural ventilation. Each condition was replicated at least three times, except the baseline (n = 1). A standardized cooking protocol was used: beef patties were pan-fried for 13 minutes (4 min and three 3-min flips), with ventilation devices activated simultaneously at the start of cooking. $PM_{2.5}$ and PM_{10} were measured using a DustTrak DRX, and UFPs using a P-Trak (TSI Inc.), at breathing-zone height (~4 ft) and 3 ft from the stove. Decay rates (k, h^{-1}) were estimated by fitting a first-order exponential decay model to post-cooking concentration data [5,6].

III. RESULTS

Kitchen hoods produced significantly lower peak PM concentrations compared to window fan strategies, as the hood captures cooking emissions directly above the source during cooking, with sensors placed 3 ft apart from the cooking source to measure exposure. However, the decay rates under window fan strategies achieved comparable pollutant removal performance. For $PM_{2.5}$, the kitchen hood (high mode) achieved the highest decay rate (3.73/hr), followed by window fan with natural ventilation (low: 3.10/hr, high: 2.92/hr). Similar trends were observed for PM_{10} and UFPs. The addition of natural ventilation consistently improved removal efficiency when paired with window fans across all pollutant types.

IV. CONCLUSION

Both low-cost ventilation strategies (window fan only and window fan with natural ventilation) showed particle removal efficiencies comparable to those of the kitchen hood. Natural ventilation consistently enhanced removal efficiency when paired with window fans. Given their low cost ($30–50 vs. $2,000+), window fans can serve as a practical alternative to kitchen hoods for improving IAQ in homes without adequate exhaust ventilation. Future work will conduct additional experiments in different home environments.

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Effectiveness of Mold and Dampness Interventions for Occupant Health: A Systematic Review

San Jin[1], Insung Kang[1]
[1]Department of Civil Engineering, University of Texas at Arlington

I. SUMMARY

This study aims to systematically review interventions for mold and dampness in buildings, focusing on their effectiveness in improving health outcomes, stratified by intervention types, study population, building characteristics, study design, and follow-up duration.

II. INTRODUCTION

Mold and dampness represent significant hazards within the built environment, leading to adverse health outcomes such as asthma. These problems are prevalent across residential building, schools, and commercial buildings, where occupants may be exposed for extended periods.

There are a range of interventions targeting moisture and dampness in buildings, including such as moisture control, ventilation improvements, and remediation of contaminated materials. However, these interventions differ substantially in their underlying mechanisms and implementation strategies, making it challenging to systematically understand how they contribute to occupant's health improvements. Therefore, a structed synthesis of intervention-based findings is required to clarify the effectiveness of different interventions.

III. METHODS

To address this critical gap, this study systematically reviews different interventions following PRISMA guidelines. Relevant studies were identified from various databases. Studies were selected based on the PICO framework:

(1) **P**opulation: occupants exposed to mold or dampness in buildings;
(2) **I**nterventions: Source control, Ventilation, Thermal/humidity control, Remediation, Envelope upgrade, Behavioral interventions, and Combined interventions;
(3) **C**omparison: no interventions or alternative interventions;
(4) **O**utcomes: asthma-related symptoms, and respiratory symptoms and infections.

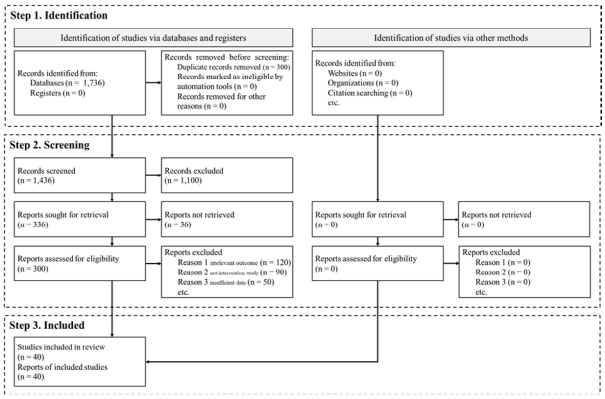


Figure 1: PRISMA flow chart for study selection

IV. RESULTS

The impacts of mold and dampness interventions were analyzed by intervention type, including source control, ventilation, thermal and humidity control, remediation, building envelope upgrades, behavioral interventions, and combined approaches. The review examined the following hypotheses: (1) interventions targeting source control, ventilation, and remediation showed positive effects on respiratory symptoms and asthma-related outcomes. (2) the effectiveness of interventions was more strongly influenced by intervention type than by building characteristics. (3) interventions combining thermal and humidity control strategies with envelope upgrade were associated with more sustained health improvements than single-component interventions.

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Simulation Study of Mechanically Tunable Phononic Crystals: Effects of Scatterer Geometry and Material on Acoustic Band Gap Properties

D. Lee[1], H. Shin[2], T. Y. Choi[3]

[1]Wakeland High School, Frisco, TX, USA; [2]International Leadership of Texas in Garland High School, Garland, TX, USA

[3]University of North Texas, Denton, TX, USA

SUMMARY

Using COMSOL's Finite Element Method to simulate acoustic properties in Phononic Crystals, we have investigated two different configurations; The first is a mechanical 2D-to-1D tunable configuration modeled as an array of rectangular bars. The second is a circular scatterer configuration with one central defect element. The geometrical parameters for the scatterer arrays (scatterer size, spacing) along with material parameters (Steel, Plastic), were varied in a systematic manner across a 200 – 600 kHz frequency band. For both arrays, attenuation was significantly higher when steel scatterers were used as compared to plastic scatterers. Further, decreasing the scatterer dimension and increasing the proximity of elements resulted in shifting and widening of the acoustic stop-bands. Additionally, for the circular defect configuration, by decreasing the lattice spacing, the largest transmission dips were achieved, showing that geometrically controlled acoustic band gaps are possible.

Keywords: phononic crystal, acoustic band gap, COMSOL simulation, mechanical tunability, defect resonance

I. INTRODUCTION

The mechanical tunability of phononic crystal devices is based on their ability to dynamically filter acoustic waves. The mechanical tunability can be achieved by adjusting either the geometric parameters of the scattering elements or the geometric parameters of the lattice (i.e., the periodic structure) and represents a means for achieving real-time acoustic filtering as well as controlling frequency responses [1, 2]. A key limitation of conventional phononic crystal devices has been that they have used fixed periodic structures. In order to overcome these limitations, we have developed COMSOL-based simulations of two new types of tunable phononic crystal devices: a rectangular pillar array, which represents a mechanically adjustable 2-D to 1-D transition, and a circular lattice containing a central defect element of variable size. Both device architectures were modeled with respect to how both geometric parameter choices and material selections would affect band gaps within the 200 – 600 kHz range.

II. SIMULATION

The acoustic pressure transmission through two types of phononic crystal geometries is modeled by using COMSOL Multiphysics. The rectangular model contains pillar arrays having dimensions that vary from 2×4 mm to 2×12 mm and have variable inter-element spacing from (2,11) to (14,6) mm (see Fig. 1b); the material for the pillar is either steel or plastic, and the pillars are immersed within a fluid medium. On the other hand, the circular defect model consists of a 7x8 periodic arrangement of plastic cylinders that range from 3–8 mm in diameter and surround a single cylindrical scatterer made of either aluminum or steel, which has diameters varying from 3-14 mm (see Fig. 1a). The center-to-center distance between these cylinders varies from 4 to 17mm. Sound pressure levels (total dB) are measured at an output face by using a boundary probe over a 200-600 kHz sweep.

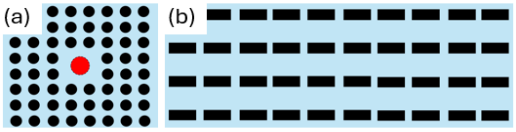


Fig. 1 Mechanically tunable PnC models. (a) by defect (the red circle represents a defect in PnC); (b) by mechanical rotation of each scatterer (black rectangles).

III. RESULTS AND DISCUSSION

The steel rectangular bar models show greater attenuation (to -65 dB) as opposed to plastic (-36 dB). Steel has a much greater acoustic impedance than plastic (see Table 1). Narrower pillars reduced the depth of the transmission dips and increased the frequency of the stop bands.

Table 1. Minimum attenuation with various rectangular bar models.

Scatterer shape	Material	Parameters	Min. Attenuation (dB)
Rectangle	Steel	2×12 mm, gap (2 mm)	−65
Rectangle	Plastic	2×12 mm, gap (2 mm)	−36
Rectangle	Plastic	2×12 mm, gap (4 mm)	−38
Rectangle	Plastic	2×4 mm, gap (6 mm)	−38

The circular defect model shows an increase in the local resonant peak at approximately 330 kHz when the central defect size is enlarged compared to the surrounding lattice. When the distance (gap = 1mm) was minimized between elements, it resulted in the largest bandwidths, whereas increasing this same parameter caused narrower peaks and separate minima (See Fig. 2).

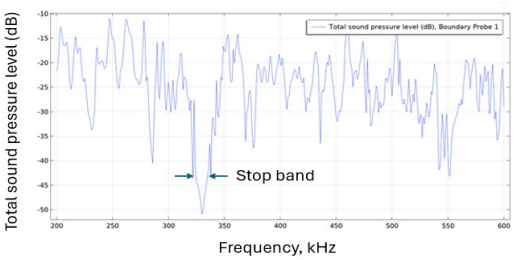


Fig. 2 Measured total sound pressure level based on circular defect model

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Soft Piezoelectric-Powered Capacitive Sensor for High-Fidelity Vibration Detection

Jeng-Hun Lee[1,2]
[1]Department of Chemical Engineering, Pohang University of Science and Technology,
[2]School of Computer Science and Engineering, Georgia Institute of Technology

I. SUMMARY

Mechanical stimuli are ubiquitous and carry key information for physical AI. They range from pronounced quasi-static cues (e.g., strain and pressure) to faint yet highly dynamic vibrations. Detecting subtle vibrations requires soft vibration sensors with exceptional performance, but existing devices struggle to achieve uniformly high sensitivity across a broad frequency band while maintaining reliable, low-power operation.[1,2] Here, we present a piezoelectric-powered capacitive sensor that resolves this trade-off.[3] A piezoelectric diaphragm serves as a built-in bias source, supplying a stable polarization field while generating vibration-induced charges that modulate the capacitive output for self-powered operation. Combining this scheme with in-plane air ventilation and a densely packed diaphragm array, the device achieves high linear sensitivity, a flat broadband frequency response, an ultralow detection limit, and a high signal-to-noise ratio (SNR), surpassing reported soft vibration sensors. We further demonstrate high-fidelity capture of music, voice, and respiratory signals from subtle mechanical vibrations.

II. DEVICE CONCEPT AND DESIGN

We replace the external bias source of conventional capacitive vibration sensors with a piezoelectric PVDF-TrFE diaphragm (Figure 1). The remnant polarization of the diaphragm establishes a stable built-in bias field, while vibration-induced piezoelectric charges combine with capacitance changes to produce the output signal. This built-in piezoelectric scheme enables self-powered operation without bulky power supplies or environmentally unstable electret layers. A star-shaped support introduces in-plane ventilation channels around each diaphragm, suppressing air damping without reducing the active diaphragm area. Densely connecting the suspended diaphragm units in parallel yields a hyperpacked array that enhances output signal, mechanical flexibility, and fabrication simplicity.

III. PERFORMANCE AND APPLICATIONS

The optimized sensor array achieved a linear sensitivity of 626 mV g^{-1} over 0.1-2.5 g, a flat frequency response across 80-5,000 Hz, a detection limit of 0.01 g, and an SNR of 80 dB. These combined characteristics address the central trade-off in soft vibration sensors: maintaining high sensitivity while preserving broadband, low-noise operation. The sensor recorded solid-borne music with high fidelity (preserving the distinct timbres of multiple instruments), detected neck-skin-transmitted voice signals with minimal acoustic interference, and captured breath sounds to distinguish normal from abnormal breathing. These demonstrations show that subtle mechanical vibrations can serve as a rich information channel for soft-contact microphones, laryngophones, wearable healthcare devices, and future physical AI systems.

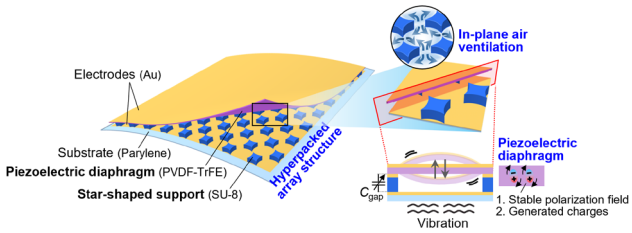


Figure 1: Schematic of the hyperpacked piezoelectric-powered capacitive vibration sensor.

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Balancing Dark Current and Photoresponse in Organic Photodetectors via Cleavable Side Chain Engineering

Seung Hyun Kim[1], Wei You[1]
[1]Department of Chemistry, University of North Carolina at Chapel Hill, Chapel Hill, NC, USA

I. SUMMARY

Acid-catalyzed cleavage (ACC) removes the insulating alkyl groups of thermally cleavable tertiary-ester (TCS) side chains at mild temperature (5 wt% DPP, 140 °C), avoiding the morphological damage of high-temperature thermolysis [1].

We extend this to layer-by-layer (LbL) organic photodetectors (OPDs), where the resulting solvent resistance preserves the donor underlayer and sets the donor-acceptor interface governing dark current density (J_D). The TCS content of D18-based donors controls this balance: more TCS suppresses J_D but over-rigidifies the interface and limits collection. TCS50 gives the best compromise, with the lowest J_D (5.05 × 10^{-7} A cm^{-2}) and the highest detectivity (D_{sh}* = 1.11 × 10^{12} Jones, −1 V, 840 nm).

II. METHODS

D18-Cl (TCS0), D18-TCS (TCS100), and their copolymers (TCS50, TCS70) were used as bottom donor layers, followed by sequential Y6 deposition in ITO/PEDOT:PSS/donor/Y6/PDIN/Ag devices. TCS-containing films were thermally treated to enhance solvent resistance. OPD performance was evaluated using dark current density, responsivity, EQE, and shot-noise-limited detectivity.

III. RESULTS

Acid-catalyzed cleavage (5 wt% DPP, 140 °C, 30 min) renders the donor film insoluble, preserving the bottom layer during Y6 casting (Fig. 1A). TCS50 reaches the lowest J_D (5.05 × 10^{-7} A cm^{-2}), the highest EQE (70.7 %), and D_{sh}* near 10^{12} Jones across the visible-NIR range, while TCS70 remains intermediate (Fig. 1B,C; Table 1). TCS0 suffers leakage from poor solvent resistance, whereas fully cleavable TCS100 suppresses dark current at the cost of reduced photoresponse.

These trends indicate a trade-off: solvent resistance rises with TCS content, while efficient collection requires enough residual solubility for controlled Y6 interdiffusion. TCS50 satisfies both, consistent with its suppressed shunt leakage and reduced band-tail disorder.

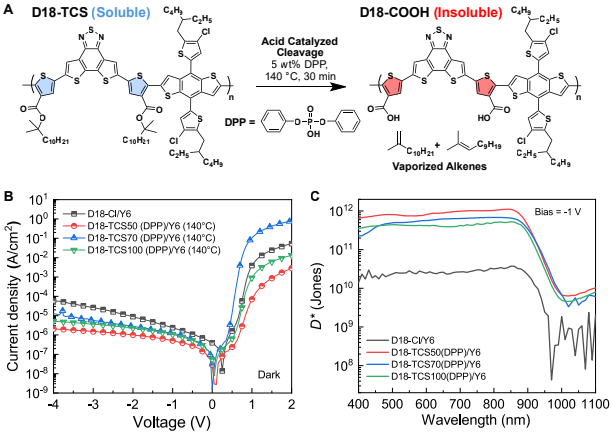


Fig. 1. (A) Acid-catalyzed side chain cleavage; (B) J_D-V; (C) D_{sh}* (−1 V) of D18-TCSx/Y6 OPDs.

Table 1. Performance summary (bias = −1 V)

System	J_D (A/cm^2)	EQE (%)	D_{sh}* (Jones)
TCS0	2.40×10^{-6}	43.2	3.76×10^{10}
TCS50	5.05×10^{-7}	70.7	1.11×10^{12}
TCS70	1.16×10^{-6}	57.1	6.76×10^{11}
TCS100	1.07×10^{-6}	46.2	5.31×10^{11}

IV. CONCLUSION

Moderate side chain cleavage balances solvent resistance, dark-current suppression, and carrier collection in LbL OPDs. TCS50 best resolves this trade-off, indicating that tuning rather than maximizing the cleavable side chain content is a practical strategy for solution-processed multilayer photodetectors.

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This work was supported by the National Science Foundation under Award No. CHE-2328869.

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Machine Learning Enhanced Modeling of Orientation-Dependent van der Waals Interactions in Nanostructured Cuboids with Surface Roughness Effects

Jaewon Lee[1],

[1] *Department of Mechanical and Aerospace Engineering, University of Missouri, Columbia, MO 65211, USA.*,

Van der Waals (vdW) interactions play a critical role in guiding nanoparticle approach, alignment, aggregation, and oriented attachment, but direct numerical evaluation of vdW potentials over large configurational spaces is computationally expensive. [1-2] In this study, we develop a machine-learning-assisted framework to rapidly predict and map vdW interaction potentials between anisotropic particles with different shapes and relative orientations. The trained machine-learning model was validated against physics-based numerical calculations derived from geometric vdW formulations. The predicted potentials showed excellent agreement with the numerical results over a wide range of separation distances and particle configurations, including short-range regimes where the vdW potential changes rapidly. Additional testing across 120 new input conditions yielded strong predictive accuracy, confirming that the machine-learning model can serve as a reliable surrogate for accelerated vdW calculations.

Using this framework, high-resolution vdW potential maps were generated for representative cube–cube configurations, including face-to-face, face-to-edge, and face-to-point orientations. The results show that face-to-face alignment produces a broad and symmetric attractive potential field due to large surface overlap, while face-to-edge configurations generate anisotropic and heterogeneous attraction regions. Face-to-point interactions exhibit highly localized attraction and rapid potential decay upon lateral displacement. Scaling analyses further revealed that particle morphology strongly modifies both the magnitude and separation-dependent decay of vdW interactions. As particle shape evolves from cuboid to polygonal rod-like structures, or from faceted polyhedra to rounded sphere-like morphologies, the vdW potential becomes weaker and less sensitive to separation distance.

These findings demonstrate that machine-learning-accelerated vdW mapping can efficiently reveal orientation- and morphology-dependent interaction landscapes that are difficult to access through repeated numerical calculations alone. This approach provides a useful physical and computational tool for understanding and designing nanocrystal assembly, aggregation, and attachment pathways in shape-controlled colloidal systems.

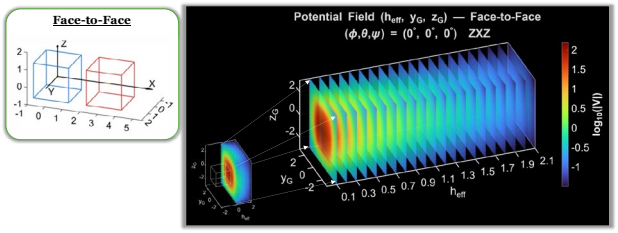


Figure 1 van der Waals potential mapping according to the center position of Body 2.

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Low-Cost Titanium Powder Design and in-situ Alloying Approach for Laser Powder Bed Fusion

Bin Lee[1,2]

[1]Department of Materials Science and Engineering, Kyung Hee University, Yongin, 17104, Republic of Korea
[2]G-LAMP NEXUS Institute, Kyung Hee University, Yongin, 17104, Republic of Korea

I. SUMMARY

Laser powder bed fusion (L-PBF) enables high-precision fabrication of titanium components, but still relies mainly on costly spherical or pre-alloyed powders. This work summarizes recent studies using low-cost HDH, non-spherical, and elemental Ti-based powders, with emphasis on hydrophobic SiO_2 coating, mixed-powder design, and LPBF-based in-situ alloying.

II. POWDER DESIGN AND PROCESS OPTIMIZATION

The first approach was SiO_2-assisted powder surface modification. Low SiO_2 contents, generally 0.1-0.2 wt.%, reduced interparticle cohesion while avoiding agglomeration. For spherical Ti-6Al-4V, 0.1 wt.% SiO_2 coating improved flowability and produced dense L-PBF specimens with 1188 MPa UTS and 11.4% elongation. For HDH Ti-6Al-4V, the same concept enabled standard recoating and increased hardness by about 36%.

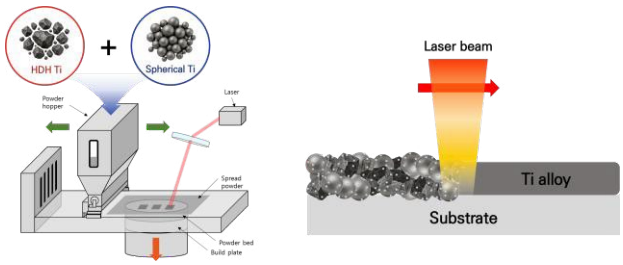


Figure 1: Schematic illustration of the mixed-powder strategy using low-cost non-spherical Ti powder, spherical powder or elemental powder

Mixed-powder strategies were also used to balance cost and processability. In pure Ti systems, a 6:4 non-spherical:spherical powder mixture with SiO_2 (0.1 wt.%) gave 99.7% relative density, 762.6 MPa tensile strength, and 22.1% elongation. For Ti-6Al-4V, a 1:1 SiO_2-coated HDH/spherical powder mixture optimized by Gaussian process regression improved hardness and tensile strength.

In-situ alloying was examined as a second cost-reduction route because it eliminates pre-alloying and enables alloy design from elemental powders. Near beta-Ti was fabricated by mixing non-spherical Ti with 3 wt.% Fe and 0.1 wt.% SiO_2. The optimized Ti-3Fe specimen reached 99.21% relative density, 49.2% higher hardness than pure Ti, and yield strength/UTS of 1063.9/1245.5 MPa. In a related Ti-Nb study, SiO_2-assisted dry mixing and process optimization improved the processability and beta-phase formation of elemental Ti/Nb powders.

III. DISCUSSION

These studies show that dry surface modification and in-situ alloying can expand the usable feedstock range for L-PBF. SiO_2 nanoparticles improve spreading by reducing cohesion and stabilizing powder-bed packing, while Fe and Nb additions enable beta-phase alloy design without pre-alloyed powders. Oxygen content, elemental-powder melting, mixing uniformity, and L-PBF parameters must be controlled to avoid ductility loss or process instability.

ACKNOWLEDGEMENTS

This work was supported by the NRF G-LAMP Program funded by the Ministry of Education (No. RS-2025-25442355).

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Improved Hydrogen Yield and Safety in Solid-State Hydrolysis of Sodium Borohydride Using Water Adsorbents

Hyun Tae Hwang, Savannah Murt, Lanny Hays, Henry Clark, Hayden Thompson, Brody T. Greer
Department of Chemical and Materials Engineering, University of Kentucky

I. SUMMARY

Hydrogen is considered one of the most promising clean energy carriers for future sustainable energy systems. Among various hydrogen storage materials, sodium borohydride (SBH) has attracted considerable attention because of its high theoretical hydrogen storage capacity (10.8 wt%). However, conventional hydrolysis systems suffer from several limitations, including low practical hydrogen yield due to excessive water requirements, self-hydrolysis safety concerns, and inefficient water utilization.[1]
Previously, our group demonstrated improved solid-state hydrogen generation by mixing SBH with sodium metaborate tetrahydrate (SMB4H), which enabled hydrogen production under moderate temperature conditions while avoiding direct liquid water addition.[2] However, further improvements in hydrogen yield, water utilization efficiency, and system safety remained necessary.

II. Results and Discussion

Figure 1 compares the overall hydrogen yield obtained at target reactor temperatures of 150°C and 200°C for three different systems: conventional solid-state hydrolysis, adsorbent-assisted solid-state hydrolysis, and adsorbent-assisted hydrolysis with water recycling.

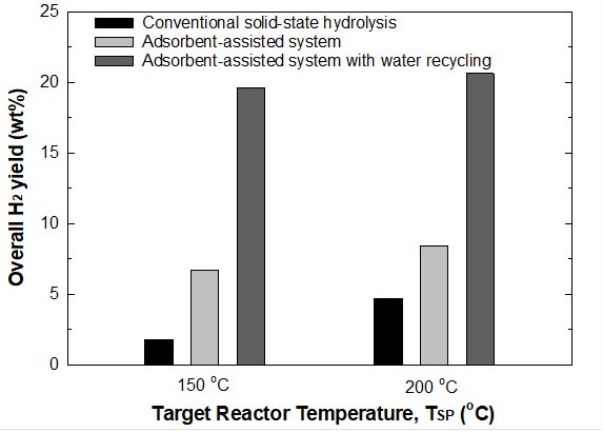


Figure 1: Comparison of overall hydrogen yield for conventional and adsorbent-assisted solid-state hydrolysis systems at different reactor temperatures

Without adsorbents, hydrogen yields were limited to approximately 1.8 and 4.7 wt% at 150 and 200°C, respectively. By introducing water adsorbents, the H_2 yield significantly increased to approximately 6.7 wt% at 150°C and 8.3 wt% at 200°C due to improved water delivery and reduced water loss. Furthermore, when partial water recycling from the fuel cell system was considered, the effective hydrogen yield increased dramatically to approximately 19.8 and 20.6 wt% at 150 and 200°C, respectively. These values approach the theoretical maximum effective hydrogen yield of 21.1 wt%.
The results clearly demonstrate that the proposed adsorbent-assisted system substantially improves hydrogen yield, operational safety, and water utilization efficiency compared to conventional solid-state hydrolysis systems.

III. CONCLUSIONS

A new adsorbent-assisted solid-state hydrolysis system for sodium borohydride was successfully developed and evaluated. The proposed approach enables thermally controlled water delivery, eliminates self-hydrolysis risk, improves hydrogen yield, and simplifies regeneration through formation of a single solid-phase product. In addition, integration of water recycling can significantly enhance the effective hydrogen storage capacity. The proposed system provides a promising pathway toward safe, efficient, and recyclable hydrogen generation technologies for future fuel cell applications.

ACKNOWLEDGEMENTS

The support of the Lighthouse Beacon Foundation is gratefully acknowledged.

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Fabrication of Textured pHEMA Hydrogels: The Impact of Micro/Nano Textures on Optical Property

Shima Rastgordani[1], Shuai Yu[1], Yiwen Xi[1], Yang Zhang[1], and Chang-Hwan Choi[1]
[1]Department of Mechanical Engineering, Stevens Institute of Technology, Hoboken, NJ, USA

I. SUMMARY

Poly(2-hydroxyethyl methacrylate) (pHEMA) hydrogels are valued in contact lenses and transparent biomedical devices for their hydration, biocompatibility, and optical transmission. Surface texturing adds functions such as friction control, sensing, and antibacterial response. However, it can also scatter light and reduce clarity. This work examines the fabrication of micro- and nanotextured pHEMA, followed by the investigation of the effects of the micro- and nanotextures on the optical transmittance and haze in dry and hydrated states.

II. FABRICATION

Textured silicon template substrates patterned with grating, pore, and pillar geometries were made by UV photolithography for microscale and Lloyd mirror interference lithography for nanoscale, respectively, followed by deep reactive ion etching. The self-assembled monolayer coating of Perfluorodecyltrichlorosilane (FDTS) was applied on their surfaces for anti-adhesion treatment. For microtextured pHEMA, Sylgard 184 PDMS molds were prepared by soft lithography, and their patterns were transferred to pHEMA by UV imprinting. For nanotextured pHEMA, two different soft lithography approaches were examined, including monolithic 184-PDMS and a composite mold of a thin h-PDMS layer on 184-PDMS cured stepwise at 60, 80, and 90 °C to limit interlayer stress, and their patterns also transferred to pHEMA by UV imprinting.

III. RESULTS

A. Replication Quality

Microtextured pHEMA replicated reliably with 184-PDMS, giving well-defined micrograting, micropores, and micropillars with no visible residue. However, pHEMA nanotextures from monolithic 184-PDMS were shallow, distorted, and residue-contaminated, reflecting its high viscosity and low modulus of soft PDMS. The composite h-PDMS/184-PDMS mold generally improved the transfer fidelity. However, curing directly at 90 °C still left residue. An added 80 °C intermediate step gave clean nanogratings, nanopores, and nanopillars with no measurable PDMS residue on pHEMA with high pattern transfer fidelity.

B. Optical Properties

The optical quality of the micro- and nanotextured pHEMA was assessed by direct image observation and UV-visible haze measurements. Viewed through microtextured pHEMA, a printed letter showed visible distortion, which is more pronounced when the sample was separated from the object, in both dry and hydrated states. In contrast, nanotextured pHEMA generally showed significantly less distortion. Quantitative haze and transmittance values confirmed the scale-dependent optical responses (Table 1).

Table 1: Haze of textured pHEMA hydrogels

Texture	Haze%, dry	Haze%, wet
Microtextured	30 to 40%	55 to 68%
Nanotextured	below 4%	below 6%

IV. CONCLUSION

In nanopatterning of pHEMA hydrogel via soft lithography, the composite h-PDMS/184-PDMS molds with stepwise curing gave cleaner and more faithful transfer than monolithic 184-PDMS. Optical characterization showed that microscale textures increased haze and image distortion, while nanotextures preserved high transmittance and low haze in both dry and hydrated states.

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Controlling Surface Cation Configurations in $Ir_xRu_{1-x}O_2(110)$ and Their Effects on Adsorption

Jisu Shin[1,2], David Hibbitts[1,2]
[1]Davidson School of Chemical Engineering, Purdue University, West Lafayette, IN 47907, USA,
[2]Department of Chemical Engineering, University of Florida, Gainesville, FL 32611, USA

I. SUMMARY

These instructions outline our density functional theory (DFT) investigation into the local cation arrangements on mixed $Ir_xRu_{(1-x)}O_2(110)$ surfaces. Understanding atomic-scale structural configurations is critical for rationally designing mixed metal oxide catalysts with tunable chemical properties. We demonstrate that adsorbate binding energies are governed primarily by the identity of the coordinatively unsaturated (M_{cus}) binding site and its two underlying subsurface (M_{subcus}) cations.

II. COMPUTATIONAL METHODS

Periodic plane-wave DFT calculations were performed using the Vienna ab initio simulation package (VASP) equipped with the PBE exchange-correlation functional. Plane waves were constructed using projector augmented wave (PAW) pseudopotentials with an energy cutoff of 400 eV. We modeled the rutile (110) surface using 6-layer slab models, fixing the bottom two layers at their bulk positions. Exchange energies for replacing Ir with Ru (and vice versa) were evaluated at symmetrically distinct surface and subsurface sites to quantify the relative stability of mixed metal oxide arrangements.

III. RESULTS AND DISCUSSION

A. Adsorbate Binding on Mixed Sites

Our computational analysis reveals distinct binding preferences depending on the local cation environment. Ir_{cus} atoms bind N_2 more strongly than Ru_{cus}, but bind on-top O (O_t) more weakly.[1] The presence of Ir_{subcus} atoms strengthens both N_2 and O_t binding significantly due to localized ligand effects mediated through the subsurface oxygen atoms.

B. Exchange Energies and Site Preferences

Exchange energy calculations indicate that for Ru substitution into IrO_2, the M_{cus} and M_{subcus} positions are strongly favored (~-27 kJ/mol) over bridging (M_{br}) sites. On stoichiometrically terminated surfaces, Ru exhibits a nearly equal preference for cus and subcus sites.

C. Oxygen-Driven Cation Intermixing

In the presence of adsorbed O_t, the thermodynamic preference shifts dramatically.[1] Ru_{cus} is strongly preferred due to the enhanced O_t binding on Ru relative to Ir, combined with the stabilization provided by neighboring Ir_{subcus} atoms. Utilizing Boltzmann weighting factors to estimate exchange energies, the DFT-predicted binding-site distributions for O-covered surfaces closely matched the experimental site distributions obtained from temperature-programmed desorption (TPD).

IV. CONCLUSION

Our DFT calculations provide fundamental insights into the thermodynamic and adsorbate-driven forces that dictate surface composition in mixed Ir-Ru oxides. The enhanced oxygen binding on Ru_{cus} combined with stabilization from Ir_{subcus} drives the surface toward Ru-enriched cus arrangements. Controlling these near-surface cation configurations offers a promising pathway to optimize the chemical properties of mixed-oxide catalytic materials.

ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation (NSF CHEM #2102211). Computational resources were provided by ACCESS and University of Florida Research Computing

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Effect of Hexagonal Boron Nitride Fillers on Ion Transport and Viscoelasticity of Vitrimer Electrolytes

Seongon Jang, Russell J. Composto*
Materials Science and Engineering, University of Pennsylvania

ABSTRACT

Vitrimers are being studied for a range of applications because of their tunable viscoelasticity, reprocessability, and self-healing. In particular, they are promising as solid polymer electrolytes. Although vitrimer electrolytes containing lithium salts have been reported, the role of hexagonal boron nitride flakes (h-BN) as fillers in controlling the physical and chemical properties of sodium-ion vitrimer electrolytes remains largely unexplored. In this work, imine-based composite vitrimer electrolytes were prepared with various h-BN loadings and a fixed concentration of sodium bis(trifluoromethanesulfonyl)imide) (NaTFSI), below the theoretical critical percolation threshold. Structural characterization by scanning electron microscopy (SEM) revealed that higher h-BN loading resulted in greater aggregation of h-BN flakes. X-ray diffraction (XRD) further confirmed the successful incorporation of increasing h-BN content into the vitrimer matrix, based on the increased normalized intensity of h-BN characteristic peak. Stress relaxation experiments were performed to measure characteristic relaxation times (τ) of the vitrimer electrolyte and to examine how h-BN affects dynamic bond exchange kinetics. Characteristic relaxation times increased with h-BN loading. At the highest h-BN loading, however, bond exchange was faster than in all other samples. This nonmonotonic trend may reflect complex interactions among dissociated ions, fillers, and the polymer matrix. Electrochemical impedance spectroscopy (EIS) showed that ionic conductivity increased up to an optimal h-BN loading of 0.6 wt% and then decreased monotonically. This behavior may arise from competition between h-BN-assisted salt dissociation and the formation of larger h-BN aggregates. Raman spectroscopy supported that increasing h-BN loading promoted salt dissociation and produced more free ions. Nevertheless, the fraction of dissociated ions that contributes to ion transport, rather than interacting with the fillers or polymer matrix, remains uncertain. Finally, the reprocessability of the h-BN-filled vitrimer electrolytes was demonstrated. After multiple reprocessing cycles, the samples showed no significant degradation, and their ionic conductivity and rubbery plateau modulus were retained. Overall, these findings relate h-BN loading to viscoelasticity and ion transport in vitrimer electrolytes for sodium-ion batteries.

ACKNOWLEDGEMENTS

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Purpose-Engineered Alloys for LPBF Additive Manufacturing: From Computational Alloy Design to Functional Component Demonstration

Yongho Sohn, Nicolas Ayers, Sydney Lynch, Shayndel Pido
Department of Materials Science and Engineering, University of Central Florida, Orlando, FL, 32816, USA

Additive manufacturing (AM) has fundamentally transformed advanced materials processing, enabling the fabrication of complex, near-net-shape components with unprecedented geometric freedom. However, widespread adoption of AM across high-performance sectors—including aerospace, biomedical, automotive, and energy—has exposed critical limitations of conventional alloy compositions originally developed for casting, forging, and wrought production. These legacy alloys were not formulated to accommodate the rapid solidification rates, steep thermal gradients, and cyclic thermal histories inherent to AM, resulting in microstructural anomalies, residual stress accumulation, anisotropic properties, and susceptibility to defect formation.

This work presents a comprehensive framework for the application-specific design and development of metallic alloys purpose-engineered for laser powder bed fusion (LPBF). The approach integrates computational thermodynamics, CALPHAD (Calculation of Phase Diagrams) modeling, and alloy theory to guide compositional design by predicting phase stability, solidification pathways, and properties under AM-relevant thermal conditions. Particular attention is directed toward suppressing hot cracking susceptibility, minimizing solidification shrinkage, and promoting microstructurally stable phases that confer application-specific mechanical and functional properties.

Three industry-sponsored case studies are presented, each targeting distinct application requirements: (1) high-temperature oxidation and creep resistance for the energy sector, (2) magnetic shielding for biomedical devices, and (3) neutron radiation shielding for nuclear applications. In each case, alloy design explicitly accounts for composition- and microstructure-dependent functional performance alongside LPBF printability. Both novel and commercially available alloys, with and without targeted compositional modifications, were systematically evaluated across a range of material families, including high-entropy alloys (HEAs), ferrous (Fe), and nickel (Ni) base alloys [1–4]. Candidate alloys were assessed for melt pool dynamics, grain nucleation and growth behavior, and post-build heat treatment response. Down-selected "designer alloys" were fabricated by LPBF for experimental validation, including microstructural characterization and application-relevant property assessment. Functional demonstrator components were additionally manufactured to validate real-world performance under representative service conditions.

Results across all three case studies demonstrate that alloys designed with explicit consideration of both functionality and AM-processability enable engineering components with significantly enhanced performance compared to conventional alternatives. The work underscores the critical role of iterative feedback loops between process assessment, computational alloy design, and experimental characterization in accelerating the qualification of AM-specific compositions. Collectively, the findings advance a robust “materials-by-design” paradigm that aligns alloy chemistry, microstructure, and processing parameters to meet precise application requirements, contributing to the maturity and reliability of LPBF as a mainstream production technology.

ACKNOWLEDGEMENTS
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Materials and Devices for Event–Memory Bifurcation in Dynamic Vision

Won Il Park*, Yelim Kim, Dae Yeop Jeong, Hyeonsu Park, Lia Saptini Handriani
Division of Materials Science and Engineering, Hanyang University, Seoul 04763, Republic of Korea

Real-time dynamic vision requires simultaneous capture of instantaneous brightness changes (events) and accumulated motion context (memory). Conventional event sensors are stateless, and reconstructing memory relies on power-hungry analog-to-digital conversion and digital accumulation. Here, we present complementary in-sensor architectures that physically generate event spikes and decaying memory tails directly at the device, entirely in the analog domain.

We first developed an analog event–memory sensor (AEMS), in which each pixel pairs silicate and garnet phosphors with Si photodiodes and transimpedance amplifiers. Mismatched fast-response kinetics and persistent-luminescence amplitudes between the two channels yield, in their real-time analog difference, fast event spikes (~50–100 μs) and slowly decaying memory tails (>1 ms) whose dynamics are well captured by a linear leaky-integrator reservoir model. The dual analog stream supports lightweight CNN classification of human actions and motion trajectories without any ADC or digital buffering.

To realize a similar event–memory bifurcation within a single device rather than a paired sensor, we further developed a 2D nanofluidic bimodal synapse (2D-NBS). The 2D-NBS integrates a cation-selective 2D nanofluidic ion channel—formed by selectively grown WS_2 (or Al_2O_3) along multilayer-graphene grain boundaries—with an electrode/electric-double-layer (EDL) interface. The ionic current $I(t) = I_0 \cdot \exp(-t/\tau) + I\_ss$ naturally decomposes into a fast EDL event peak and a slow ion-transport memory tail, with τ tunable from ~0.3 to >7 ms. This trajectory-memory representation enables CNN classification and physical-reservoir forecasting at substantially lower energy than digital recurrent baselines.

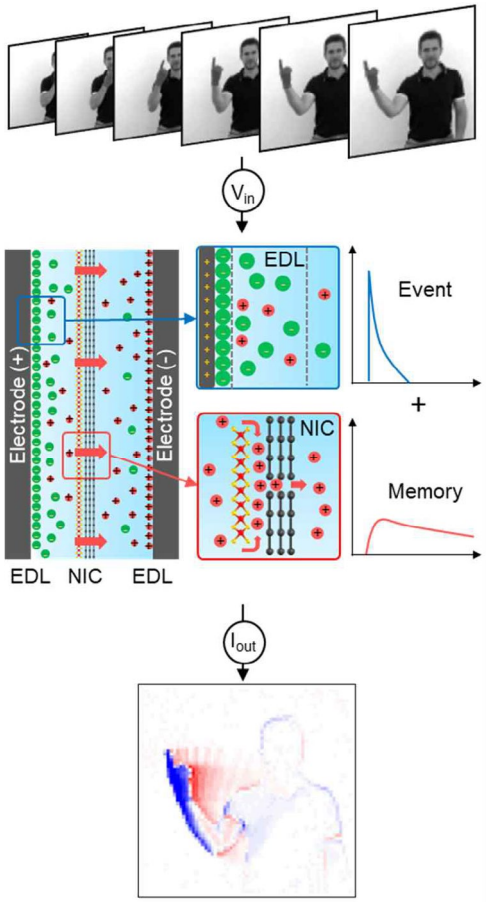


Figure 1: Schematic of the in-sensor event–memory bifurcation realized in the 2D-NBS nanofluidic bimodal synapse.

ACKNOWLEDGEMENTS
This work was supported by the NRF of Korea funded by the MSIP of Korea (RS-2024-00353762).

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IT / Quantum / Semiconductors

Silicon/Glass Interposer Metrology and Inspection by Shadowgraphy

ChaBum Lee[1] and Kuan Lu[1]
[1]J. Mike Walker '66 Department of Mechanical Engineering, Texas A&M University, College Station, TX, USA

I. SUMMARY

Through-glass vias (TGVs) and through-silicon vias (TSVs) are critical vertical interconnects in advanced 3D packaging, where geometric defects and sidewall roughness directly degrade electrical reliability and yield [1-2]. Conventional methods such as SEM and AFM require destructive preparation and offer limited throughput. This work presents a shadowgraphy approach for non-destructive TGV/TSV array metrology with sub-micron accuracy in diameter, depth, and sidewall roughness.

II. METHODOLOGY

The shadowgraphy system employs oblique-angle illumination to project via contours onto a single imaging plane (Figure 1). The TGV system uses 450 nm blue light, and the TSV system uses 1200 nm IR light to penetrate silicon.

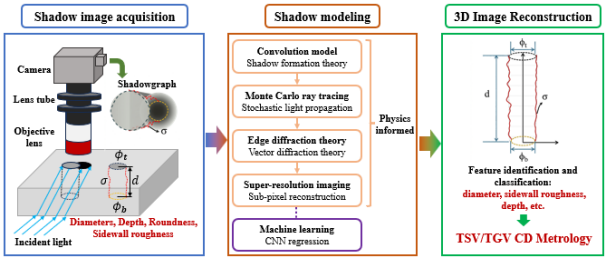


Figure 1: Shadowgraphy-based metrology framework for TGV/TSV inspection.

Top and bottom apertures appear as distinct shadow contours, with TGVs producing an additional waist contour. Diameter and depth are extracted via edge detection and circle fitting. For sidewall roughness, shadow edge gradient is modeled as a diffraction PSF encoding LER information [3], and MCRT simulation combined with CNN inverse mapping estimates roughness from gradient profiles.

III. RESULTS

Table 1 summarizes the measurement results on TGV (60/45 µm surface/waist diameter, 630 µm depth) and TSV (10 µm diameter, 90 µm depth) samples. Both achieve sub-micron diameter and depth accuracy against optical microscopy and SEM references. CNN-based LER estimation yields RMSE of 0.031 µm, consistent with SEM cross-section observations. Single-image acquisition enables simultaneous inspection of entire via arrays without cross-sectioning.

Table 1: Summary of measurement accuracy for TGV and TSV metrology.

	Ref.	RMSE (µm)	MADR (%)
TGV Dia.	OM	1.48	2.54
TGV Dep.	Nom.	0.87	0.13
TSV Dia.	OM	0.19	1.40
TSV Dep.	SEM	1.04	1.00
TSV LER	CNN pred.	0.031	-

IV. CONCLUSION

The proposed shadowgraphy framework enables non-destructive, array-scale TGV and TSV inspection from a single image, with sub-micron accuracy for both dimensional and roughness characterization. Future work will extend this methodology to other interconnect structures.

ACKNOWLEDGEMENTS

This research was supported by the National Science Foundation (2426512).

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Multiphysics Analysis of Architecture-Dependent Variability in Valence-Change Resistive Memory

Jinwoo Oh and Yongwoo Kwon
Department of Materials Science and Engineering, Hongik University

SUMMARY

This study presents a comprehensive electrothermal–phase-field simulation framework designed to quantitatively analyze conductive filament formation and switching voltage variability in hafnia-based Resistive Random-Access Memory (RRAM). By concurrently solving governing equations for current continuity, heat conduction, and oxygen vacancy evolution via the Cahn–Hilliard formulation, we successfully captured the full switching cycles. The simulation results demonstrate how the spatial restriction of the active HfO_2 layer—comparing planar and confined architectures with identical electrodes—influences the distribution of electric fields and dictates the uniformity of switching voltages.

Keywords: RRAM, device simulation, phase-field model, variability

I. MOTIVATION

RRAM is a leading candidate for next-generation non-volatile memory due to its high scalability and low power consumption. However, the stochastic nature of conductive filament (CF) formation leads to significant variability in switching voltages, posing a major challenge for reliability. Since the transient, nanoscale dynamics of oxygen vacancies are difficult to observe experimentally, developing a robust numerical model is essential. Such a model allows for the visualization of filamentary evolution and provides a predictive tool to optimize device architectures, specifically by controlling the active layer geometry to improve switching uniformity.

II. SIMULATION MODEL AND RESULTS

We developed a comprehensive 3D multiphysics model that self-consistently couples electrostatic potential, heat dissipation, and ionic transport. The dynamic evolution of CFs is captured by a phase-field variable governed by the Cahn–Hilliard equation, allowing for the simulation of CF growth and rupture. Utilizing this framework, we analyzed switching variability of device architectures adopting planar and confined HfO_2.

In the planar architecture, the lateral extent of the HfO_2 layer beyond the electrodes allows an initial defect (ID) to be randomly distributed over a broad area. This structural feature, combined with electric field enhancement at the electrode edges, creates competitive CF paths, leading to significant stochasticity. In contrast, the confined structure restricts the HfO_2 within the electrode width, effectively focusing the electric field toward the center. This confinement limits the available site for ID-driven filamentation and forces growth along a localized path. Consequently, the confined architecture demonstrates a remarkable reduction in voltage variation and a substantial improvement in switching uniformity, regardless of the inherent randomness of initial defect locations.

ACKNOWLEDGEMENTS

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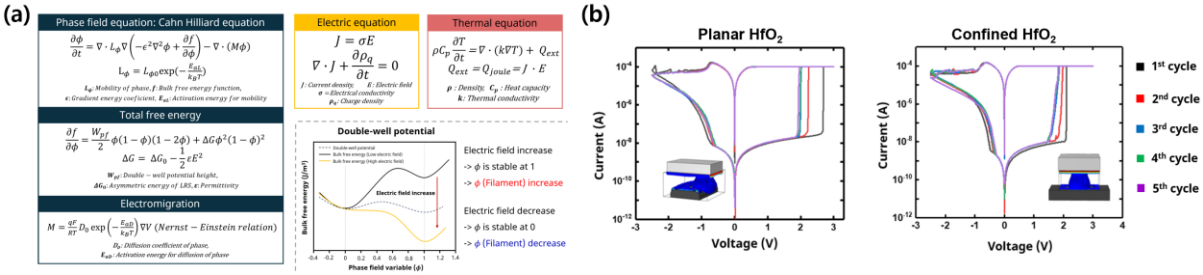


Figure 1. Simulation model and results: (a) description of simulation model and equations, (b) simulated I-V curves of RRAM devices adopting planar and confined HfO_2.

Novel framework for non-equilibrium quantum physics

Jong Yeon Lee[1]
[1]University of Illinois Urbana-Champaign

ABSTRACT

Real quantum materials and quantum devices are never perfectly isolated: interactions with the environment create noise and turn what would be a clean quantum state into a messy statistical mixture. In that "messy" regime, many of the usual tools physicists rely on stop being helpful. My research program builds a practical way to understand and classify these noisy quantum systems. It has two goals. First, I want to define and detect different "phases" of quantum matter directly in the noisy, mixed-state setting, using ideas from quantum information—essentially, asking what information about the system remains stable even when the system is imperfect and interacts with its environment [1]. Second, I want to explain how familiar large-scale behavior—like diffusion (slow spreading of heat or charge) and sound-like waves—emerges from the underlying microscopic quantum dynamics when the system is open to the environment [2,3]. The key idea is to replace the conventional equilibrium criterion with new stability conditions based on how information behaves when you zoom out and average over small details. The outcome will be both fundamental (new organizing principles for noisy quantum matter) and practical (diagnostic tools that connect microscopic quantum processes to measurable transport in experiments and quantum devices).

Significance

Phases of matter are the organizing principle of condensed-matter physics, but the standard phase concept is built around equilibrium assumptions. Outside those assumptions—such as transient snapshots of decohering systems, driven platforms, and non-equilibrium steady states—there has been no general, self-contained definition of phase that is physically. The main challenge is that the conventional notion of phase relies on local, gapped parent Hamiltonians and adiabatic connectivity, which does not exist for generic mixed states. A fully consistent framework has been an open problem.

My research program addresses two connected problems. First, I seek guiding principles for mixed-state phases by introducing an information-theoretic surrogate for a spectral gap—a quantitative constraint on mixed states that plays the same stabilizing role a gap plays for pure-state phases, see **Fig. 1**. Second, I develop a bottom-up route from microscopic open-system dynamics to emergent hydrodynamics, yielding controlled predictions for heat and charge transport and practical diagnostics for noisy quantum simulators. Together, these efforts sharpen and ultimately resolve the long-standing, often imprecise link between microscopic quantum dynamics and macroscopic phenomenological hydrodynamics with quantitative, testable predictions.

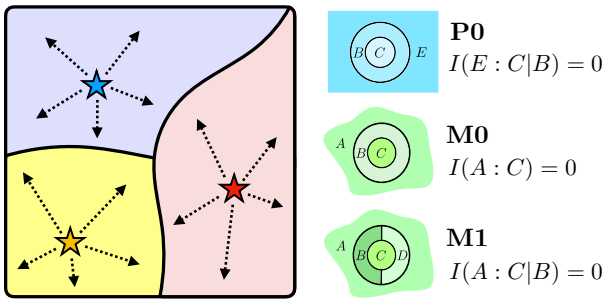


Figure 1: ABC

ACKNOWLEDGEMENTS

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IGZO-Based Neuromorphic System for Spiking Neural Networks

Yumin Yun[1]
[1]Department of Electrical and Computer Engineering, Seoul National University, Seoul, Republic of Korea

I. SUMMARY

Neuromorphic computing has emerged as a leading approach to overcoming the memory bottleneck of conventional von Neumann architectures by mimicking the human brain's efficient computational operations. A hardware-based spiking neural network (SNN), regarded as the third generation of neural networks[1], requires two tightly coupled components: artificial synapses that retain analog weights and neuron circuits that perform integrate-and-fire (I&F) operations. Amorphous indium–gallium–zinc–oxide (IGZO)[2] is an attractive channel material for both components because of its extremely low leakage current, low-temperature fabrication process, and compatibility with back-end-of-line (BEOL) and monolithic three-dimensional (M3D) integration, enabling both high-performance operation and area- and energy-efficient computing systems.

In this work, we present an IGZO-based neuromorphic system[3],[4] in which the synapse and neuron are built on the same fabrication process, and we evaluate the integrated system through SNN simulation.

II. IGZO-Based Neuromorphic System

Building on our recent reports[3], [4], we summarize an IGZO-based optoelectronic neuromorphic system that leverages the photosensitivity of IGZO originating from photoinduced ionization of oxygen-related defects. The proposed double-gate IGZO neuron circuit operates as a pulse generator during programming and as an integrate-and-fire (I&F) neuron during inference. SNN-based pattern recognition was simulated with 784 input neurons, three fully connected hidden layers, and one output layer, with pixel grayscale encoded as proportional spike counts. The system achieved a maximum classification accuracy of 95.46%.

III. Discussion

These results demonstrate the potential of an IGZO-based neuromorphic system for next-generation low-power computing through synapse–neuron co-integration.

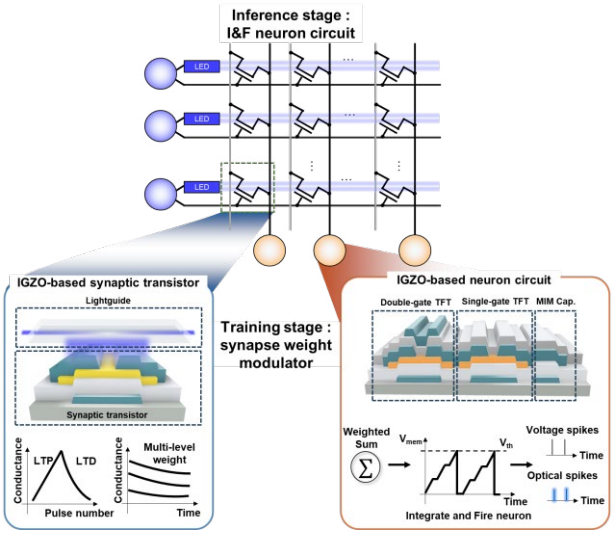


Figure 1: IGZO-based neuromorphic system. Reproduced and adapted from [3] under CC-BY 4.0.

ACKNOWLEDGEMENTS

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Research Trends in LLM-Based Code Generation

Uisang Lee[1]

[1]Department of Electrical and Computer Engineering, Seoul National University

I. SUMMARY

Large language models (LLMs) have recently achieved strong performance in code generation, demonstrating high accuracy on benchmarks such as HumanEval and MBPP. These capabilities are now extending to domain-specific tasks, including quantum code generation evaluated by QuanBench. However, despite these advances, LLMs still struggle with complex reasoning, domain-specific constraints, and probabilistic outputs. This paper briefly reviews recent trends in LLM-based code generation, analyzes benchmark performance, and discusses key limitations and future directions.

II. BACKGROUND

LLMs have rapidly evolved into powerful tools for automated code generation by leveraging large scale code datasets. Current research is broadly divided into two paradigms:

- Autoregressive (AR) Models : generate tokens sequentially and achieve strong performance in syntactic correctness, but often struggle with long-range dependencies and reasoning tasks.
- Diffusion-based Models : refine entire sequences, enablng bidirectional context modeling and potentially improving global consistency.

LLMs are increasingly applied beyond general-purpose programming to domain-specific areas such as quantum computing. In this domain, frameworks such as Qiskit, Cirq, and Pennylane are widely used, and outputs are probabilistic rather than deterministic. To evaluate code generation performance, several benchmarks are commonly used: HumanEval for function-level synthesis, MBPP for general Python tasks, and QuanBench for quantum code generation.

In these benchmarks, performance is commonly measured using pass@1, which denotes the probability that a model generates a correct solution on the first attempt. Unlike metrics that allow multiple samples (e.g., pass@k), pass@1 reflects the model's ability to produce correct and executable code without retries, making it a strict and practical measure for real-world deployment.

III. LLM-Based Code Generation

Benchmark	Paradigm	Model Type	Pass@1 (%)
HumanEval	AR	GPT-4 [1]	67.0~86.6
		Codex 5.3 [5]	93.1
MBPP		GPT [1]	75–90
		Claude Opus 4.6 [5]	88.6
HumanEval	Diffusion	LLaDA [2]	35~45
MBPP			50~65
QuanBench	AR	GPT-4 [4]	< 40
QuanBench Plus		GPT-4 [4]	42.9~59.5

AR models achieve strong performance on standar d code generation benchmarks, but their sequential nature limits global consistency. Diffusion models of fer an alternative by refining entire sequences, thou gh large-scale models are still under development. Performance degrades in domain-specific tasks suc h as QuanBench due to specialized constraints.

IV. CONCLUSION

In this paper, we reviewed recent advances in LLM-based code generation across general and domain-specific benchmarks. While autoregressive models achieve strong performance, they remain limited in handling complex structure and specialized constrai nts. Diffusion-based approaches offer a promising a lternative, but large-scale models are still under dev elopment.

ACKNOWLEDGEMENTS

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Toward the Quantum Simulation and Computing Platform of Ultracold Quantum gases of Polar Molecules

Sungjun Lee, Jongyeol Kim, Jaeryuong Chang
Pohang University of Science and Technology

Ultracold dipolar molecules have become a promising platform for quantum science and technology. Their large electric dipole moments enable strong, long-range, and anisotropic interactions, allowing access to many-body phenomena beyond conventional contact-interacting systems. These features open opportunities to study exotic quantum phases and implement quantum simulation of extended lattice models. In addition, the rich internal structure of molecules provides a versatile resource for quantum information processing and precision measurements.

The realization of stable, quantum degenerate gases of polar molecules is a key milestone for these applications. A well-established approach involves the association of weakly bound molecules near an interspecies Feshbach resonance, followed by coherent transfer to the rovibrational ground state via STIRAP. This method has enabled the production of a wide range of bialkali molecular systems and rapid progress toward quantum degenerate molecular gases. Among these, NaK molecules are particularly attractive due to their large electric dipole moment and chemical stability in the ground state, which suppresses two-body losses. In addition, the availability of both bosonic and fermionic isotopologues makes NaK a versatile platform for exploring dipolar many-body physics and quantum statistical effects.

We report the development of an ultracold bosonic ^{23}Na–^{41}K molecular platform for quantum simulation and quantum computing. Ultracold polar molecules provide a promising route toward scalable quantum computing and simulation due to their long-range and anisotropic dipolar interactions. However, realizing stable bosonic molecular systems remains experimentally challenging.

In this work, we constructed the experimental apparatus from the ground up and successfully realized the first bosonic NaK platform in our laboratory. Starting from dual-species Bose–Einstein condensates, we achieved Feshbach molecule formation near interspecies resonances. The system benefits from a large positive background scattering length, enabling efficient molecule association and favorable stability near threshold.

Our current efforts focus on extending this platform toward coherent control and excited-state spectroscopy, with the long-term goal of creating ground-state polar molecules for quantum simulation applications. The developed system provides a robust starting point for exploring dipolar many-body physics and implementing molecule-based quantum technologies.

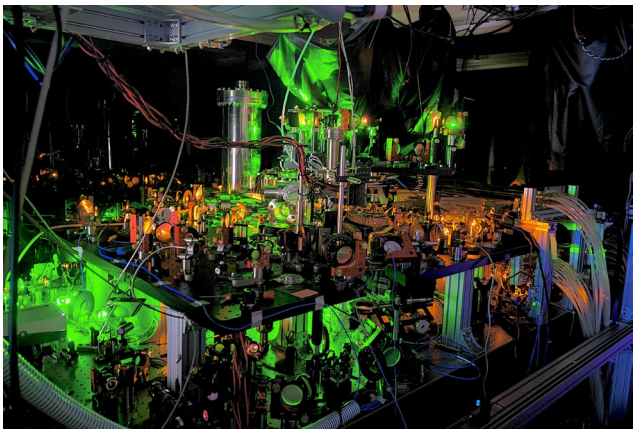


Figure 1: Machine of ultracold dual species NaK platform.

ACKNOWLEDGEMENTS

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Radiation Effects on DDR4 DRAM Under Cryogenic Conditions: Temperature-Dependent Analysis of Proton and Gamma-Ray Induced Errors

Jungsik Kim
Department of Electrical Engineering, Gyeongsang National University

I. SUMMARY

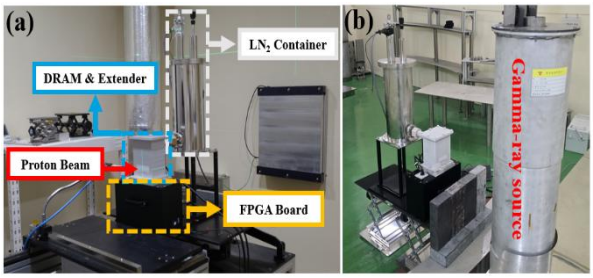


Figure 1: (a) Test equipment setup for the DRAM samples in the proton irradiator at the Korea Multi-Purpose Accelerator Complex (KOMAC), (b) low-level gamma-ray equipment at the Advanced Radiation Laboratory of the Korea Atomic Energy Research Institute.

This work investigates radiation-induced error characteristics in DDR4 DRAM under cryogenic conditions using both proton and gamma-ray irradiation. An 8 GB DDR4 device was irradiated with 53 MeV protons at 77 K, 153 K, and 300 K, and complementary gamma-ray irradiation up to 400 Gy was performed under identical temperature conditions to isolate total ionizing dose (TID) effects [1-3].

Real-time measurements show that single-event functional interrupt (SEFI) occurs across all temperatures [4], [5]. The error density increases significantly under cryogenic conditions, rising from 1.45×10^{-6} at 153 K to 3.98×10^{-6} at 77 K. This behavior is attributed to reduced operating margin caused by threshold-voltage increase and incomplete dopant ionization at low temperatures.

For hard-error analysis, post-irradiation measurements were performed after room-temperature annealing. In proton-irradiated devices, error density decreases as temperature is lowered from 300 K to 173 K but reappears at new memory addresses below 173 K. In contrast, gamma-ray-irradiated devices show a continuous reduction in error density with decreasing temperature, with no errors observed below 173 K.

These results indicate that the cryogenic hard errors observed after proton irradiation cannot be explained solely by TID effects. Instead, displacement damage (DD) plays a dominant role in low-temperature error mechanisms. Therefore, accurate radiation reliability evaluation of DRAM for space applications must consider both temperature-dependent effects and the distinct contributions of TID and DD.

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Liquid Metal Based Flexible Metamaterials and Sensors

Jeong Bong (JB) Lee
Department of Electrical and Computer Engineering, Baylor University, Waco, TX

I. ABSTRACT

Gallium-based liquid metals maintains liquid phase at around room temperature, low vapor pressure, elevated boiling point (1300 °C), and high electrical (3.4×10^6 S/m at 20 °C) and thermal conductivity. When used in combination with soft polymers such as PDMS, it finds applications in soft/flexible electronics. This presentation will give an overview of recent study of liquid metals and their applications in metasurfaces and sensors.

II. LIQUID METAL FLEXIBLE METASURFACES

Metasurface-based frequency selective surface (FSS) exists in 1-D or 2-D as periodic arrays of sub-wavelength metallic elements on dielectric surfaces. Traditional metasurfaces have been realized on rigid substrates. Recently, liquid metal injection in microfluidic channels in PDMS has been used to realize physically flexible metasurfaces. While the metasurface is flexible, serial injection/withdrawal of liquid metal in all connected microfluidic channels may limit its application. Injection filling is also known for leaving airgaps and may cause device delamination.

Mitra et al. reported high-throughput rapid manufacturing of a large (up to 10 x 10) array of physically flexible (bendable, stretchable – up to 89.13%, twistable, and foldable) self-healing metasurface designed to be operated in the X-band using galinstan liquid metal encapsulated in PDMS [1]. Repairability and self-healing of the flexible metasurface have been tested and the repaired/self-healed flexible metasurface showed its transmission characteristics have been completely restored.

III. LIQUID METAL TILT SENSOR

Capacitive liquid-based tilt sensors offer advantages such as environmental stability, mechanical robustness, and linear output characteristics. However, achieving high sensitivity remains challenging due to the low permittivity of dielectric liquids and the inevitable air gaps between the electrodes.

Jeong et al. reported a new design using a liquid metal movable electrode to improve the sensitivity of capacitive tilt sensors [2]. The tilt sensor was fabricated using liquid metal as a movable electrode, a metallic fixed electrode, and a plasma-etched polyimide as fixed dielectric layer. To make the liquid metal electrode moveable, optimization of plasma process was performed to achieve non-wetting surface against the liquid metal. By using liquid metal movable electrode, the proposed tilt sensor showed high sensitivity of 3.67 pF/°, several orders of magnitude higher than the previous works.

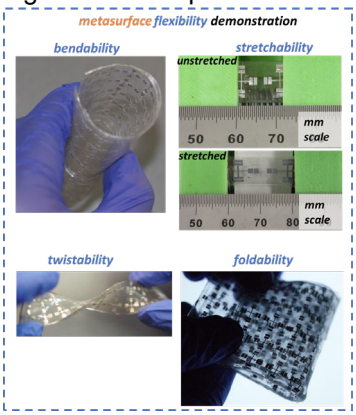


Figure 1: Liquid metal based 10x10 array flexible X-band band-stop metasurface.

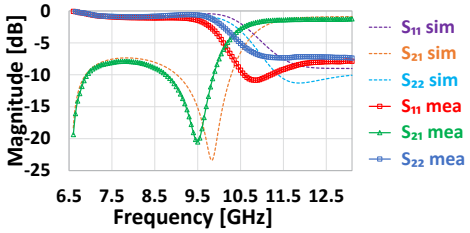


Figure 2: Simulation and measurement of the 1 x 2 metasurface sample using WR-90 waveguide.

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A Low Loss RF Conductor Using Cu/Co Multilayer Metaconductor for W Band Applications

Hanna Jang[1], Alexander Wilcher[2], Yong-Kyu Yoon[3]
[1]Department of Electrical and Computer Engineering, University of Florida

I. INTRODUCTION

The rapid growth of W band systems requires low loss transmission lines with high signal integrity. However, conductor loss increases at high frequencies because the skin effect confines current near the conductor surface, increasing RF resistance and insertion loss. Cu/Co multilayer metaconductor can suppress the skin effect by engineering the effective magnetic permeability of the conductor [1]. Although RF loss reduction using Cu/Co and Cu/Fe metaconductor has been demonstrated at millimeter wave (mmWave) frequencies [1][2], W band operation has not yet been experimentally verified. In this work, we demonstrate a 5 mm length Cu/Co metaconductor transmission line for low loss W band interconnect applications.

II. METACONDUCTOR ANALYSIS AND DESIGN

A. Skin Effect

At DC, current flows uniformly through the entire conductor cross-section, whereas at high frequencies, the skin effect confines current near the conductor surface. The characteristic penetration depth at which the current density decreases to approximately 37% of its surface value is defined as the skin depth, δ.

$$\delta = \sqrt{\frac{2}{\omega_{\mu_{eff}}\sigma}} \quad (1)$$

where ω, μ_{eff}, and σ are the angular frequency, effective magnetic permeability, and electrical conductivity, respectively. According to (1), reducing μ_{eff}increases the skin depth, and δcan theoretically become infinite when $\mu_{\text{eff}} = 0$. By stacking non-ferromagnetic Cu layers with ferromagnetic Co layers, their positive and negative permeabilities can partially cancel, reducing the effective permeability of the multilayer conductor as follows:

$$\mu_{\text{eff}} = \frac{\mu_N t_N + \mu_F t_F}{t_N + t_F} \quad (2)$$

Thus, μ_{eff} approaches zero when the magnetic permeability and layer thickness can be properly selected.

B. Magnetic Behavior of Cobalt Thin Film and Measurement Results

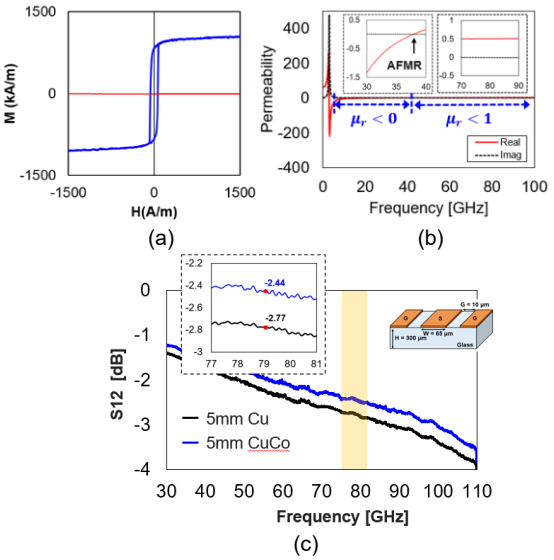


Figure 1. Characterization of Cu/Co metaconductor for W-band low-loss transmission line applications.

Cobalt was selected as the ferromagnetic layer of the Cu/Co metaconductor due to its high frequency magnetic response. The magnetic properties of a 25 nm Co thin film were characterized by VSM, and its frequency-dependent permeability was extracted using the Landau Lifshitz Gilbert model. Fig. 1(a) and (b), Co exhibits FMR and AFMR behavior, resulting in negative permeability between FMR and AFMR. Although the Co thin film shows positive permeability in the W band range, the Cu/Co multilayer still exhibits a lower effective permeability than solid Cu, whose relative permeability is approximately 1. This reduced μ_{eff} increases the skin depth and promotes a more uniform current distribution compared with solid Cu. Therefore, the Cu/Co metaconductor is expected to reduce RF conductor loss in W band transmission lines.

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Dry Metal-Assisted Chemical Etching (MACE) for Black Silicon Fabrication

Taeyon Kwon[1], Yong-Kyu Yoon[1]
[1]University of Florida

I. SUMMARY

Black silicon (B-Si) is widely known for its ultra-low reflectivity and high absorptance, enabled by micro/nano-structured surfaces that trap incident light. Conventional fabrication methods, including reactive ion etching (RIE), femtosecond laser processing, and wet metal-assisted chemical etching (MACE), often involve high cost, complex processing, or liquid-phase limitations [1].

In this work, we demonstrate black silicon fabrication using a dry metal-assisted chemical etching (d-MACE) process based on HF vapor and Pt catalyst, following the approach introduced by Hwang et al. [2]. Unlike conventional wet MACE, this method operates in a vapor-phase environment under atmospheric conditions, enabling directional etching without liquid immersion.

II. BACKGROUND

Black silicon is formed by introducing micro- and nano-scale structures on silicon surfaces, such as spikes, pores, or columns, which significantly reduce reflection through multiple internal reflections and light trapping, enabling high absorptance. MACE is attractive for its simplicity and ability to form high aspect-ratio structures via catalyst-assisted etching in HF solutions. However, wet MACE requires liquid handling, can introduce contamination, and limits process integration. Dry alternatives remain largely unexplored.

III. SIMULATION

Electromagnetic simulations were performed using COMSOL Multiphysics to evaluate the optical response of B-Si structures. The model consists of an N-doped silicon substrate (5.2×10^{10} cm^{-3}) with cylindrical pillar arrays representing the nanostructure. Key parameters include aspect ratio, radius, and density in the mid-long infrared range (5–25 μm).

The results show ~90% average absorptance over 5–25μm, attributed to multiple scattering and refractive index grading.

IV. EXPERIMENT

The process uses HF vapor etching with a Pt catalyst. After Pt deposition and annealing, the substrate is exposed to diluted HF vapor, where localized hole injection enables directional silicon dissolution, analogous to wet MACE but in the vapor phase. This enables anisotropic etching while reducing moisture-induced nanostructure aggregation.

By controlling HF concentration and substrate temperature, black silicon-like micro/nano-textures are formed. Heating suppresses moisture condensation and structure grouping, with a trade-off in etch rate. The resulting high-aspect-ratio structures enhance light trapping via scattering and refractive index grading, leading to reduced reflectivity and increased absorption.

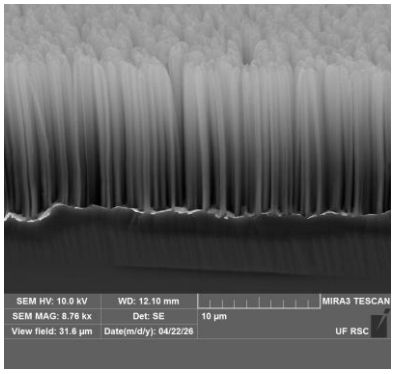


Figure 1: SEM image of the cross section of nanostructure formed on silicon substrate

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An Artificial-Intelligence Agent Framework for Intelligent Livingcare Services at Smart Home

Jaehoon (Paul) Jeong* and Yoseop Ahn*
*Department of Computer Science & Engineering,
Sungkyunkwan University, Suwon, Republic of Korea
Email: {pauljeong, ahnjs124}@skku.edu

***Abstract*—This paper proposes an Artificial-Intelligence (AI) agent framework for intelligent livingcare services at smart home. An AI agent is an intelligent autonomous software system that has capabilities of sensing, inferencing, and action for humans. This AI agent assists in livingcare for all people including elderly people and disabled people in our living environments like smart home. This paper suggests a software framework and interfaces to construct an intelligent and autonomous system that can interact with human users in human languages and actively work for them by sensing their living environments and monitoring their health conditions.**

I. Introduction

Recently, Agentic Artificial Intelligence (AI) has opened a phase in the AI era in our lives, especially livingcare at smart home [1]. The agentic AI provides human users with various intelligent services through AI agents. An AI agent consists of a perception function, reasoning function, and action function. The perception function collects sensing data from various sensors. The reasoning function performs inference from the sensing data for classification, regression, and clustering. The action function performs an appropriate action based on the inference to satisfy a user's intent.

This papers proposes a software framework for an AI agent framework for intelligent livingcare at smart home. This framework is an intent-driven autonomous system to perform a user's intent through intent translation and closed-loop intent control for human users. This AI agent framework consists of a manager agent (e.g., edge computing device) and worker agents. These agents are AI agents that communicate with each other via Agent-to-Agent (A2A) protocol [2] and collaborate with each other for a given user intent. Worker agents include Internet-of-Things (IoT) devices (e.g., appliances), robots, and humanoids. Each worker agent contains Service Functions (SFs) such as a perception function, reasoning function, and action function. Such SFs can be constructed by containers that can be managed by Kubernetes [3].

II. AI Agent Framework for Intelligent Livingcare

For intelligent livingcare services, an AI agent framework includes a Manager Agent and multiple Worker Agents. Fig. 1 shows an AI Agent Framework for Intelligent Livingcare Services at Smart Home. The Manager Agent consists of Manager Controller (as an orchestrator for the AI Agent Framework), Knowledge Graph (as a repository for AI management and orchestration), Manager Analyzer (as an analyzer for worker agents), and Manager Management System (as a vendor system to provide cloud-native containers to worker agents). A Worker Agent consists of Worker Controller (as a manager for the worker agent), Worker Analyzer (as an analyzer for containers), Worker Management System (as a vendor system to manage containers for SFs within the worker agent), and SFs such as perception, reasoning and action functions.

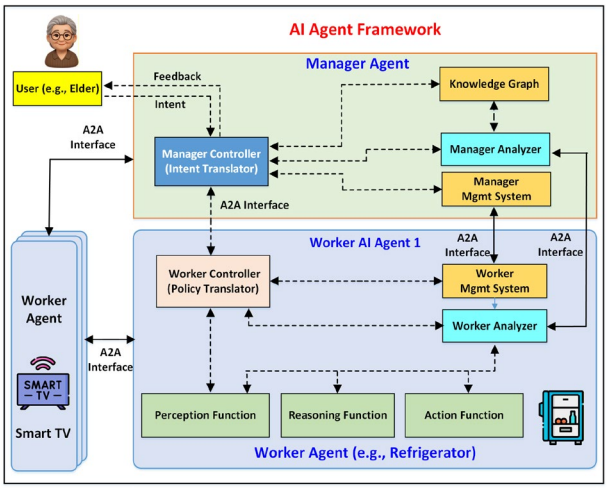


Fig. 1. AI Agent Framework for Intelligent Livingcare Services

A User (e.g., elder) gives her intent in a natural language to the AI Manager. An Intent Translator in the Manager Controller translates the intent into a high-level policy with a Large Language Model (LLM) and the Knowledge Graph. It delivers the high-level policy to an appropriate Worker Agent via A2A Protocol [2]. A Policy Translator in the Worker Agent translates the high-level policy into a low-level policy and delivers it to SFs to perform the intended task.

Acknowledgment

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Air-Hermetic Wafer-Level Packaging for High-Power RF MMICs

Su-Geun Kim, Ju-Yong Lee, Jein Yu, and Jongmin Yook
Korea Electronics Technology Institute

I. SUMMARY

Previous studies have shown that plastic overmold packages can increase thermal resistance and reduce peak CW power in high-power GaN RF devices [1]. To address these limitations, this study presents an air-hermetic wafer-level package for high-power RF MMICs. The proposed package combines air-hermetic sealing, a low-loss RF transition, and Cu-based heat dissipation. By separating the active RF region from organic molding materials, it improves thermal and RF performance.

II. PACKAGE DESIGN

As shown in Fig. 1, the proposed package includes a front-side air-hermetic region and backside Cu structures for heat dissipation. The sealed air region is designed not only as a cavity for air-hermetic sealing but also as an RF design parameter. From the simulated S21 phase response, the equivalent permittivity of the top medium was calculated to be 1.35 at an air-hermetic height of 60 μm.

The RF transition was designed as a GCPW structure using ABF GX-92 as the dielectric material. The optimized transition showed simulated values of a return loss greater than 20 dB and an insertion loss of 0.21 dB at 28 GHz.

III. MEASUREMENT RESULTS

The proposed package was evaluated in terms of thermal, RF transition, and PA performance. At a base plate temperature of 85 °C and a DC power of 6 W, the full-Cu backside WLP reduced the IC surface temperature from 183.0 °C to 108.9 °C and the thermal resistance from 1.33 °C/W to 0.30 °C/W.

For the RF characteristics, the air-hermetic package showed a package loss of 0.606 dB at 28 GHz using a 50-ohm dummy IC. After de-embedding the 50-ohm dummy IC loss, the transition loss was extracted as 0.09 dB per side, indicating low-loss RF performance. Finally, as summarized in Table 1, the embedded ARF1013 amplifier (Altum RF Inc.) achieved a Pout of 37.72 dBm. After compensating for the package transition loss, the PA performance degradation relative to the on-wafer amplifier was only about 0.12 dB.

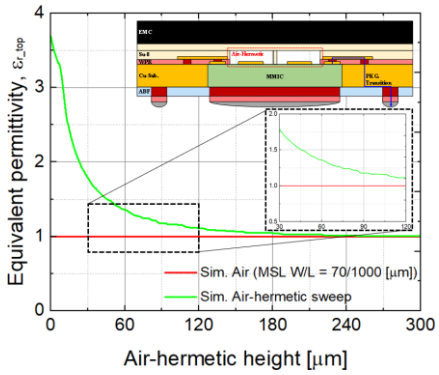


Figure 1: Equivalent permittivity versus air-hermetic height.

Table 1: Comparison of On-Wafer and Hermetic Packaged Power Amplifier Characteristics.

	ARF1013 (On-wafer)	Hermetic PKG.
VDD	22 V	22 V
IDD	1233 mA	1008 mA
Pout	38.02 dBm (6.34 W)	37.72 dBm (5.92 W)
Gain	16.02 dB	15.72 dB
PAE	22.78 %	25.96 %
Psat	-	38.37 dBm (6.87 W)

IV. CONCLUSION

The proposed air-hermetic wafer-level package provides an effective packaging approach for high-power RF MMICs by combining air-hermetic sealing, low-loss RF interconnection, and Cu-based heat dissipation. This approach can support reliable high-power operation in millimeter-wave applications.

ACKNOWLEDGEMENTS

This work was supported by the Ministry of Trade, Industry and Energy's "Super-Gap Technology Development Program (RS-2024-00447334)".

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Metal-Insulator-Metal (MIM) Diode with Different Work Function Metals

Dimitri Brozowski[1] , Honggyun Kim[2], Deok-Kee Kim[2], and Jeongwon Park[1]
[1]Department of Electrical and Biomedical Engineering, University of Nevada, Reno, NV 89557, USA
[2]Department of Semiconductor Systems Engineering, Sejong University, Seoul 05006, South Korea

I. Introduction

Metal–Insulator–Metal (MIM) diodes are emerging as critical high-frequency rectifiers for applications including THz electronics, infrared detection, solar energy harvesting, and advanced display technologies. Unlike conventional semiconductor diodes, MIM diodes rely on quantum tunneling for electron transport, enabling femtosecond-scale switching times and theoretical rectification frequencies approaching 10^{15} Hz [1]. Their performance is governed primarily by device geometry, insulator thickness, and material properties. Maintaining thin insulating layers is essential because the cutoff frequency is inversely proportional to junction capacitance, which increases with insulator thickness. Traditionally, diode asymmetry and nonlinearity have been enhanced by adding multiple insulating layers to form MIIM or MInM structures. While effective, this increases barrier thickness and degrades high-frequency response. This work presents an alternative strategy: engineering the metal electrode work functions to tune rectification characteristics while preserving a single thin insulating layer. By selecting dissimilar metals with controlled work-function differences, asymmetry and nonlinearity can be enhanced without sacrificing switching speed.

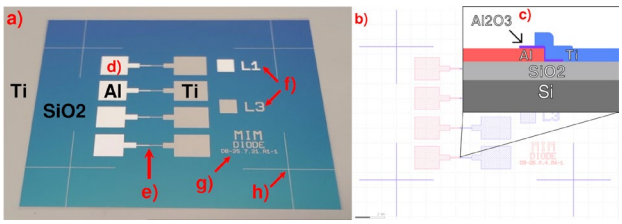


Fig. 1. a) Complete MIM Diode Revision 1 Fabricated on a Silicon Wafer. b) MIM Revision 4, 3-Layer Mask Designed in KLayout. c) MIM Diode Vertical Device Structure Exploded View. d) Test Pad Used for Probing the Diode. e) MIM Junction. f) Mask Layer Labels. g) Wafer Design Date and Revision Code. h) Alignment Markers

II. Metal–Insulator–Metal (MIM) diode structures

Using lithographic processing, multiple MIM combinations were fabricated and tested. Prior work showed that high rectification performance is achieved when the work-function difference between the two metals is [2]. This finding challenges the conventional assumption that maximizing work-function difference is always optimal and significantly expands the range of viable material combinations.

Fabrication and DC I–V/LCR testing further demonstrated that thicker insulators reduce current conduction and cutoff frequency, while larger metal work-function differences increase asymmetry and nonlinearity. Small work-function differences produced nearly linear behavior, confirming the direct correlation between work-function engineering and rectification performance.

III. Summary

This work establishes practical materials design rules and a MIM materials space map that correlates metal work function, insulator, and interfacial stability with device figures of merit. These findings provide a pathway for designing high-speed MIM diodes with tunable performance while preserving the ultra-high-frequency capabilities required for next-generation THz technologies.

ACKNOWLEDGEMENTS

The authors acknowledge support from the Bean Space Foundation and the Global Research program through the National Research Foundation of Korea (RS-2025-02303505).

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Meta-Interconnect: A Metaconductor-Based Interconnect for Energy-Efficient AI Infrastructure

Saeyeong Jeon[1], Yong-Kyu Yoon[1]
[1]University of Florida

I. SUMMARY

This paper presents a metaconductor-based meta-interconnect platform for reducing high-frequency conductor loss in next-generation AI infrastructure and high-speed communication systems. The proposed structure utilizes engineered Cu/Co multilayers to suppress skin-effect-induced AC resistance in the mmWave frequency range. Cu/Co metaconductor coplanar waveguide (CPW) transmission lines were fabricated using scalable electroplating processes and experimentally characterized. Compared with solid Cu structures of identical geometry, the metaconductor transmission lines demonstrated reduced insertion loss and improved high-frequency performance. The proposed concept is compatible with various interconnect architectures, including package routing, coaxial cable structures, and co-packaged copper (CPC) systems.

II. INTRODUCTION

The rapid growth of artificial intelligence (AI) systems and hyperscale data centers is increasing demand for high-bandwidth and energy-efficient interconnect technologies. As communication bandwidth scales toward 112–400 Gbps and beyond, conventional copper interconnects increasingly suffer from severe skin-effect-induced conductor loss at high frequencies, resulting in higher insertion loss and power consumption. To address these limitations, this work proposes a metaconductor-based meta-interconnect platform utilizing alternating ferromagnetic and non-ferromagnetic multilayer conductors [1]. By tailoring the effective magnetic permeability near zero within targeted frequency bands, the proposed structure suppresses current crowding effects associated with the skin effect, thereby reducing AC resistance while remaining compatible with existing electrical interconnect architectures and fabrication processes.

III. RESULTS AND DISCUSSION

Cu/Co multilayer metaconductor CPW transmission lines were fabricated using scalable electroplating processes and characterized in the mmWave frequency range. Figure 1 illustrates the proposed meta-interconnect concept, fabricated multilayer structure, and measured transmission performance. Compared with a solid Cu counterpart of identical geometry, the fabricated metaconductor transmission line demonstrated up to 0.087 dB/mm lower insertion loss and approximately 55% reduced AC resistance within the 28–40 GHz frequency range, attributed to suppression of current crowding effects through engineered magnetic behavior within the multilayer conductor structure. The proposed meta-interconnect platform can be extended to various high-speed communication architectures, including advanced packaging, board-level routing, coaxial interconnect systems, and co-packaged copper (CPC) platforms for next-generation AI infrastructure, providing a potentially lower-cost and manufacturing-compatible pathway toward energy-efficient computing systems.

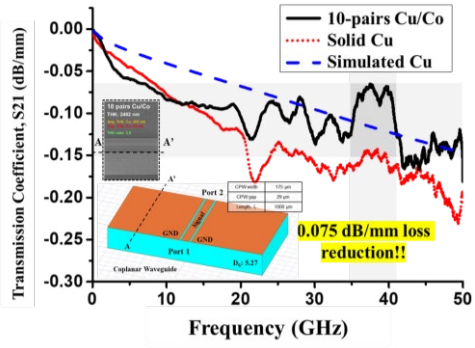


Figure 1: Measured S21 Performance of Meta-Interconnect CPW

ACKNOWLEDGEMENTS

This work was supported by NSF Engines: Florida Semiconductor Engine (Award No. 2315320).

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A Large Language Model-Based Analysis for Identifying Mold-Related Issues in Buildings

San Jin[1], Steven Tanner McCullough[1], June Young Park[1], Insung Kang[1]
[1]Department of Civil Engineering, University of Texas at Arlington

I. SUMMARY

This study proposes a large language model (LLM)-based framework to analyze mold-related issues in buildings using user-generated opinions from social media platforms. The findings will also demonstrate the feasibility of using LLM-driven text mining for detecting building-related health concerns.

II. INTRODUCTION

A growing number of epidemiological studies have found consistent associations between damp indoor environments and increased risk of adverse health effects, including asthma, allergic rhinitis, and respiratory infections.[1] However, traditional methods such as on-site inspections and surveys for assessing mold in buildings are time-consuming, costly, and difficult for reflecting real-time feedback.

At the same time, social media flatforms such as Reddit contain large volumes of user-generated opinions that reflect user's experiences with building environments. These opinions provide rich but unstructured data that are difficult to analyze using traditional methods. Recent advances in LLMs have enabled more effective interpretation of such text data by capturing contextual meaning and semantic relationships.[2]

Therefore, this study proposes a framework to systematically identify mold-related issues from online opinions and to characterize their spatial distribution and variation across building characteristics and climatic conditions.

III. METHODS

The overall methodology follows a structured text-mining workflow consisting of three steps: data collection and pre-processing, semantic structure development, and LLM-based classification.

First, user opinions were collected from social media platform, specifically Reddit, for different building types. The dataset includes user-generated contents (e.g., posts, comments, and reviews) and associated metadata. Pre-processing steps were applied to clean the text, remove short or irrelevant entries, and standardize the data format.

Second, a semantic structure was developed to organize mold-related issues. Unlike simple keyword-based approaches, this structure defines categories of mold-related issues based on building conditions and user's experiences. Enabling consistent classification across different contexts.

Third, a large language model was applied to classify and extract relevant information from the user-generated contents. A zero-shot classification approach was used to determine whether a text contains mold-related content and to assign it to predefined categories. This approach allows the model to interpret contextual meaning without requiring task-specific training data, enabling scalable analysis of large volumes of unstructured data.

IV. RESULTS & DISCUSSIONS

This study analyzed mold-related issues in buildings using an LLM-based approach. The results indicate that (1) mold issues were more frequently reported in regions characterized by higher humidity levels and frequent flooding events (e.g., the U.S. Gulf Coast and coastal Southeast regions); (2) building characteristics, including age, inadequate ventilation systems, and poor insulation, are associated with a higher prevalence of mold issues; and (3) mold issues commonly co-occurred with odor, high humidity, condensation, and water leakage, indicating broader indoor environmental quality concerns rather than isolated moisture problems.

In addition, the LLM-based classification approach demonstrated robust performance in identifying mold-related issues from user-generated opinions. The results further highlight the applicability of the proposed framework for detecting high-risk building characteristics and environmental conditions.

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HIGH-Q 3D MICROPILLAR FREQUENCY-SELECTIVE DEVICES FOR LOW-LOSS TERAHERTZ BANDPASS FILTERING

Jun Ying Tan[1], Danil Khaiumov[2], Jens Neu[2], and Jungkwun 'JK' Kim[1]

[1]Dept. of Electrical Engineering, University of North Texas, Denton, TX; [2]Dept. of Physics, University of North Texas, Denton, TX

I. SUMMARY

This work presents scalable 3D air-lifted micropillar arrays as high-performance frequency-selective devices (FSDs) for terahertz (THz) applications. Fabricated by UV lithography and copper electroplating on glass substrates, the devices achieve approximately 90% resonant absorption at 1 THz with minimal dielectric loss. By removing the substrate from the resonant cavity, the 3D architecture overcomes the ohmic and substrate losses inherent to conventional planar FSDs. Finite-element simulations (Ansys HFSS) and THz time-domain spectroscopy (THz-TDS) measurements show strong agreement, validating the proposed design. This approach provides a scalable, low-loss platform for next-generation terahertz components in 6G wireless communications, THz imaging, and sensing systems.

II. INTRODUCTION

Frequency-selective devices (FSDs) enable precise control of electromagnetic wave transmission and reflection in communication, sensing, and imaging systems. Growing demand for 6G and THz imaging requires FSDs with high selectivity, low insertion loss, and broad spectral stability [1]. Conventional 2D FSDs suffer from significant dielectric losses at THz frequencies and limited 3D field modulation. Air-lifted 3D architectures confine resonance to the metallic structure, eliminating substrate losses. While prior work demonstrated 3D pillar FSDs at Ku-band via additive manufacturing [3], printing resolution prevents scaling to THz. This work addresses that gap using UV lithography-based microfabrication.

III. DEVICE DESIGN AND FABRICATION

The micropillar FSD consists of vertically aligned copper-coated SU-8 pillars on a glass substrate with a fixed pitch P = 170 μm (P ≈ λ/2 at 1 THz). Three devices were fabricated with varying heights (H = 40, 61, 72 μm) and diameters (D = 35–42 μm). SU-8 2025 photoresist is patterned by backside UV lithography through a chromium-on-glass photomask, developed, then metallized via Ti/Cu seed layer sputtering and 10 μm copper electroplating at 10 mAcm^{-2}.

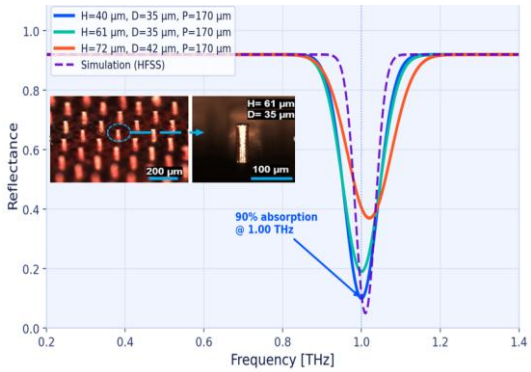


Figure 1: Measured reflectance spectra vs. frequency for three micropillar FSDs with varying heights (P = 170 μm) and HFSS simulation. Inset: optical micrographs of the fabricated array and a single pillar.

IV. SIMULATION AND EXPERIMENTAL RESULTS

HFSS simulations of a single unit cell with Floquet port boundary conditions predict a reflectance minimum of ~0.05 at 1.01 THz (~95% absorption) for the nominal geometry (H = 75 μm, D = 30 μm, P = 170 μm). THz-TDS measurements (0.2–1.4 THz, 45° incidence, Cu reference) are shown in Fig. 1. Sample 1 (H = 40 μm, D = 35 μm) achieved 90% absorption at 1.00 THz; Sample 2 (H = 61 μm) yielded 81%; Sample 3 (H = 72 μm, D = 42 μm) showed 63% with a slight shift to 1.02 THz. Measured results closely match simulation, confirming that shorter pillars produce sharper, higher-Q resonance.

ACKNOWLEDGEMENTS

This work was supported by NSF CNS 2039014, ECCS 2054567, ECCS 2029086, ECCS 2326938, CISE 2438564, and Korea Evaluation Institute of Industrial Technology (KEIT) 20018023.

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Comparative Analysis of ARIMA, LSTM, Transformer, and Prophet Models for Stock Price Forecasting

Jiyoon Moon[1], Navid Nabijou[2]
[1,2]Department of School of Mathematical Sciences, Queen Mary University of London

I. SUMMARY

Accurately predicting volatile, nonlinear stock prices remains challenging. This paper compares ARIMA, LSTM, Transformer, and Prophet models in forecasting daily closing prices for AMZN, MSFT, and XOM using Yahoo Finance data (2022–2025). Employing a walk-forward validation method across 1-day and 3-day horizons, the study reveals a distinct trade-off: statistical models (ARIMA, Prophet) excel in short-term accuracy under stable conditions, whereas neural networks (LSTM, Transformer) exhibit superior error-rate stability as the forecast horizon extends.

II. METHODOLOGY AND RESULTS

A. Data and Model Implementation

Daily data (2022–2025) for AMZN, MSFT, and XOM from Yahoo Finance were preprocessed via winsorization and min-max normalization. Four optimized models - ARIMA (AIC-based), Prophet, and sequence-based LSTM and Transformer - were evaluated using walk-forward validation across 1-day and 3-day horizons based on MAE, MAPE, and RMSE.

B. Discussion on Short-Term vs. Extended Horizons

Results revealed a trade-off between short-term statistical accuracy and long-term neural network stability. For 1-day predictions, statistical models consistently outperformed deep learning. As shown in Figure 1, ARIMA achieved the lowest baseline errors across all tickers, proving highly reliable in low-volatility conditions (XOM), while Prophet also performed robustly. Conversely, LSTM and Transformer exhibited higher initial errors due to data scarcity and high hyperparameter sensitivity in volatile environments (AMZN).

However, the comparative performance inverted at the 3-day horizon. While statistical models had lower baseline errors, their accuracy deteriorated sharply over time. As quantified in Table 1, ARIMA's MAE surged by 70.03% for AMZN and 109.71% for XOM. In contrast, the neural networks maintained highly stable error rates over time; LSTM's MAE increased by only 6.88% for AMZN and a mere 0.21% for MSFT. This confirms that neural networks maintain stable error accumulation rates over longer intervals.

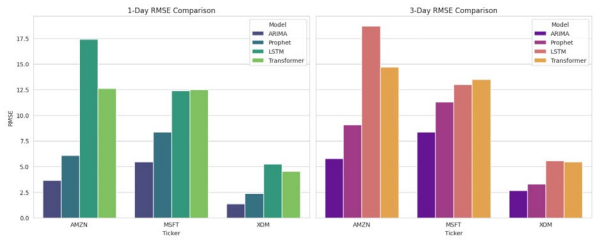


Figure 1: Comparative RMSE by ticker, model, and forecast horizon (1-day and 3-day)

Table 1: Percentage increase in MAE from 1-day to 3-day predictions by model and ticker

Ticker	MAE Increase (%)			
	ARIMA	Prophet	LSTM	Transformer
AMZN	70.03	54.79	6.88	14.95
MSFT	70.40	42.38	0.21	17.85
XOM	109.71	40.76	11.22	26.65

III. CONCLUSION AND FUTURE WORK

Traditional models (ARIMA, Prophet) excel in short-term, stable conditions, while neural networks (LSTM, Transformer) provide superior consistency against error propagation over longer horizons. Thus, model selection must align with market volatility, data volume, and the targeted prediction horizon. Future work will expand this framework by incorporating macroeconomic indicators, news sentiment, and hybrid ensembles (e.g., ARIMA-LSTM) to enhance real-world financial risk assessment.

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Experiential Learning for non-STEM Major Students' Computational Thinking Through AI-Enabled Website Development with No Coding

Sehee Ha, Sam Chung
School of Technology & Computing, City University of Seattle

I. SUMMARY

Traditional Computational Thinking (CT) [1] education relies heavily on theory and formal programming, making it difficult for non-STEM adult learners to understand CT. We challenge how hands-on skill driven experiential learning [2] can serve as an alternative path. For this purpose, we examine how a non-STEM adult learner developed CT by deploying a no-code website to a live server.

II. RELATED WORK

Aldemir et al. (2025) [3] showed that non-CS learners develop CT through hands-on, project-based maker experiences within structured teacher-training contexts. This study extends that finding to a non-traditional adult learner developing CT through real-world, no-code website deployment.

III. APPROACH

A single-case experiential design was employed, in which the participant completed a Hands-On-Skills (HOS) project involving the construction of a website using no-code tools (WordPress, Elementor) and its subsequent migration to a live server. Figure 1 shows the output of the HOS – the deployed live website. When appropriate, students were encouraged to utilize AI tools to assist with content creation and image generation.

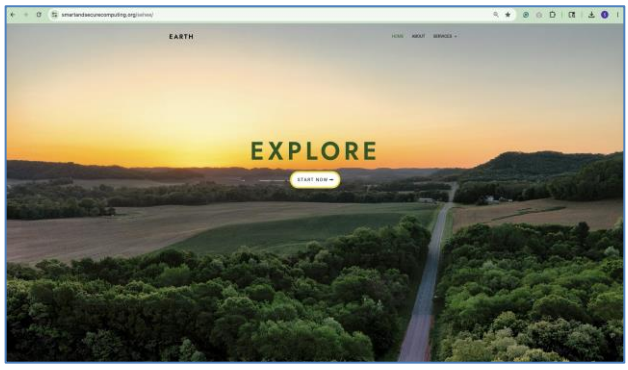


Figure 1: Deployed Live Website

IV. COLLECTED DATA & ANALYSIS

As students work through each HOS, they encounter and resolve real-world problems, fostering a deeper understanding of CT through experiential learning. For instance, the first error involving database overwrite prompted decomposition and abstraction, as the learner had not yet conceptually separated the local and live environments as distinct systems—yet was able to self-diagnose the issue. The second error, a broken link, required pattern recognition; once the instructor identified the issue, the learner realized that URL paths needed to be remapped after migration. Both scenarios necessitated algorithmic thinking: systematically identifying symptoms, hypothesizing causes, applying solutions, and verifying outcomes.

V. FINDINGS

No-code tools may simplify development, but technical challenges and errors persist. Importantly, encountering and resolving these issues through hands-on experience created pivotal opportunities for CT growth. This process shifted the participant's focus from simply identifying what was broken to analyzing the underlying reasons for the system's behavior.

VI. CONCLUSIONS

No-code website deployment offers a compelling, hands-on route for developing CT skills among non-STEM adult learners. Facing a series of iterative and incremental development and deployment rather than abstract exercises created meaningful opportunities for all four CT components - decomposition, pattern recognition, abstraction, and algorithmic design - to become not only relevant but indispensable, even for those without prior programming experience.

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Fully Optical Synaptic Operations Enabled by Wavelength-Tunable Wafer-Scale $PtSe_2$ Layers

Sang Sub Han[1,2], Jung Han Kim[3], Hee-Suk Chung[2], Yeonwoong Jung[1]
[1]University of Central Florida, [2]Korea Basic Science Institute, [3]Dong-A University

I. INTRODUCTION

Artificial synaptic devices have attracted significant interest for neuromorphic computing beyond the von Neumann architecture. However, most optical synapses require complex heterostructures or additional electrical stimuli to realize both potentiation and depression. Here, we demonstrate fully optical synaptic operations using wafer-scale $PtSe_2$ layers exhibiting wavelength-dependent bidirectional photoconductivity. The $PtSe_2$ layers were synthesized by a low-temperature chemical vapor deposition process and integrated onto flexible substrates. This unique wavelength selective photo-response enables comprehensive synaptic functionalities using a single active material platform.

II. RESULTS AND DISCUSSION

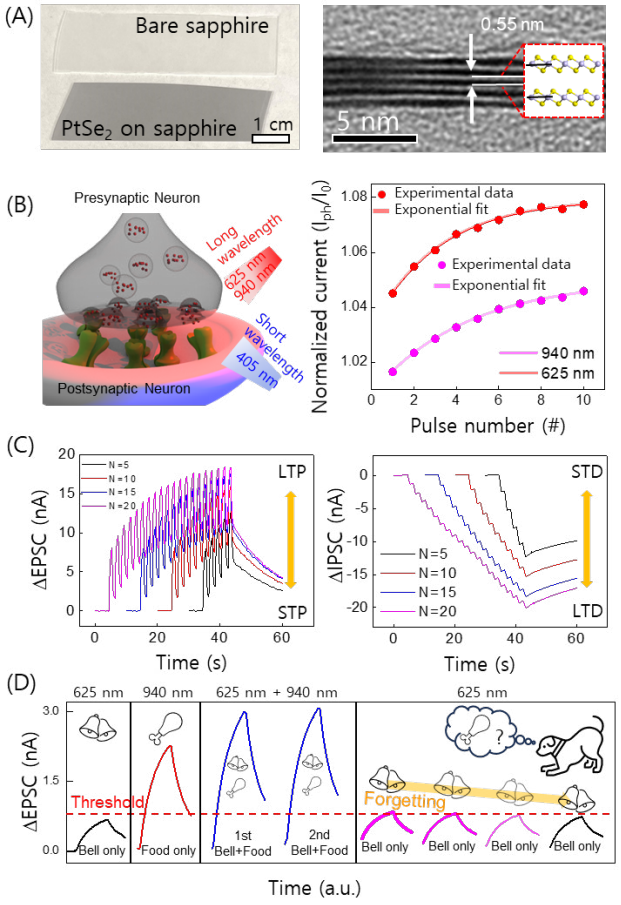


Figure 1. Wafer-scale $PtSe_2$ layers enabling fully optical synaptic operations. (A) Wafer-scale growth and structural characterization. (B) Wavelength-dependent optical synapse concept. (C) Optical potentiation and depression characteristics. (D) Pavlovian associative learning behavior.

Wafer-scale $PtSe_2$ layers synthesized by low-temperature CVD exhibited wavelength-dependent bidirectional photoconductivity, showing positive photoconductivity under 625 and 940 nm illumination and negative photoconductivity under 405 nm illumination. The $PtSe_2$ devices exhibited positive photoconductivity under 625 and 940 nm illumination and negative photoconductivity under 405 nm illumination. This bidirectional photo-response enabled fully optical synaptic characteristics including EPSC, IPSC, PPF, STP/LTP, and STD/LTD. Furthermore, the devices demonstrated stable potentiation and depression behaviors under repeated optical stimulation, highlighting their excellent operational reliability. Pavlovian associative learning was success-fully demonstrated using wavelength-selective optical stimuli, highlighting the potential of $PtSe_2$ for flexible neuromorphic computing systems. The combination of wafer-scale scalability, mechanical flexibility, and fully optical operation makes $PtSe_2$ a promising candidate for next-generation neuromorphic hardware.

III. SUMMARY

We demonstrated fully optical synaptic operations using wafer-scale flexible $PtSe_2$ layers. Wavelength-dependent bidirectional photoconductivity enabled both optical potentiation and depression without electrical stimuli. These results highlight $PtSe_2$ as a promising platform for next-generation flexible neuromorphic and optoelectronic computing systems.

ACKNOWLEDGEMENTS

This work was supported by the National Science Foundation (CAREER: 2142310), the Preeminent Postdoctoral Program (P3) at the University of Central Florida, and the Korea Basic Science Institute. (C624100)

Effectiveness of Input Vector Control for Leakage Reduction in CNFET vs CMOS Technology

Joseph (Yeong-U) Kim
Department of Electrical and Computer Engineering, Illinois Institute of Technology

I. SUMMARY

Input Vector Control (IVC) is a well-known technique to reduce static leakage current by applying a predetermined input vector while the block is unused using the stacking effect. As Carbon Nanotube FETs (CNFET) emerge as a fast, low-leakage device for the post-silicon era, the effectiveness of IVC compared to CMOS is not well known. Therefore, we implement and compare the effects of IVC using ISCAS89 s1488 benchmark built using FreePDK45 CMOS and Stanford CNFET models. Contrary to the expectation that IVC effectiveness would diminish as baseline leakage decreases, we find that IVC yields greater proportional savings in the CNFET benchmark (2.16%) over CMOS (1.31%).

II. Methodology

PMOS length and width are set to 50nm and 180nm, NMOS length and width are set to 50nm and 90nm. For structural equivalence, PCNFETs are given 4 tubes and NCNFETs are given 2 tubes.

The primary gates required for the benchmark netlist including inverters, 2-input logic gates, D-flipflops using 2 D-latches and Transmission Gate MUX are implemented manually. Multiple-input gates are implemented inside the netlist by combining 2-input logic gates. Using these, the base benchmark is built.

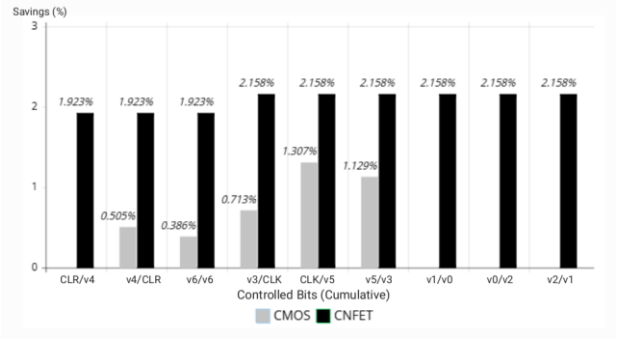
The MUX for IVC hardware is installed bitwise. Hence, there are total of 10 testbenches, from no IVC to IVC on all input bits.

We sweep all 512 input combinations (v0 ~ v6, CLK, CLR) and find the Minimum Leakage Vector (MLV) using the base s1488 benchmark. The leakage for inputs with Hamming distance 1 is measured to find the order of which impacts the leakage the most. We add a MUX in each input in this order and measure each circuit's leakage.

With each circuit using CMOS, we sweep all 512 live inputs with the MLV applied where the MUXes are present. With each circuit using CNFET, we find the input vector closest to the one which yields the average leakage and fix that input in the IVC implemented benchmark. We find the number of MUX which saves the most power. Using this method, we can prevent certain bits which have higher overhead than savings by IVC from being controlled. This is done using both CMOS and CNFETs.

III. RESULTS

Savings from CNFET IVC implementation were greater than those of CMOS, which was counterintuitive. Although CNFET's intrinsic leakage is much lower than CMOS, the relative leakage of the IVC mux network is also proportionally lower, so the overhead consumes a smaller fraction of the savings.



*Implementation with greater overhead than savings not shown

Figure 1: Overall Savings by adding IVC Bitwise

Table 1: Savings by Device

	CMOS	CNFET
Mean Leakage	3.367 e-5	2.132 e-7
MLV Leakage	3.324 e-5	2.081 e-7
IVC Savings	1.31%	2.16%

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Topological Patching for Time Series Forecasting: A Noise-Immune Transformer Framework

Hyeonkyu Kim[1]
[1]Arizona State University

I. SUMMARY

Recent deep time series models, notably patch-wise Transformers like PatchTST, have achieved state-of-the-art performance by capturing local semantic patterns through sub-series patching. However, real-world data is frequently contaminated by complex non-linear noise and temporal disturbances. Traditional patch embedding layers rely on simple linear projections, forcing the network to inevitably encode both the underlying system dynamics and the high-frequency noise. This structurally compromises forecasting accuracy.

To resolve this limitation, we propose Topological Patching, a robust representation framework that mathematically isolates geometric invariants from raw, noisy time series.

II. METHODOLOGY

Instead of mapping raw data directly through linear layers, our framework integrates Topological Data Analysis (TDA) into the tokenization phase.

A. Phase Space Reconstruction

Each temporal patch is transformed via Takens' time-delay embedding. This maps the 1D sequential signal into a multi-dimensional point cloud, reconstructing the geometric trajectories (attractors) of the underlying dynamical system.

B. Topological Tokenization

Persistent Homology is then applied to the point cloud to track structural features across multiple scales. By computing Betti numbers (β_0 for connectivity, β_1 for periodic loops), we generate persistence features. Since high-frequency noise creates only transient, short-lived topological features, it is automatically filtered out. The remaining robust geometric invariants are projected into a latent space, serving as "Noise-Immune Topological Tokens" for the self-attention mechanism.

III. ILLUSTRATIONS

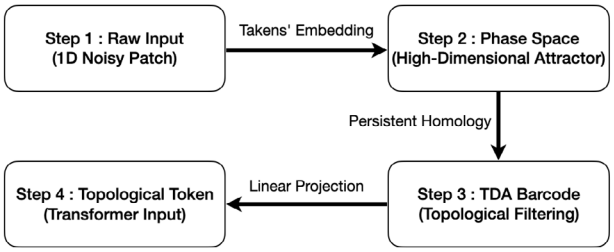


Figure 1: Topological Patching pipeline. A noisy 1D time series patch is reconstructed into a multi-dimensional point cloud via Takens' embedding. Persistent homology extracts structural invariants (long barcodes), filtering out high-frequency noise (short barcodes) to generate clean topological tokens for the Transformer.

IV. CONCLUSION

By introducing structural topological tokens rather than raw values, the self-attention layers can focus strictly on the structural evolution of the time series. Preliminary conceptual evaluations indicate that this framework significantly reduces forecasting errors, such as Mean Square Error (MSE) and Mean Absolute Error (MAE), in highly disturbed datasets. This synergy offers a highly reliable paradigm for safety-critical industrial deployments under high uncertainty.

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Towards Efficient and Context-Aware KV Cache Management for Long-Context LLMs

Gyuwan Kim (Presenter) and Tao Yang
Department of Computer Science, University of California, Santa Barbara

I. SUMMARY

As the context window of Large Language Models (LLMs) expands exponentially, advanced paradigms such as retrieval-augmented generation and cache-augmented generation have emerged as pivotal architectural solutions for processing massive-scale documents without prohibitive retrieval overheads. However, serving these long-context applications introduces a severe systematic bottleneck: the Key-Value (KV) cache size scales linearly with the input text length. This massive memory footprint leads to frequent out-of-memory errors, severely restricts serving throughput, and drastically increases operational latency in production environments.

To mitigate these infrastructure bottlenecks, conventional methods have predominantly focused on static or heuristic-based KV cache reduction, such as uniform dropping of past tokens or maintaining fixed sparsity patterns. Nevertheless, in long-context reasoning, the semantic importance of information is highly dynamic, evolving continually based on the given query and the generation trajectory. Consequently, rigid and non-adaptive compression strategies pose a substantial risk of discarding critical context, which inevitably compromises the model's complex reasoning and long-context comprehension capabilities.

II. CHALLENGES AND STRATEGIES

Instead of advocating for a single rigid compression mechanism, this position paper discusses the necessity of a paradigm shift toward context-aware, dynamic runtime optimization of the KV cache. To preserve model efficacy while maximizing serving infrastructure efficiency, future system designs must transition toward a multi-faceted, dynamic management framework during the text generation phase.

We delineate three essential high-level pillars for this evolutionary direction: (1) Selective Filtering, which precisely pinpoints and retains core contextual segments that substantially contribute to the current generation step; (2) Context-Aware Compression, which adaptively compacts the cache structure while minimizing semantic information loss; and (3) Dynamic Runtime Control, which continuously regulates resource allocation and compression triggers in real-time according to the query properties. We posit that a synergistic integration of these dynamic strategies is imperative for achieving maximal serving efficiency without compromising model performance in long-context scenarios.

Looking further ahead, as artificial intelligence systems increasingly evolve toward collaborative multi-agent environments, the scope of KV cache management must expand beyond the boundaries of a single model instance. In a multi-agent ecosystem, agents frequently operate over overlapping contextual knowledge bases. Developing distributed cache architectures capable of efficient KV cache sharing and real-time dynamic synchronization among heterogeneous agents will become a paramount frontier in system optimization. By highlighting these high-level systematic challenges and dynamic optimization strategies, this work aims to foster timely discussions within the research community regarding the foundational infrastructure for next-generation large-scale intelligent systems.

ACKNOWLEDGEMENTS

This work reflects high-level perspectives and visions shaped through invaluable discussions and collaborations, and the authors sincerely thank all research collaborators for their continuous insights.

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Estimating the Empowerment of Language Model Agents

Jinyeop Song[1], Jeff Gore[1], Max Kleiman-Weiner[2]

[1]Massachusetts Institute of Technology, Cambridge, MA, USA; [2]University of Washington, Seattle, WA, USA

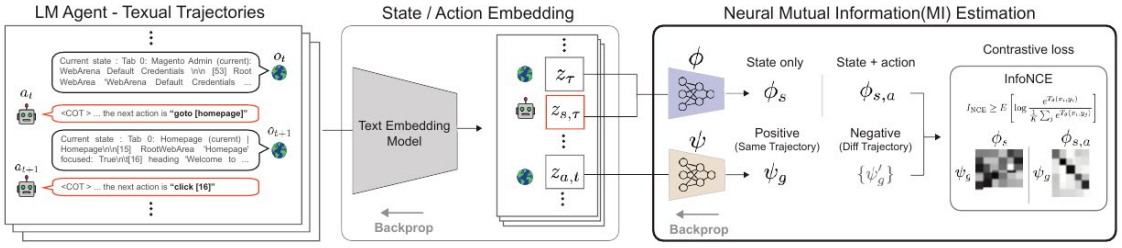


Figure 1: EELMA estimates empowerment from text trajectories by embedding observations/actions and using contrastive mutual-information objectives.

I. SUMMARY

Language-model agents are increasingly used for web navigation, tool use, and multi-step decision making, but most evaluations still depend on hand-written goals and benchmark milestones. We propose empowerment as a complementary goal-agnostic signal: how much an agent's action constrains reachable future states. A highly empowered agent can steer toward diverse futures; a low-empowerment agent loops, gets stuck, or acts without effect.

II. METHOD

Effective empowerment is the expected conditional mutual information between an action and a discounted future state:

$$\mathcal{E}(\pi_{\mathsf{LM}}) = \mathbb{E}_{s_t}[I(a_t; s_* \mid s_t)],$$
$$s_* = s_{t+\tau}, \quad \tau \sim \mathsf{Geom}(1-\gamma).$$

We introduce EELMA (Estimating Empowerment of Language Model Agents), an estimator for text trajectories where clean symbolic states are unavailable. EELMA embeds observations and actions with a pre-trained text encoder, projects them into compact representations, and trains contrastive InfoNCE objectives to approximate this mutual information from trajectory tuples. Rewards, task labels, and hand-coded milestones are not estimator inputs.

III. RESULTS

EELMA was validated on text Gridworld and Tower of Hanoi tasks where direct empowerment can be computed. Its estimates matched ground truth, remained robust under natural-language paraphrases, and assigned higher empowerment to valid state-changing actions than to invalid actions. Empowerment also tracked performance across design choices: removing chain-of-thought reasoning sharply reduced empowerment and reward, longer memory improved both, and stronger closed models and larger Qwen variants often achieved higher empowerment, though scaling was not uniform across model families.

In WebArena, EELMA correlated with discounted reward in GitLab, Reddit, and Shopping Admin domains, with GPT-4o showing the highest overall influence and reward. In tau-bench, empowerment scaled with Qwen model size in the airline domain, but inverted in retail where low-performing models produced diverse invalid tool calls. A safety case study showed that valid authentication actions had higher state-action empowerment than invalid attempts, suggesting a way to surface access-gaining behavior without reward labels.

IV. SIGNIFICANCE

EELMA measures open-ended agentic capability from trajectories when rewards are unavailable or incomplete. It can complement task-success metrics and help monitor influential actions. Its limitations are important: empowerment measures control, not usefulness or alignment. Reasoning bottlenecks, off-domain exploration, or near-floor performance can inflate or weaken its relationship to task success. Estimation still requires representative trajectories, and data needs may grow with environment complexity and horizon.

ACKNOWLEDGEMENTS

We thank the MATS Program and supporting institutions, collaborators, and discussants acknowledged in the full paper.

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How Data Centers Stream Videos

Edward Hong[1]
[1]Independent Researcher

I. SUMMARY

For the past decade there has been an explosion in the quantity of downstream video content available on the internet. The vast majority of the video content available comes from video streaming services (Netflix, Disney+, Amazon Prime) and User Generated Content (YouTube, TikTok, Instagram Reels). All of these videos need to be processed in massive data centers that consume an enormous amount of power.

Videos need to be processed and compressed in a variety of formats to maximize QOE (Quality of Experience) for the end user while simultaneously minimizing costs to the data centers. The strategies by the largest internet companies to process videos is complex and constantly evolving depending on bandwidth costs, electricity costs, and user engagement behavior.

II. TOPICS

A. Video Quality Metrics
Internet companies use industry standard metrics to quantify video quality. These include PSNR, SSIM, and VMAF.

B. QOE vs QOR
How to balance Quality of Experience vs Quality of Results when deploying different video processing strategies.

C. Video Compression Standard
There are a wide range of video compression standards used in internet video traffic. These include AVC, HEVC, VP9, and AV1.

D. VOD vs Live Streaming Strategies
Video compression techniques have to be tuned for the type of content. Video on Demand algorithms vary dramatically to Live Streaming algorithms.

E. ASIC vs FPGA vs x86
Data centers use a wide spectrum of hardware to compress video. There are pros and cons for each type of hardware.

III. ILLUSTRATIONS

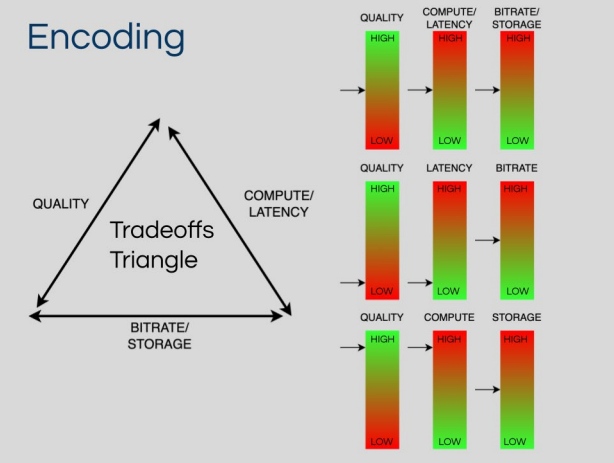


Figure 1: Video Codec Triangle

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AlN MEMS Oscillators Operating in Harsh Environments

Jaesung Lee, Daniel Eduardo Lopez Garcia, Joshua Taggart
Department of Electrical and Computer Engineering, College of Engineering and Computer Science,
University of Central Florida, Orlando, FL 32816, USA

I. SUMMARY

This work reports the high-temperature operation and radiation response of aluminum nitride (AlN) microelectromechanical systems (MEMS) resonators for extreme-environment timing and frequency-control applications. The AlN MEMS resonator maintains stable operation from room temperature (RT) to 800 °C, with a frequency decrease corresponding to a temperature coefficient of frequency (TC*f*) of −12.68 ppm/°C. At 800 °C, the quality factor (*Q*) decreases by only ~15%, while the insertion loss remains nearly unchanged, demonstrating excellent thermal robustness. We also demonstrate a self-sustaining feedback oscillator referenced to the AlN MEMS resonator, with operation at elevated temperatures and under gamma-ray (γ-ray) irradiation at RT. The oscillator results confirm that the resonator remains an effective frequency-selective element under both thermal and radiation stress. These results demonstrate the strong stability of AlN MEMS resonators and their potential for high-temperature and radiation-hard timing systems for automotive, aerospace, turbine, and nuclear energy applications.

II. METHOD & RESULTS

The resonators are fabricated using a Mo/AlN/Mo multilayer stack on Si. The top Mo electrode is defined by dry etching, selected AlN regions are opened using TMAH, Au pads are deposited for reliable electrical contact, and the resonator body is released by SF6-based Si etching. The fabricated device is mounted on an alumina circuit board with Au interconnects and wire bonds to provide stable electrical interfacing during high-temperature testing. Resonance measurements are performed in a high-temperature probe station at ~20 mTorr. At each temperature step, the device is stabilized for one hour before measurement. The measured frequency response remains clearly observable up to 800 °C, with only modest *Q* degradation and nearly constant insertion loss, indicating stable electromechanical coupling and limited additional dissipation under extreme thermal stress. For oscillator characterization, the AlN MEMS resonator is placed in the heated environment while the sustaining feedback electronics remain at RT. The loop includes a low-noise amplifier, phase shifter, filters, directional coupler, attenuator, and limiter to satisfy the Barkhausen gain and phase conditions. Clear oscillation spectra are observed up to 800°C. The measured phase-noise spectra maintain a decreasing trend with offset frequency, showing that the resonator continues to function as an effective frequency-selective element under elevated temperature. We also test the resonator under intense radiation conditions and find robust operation with minimal performance variation, confirming the suitability of the devices for harsh-environment timing and frequency-control systems.

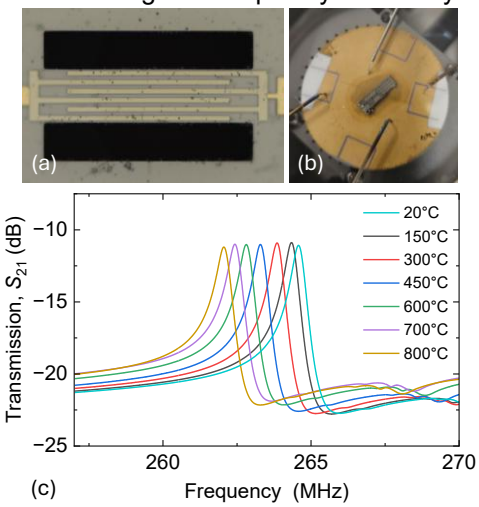


Figure 1: High-temperature operation of AlN MEMS resonators. (a) Optical image of fabricated AlN MEMS resonators. (b) Device chip mounted on an alumina circuit board for high-temperature testing. (c) Measured resonance characteristics from 20 °C to 800 °C, demonstrating stable performance across a wide temperature range

ACKNOWLEDGEMENTS

We thank support from the NASA STTR Program and the Florida High Tech Corridor

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On the Phase of Autocorrelation for Initializing Fourier Phase Retrieval

DongHun Ryu

Department of Electrical Engineering and Computer Science, Massachusetts Institute of Technology

I. SUMMARY

Phase retrieval from intensity-only measurements is central to coherent diffraction imaging (CDI) [1,2]. While the measured intensity's autocorrelation (Patterson map) is widely used for support estimation, it is typically deemed to lack usable phase information. We demonstrate that the autocorrelation phase encodes the object's global phase gradient. We propose *Autocorrelation Phase Initialization* (API), a deterministic initializer extracting this global ramp. API removes global degeneracies and provides a physics-guided prior, improving convergence and stability for solvers like Error Reduction (ER) and Hybrid Input-Output (HIO).

II. THEORY AND METHODS

A. API Phase and Gradients

For an object $\psi(\mathbf{r}) = A(\mathbf{r})e^{i\phi(\mathbf{r})}$, the autocorrelation is $\gamma(\mathbf{u}) = \mathcal{F}^{-1}\{I(\mathbf{q})\}$. For an affine phase $\phi(\mathbf{r}) = \phi_0 + \mathbf{g}\cdot\mathbf{r}$, the phase exactly obeys $\arg\gamma(\mathbf{u}) = \mathbf{g}\cdot\mathbf{u}$. For general non-affine phases, the small-lag slope at the origin equals the amplitude-squared weighted mean of the true phase gradient:

$$\nabla_{\mathbf{u}} \arg\gamma(\mathbf{u})\big|_{\mathbf{0}} = \frac{\int A(\mathbf{r})^2\,\nabla\phi(\mathbf{r})\,d\mathbf{r}}{\int A(\mathbf{r})^2\,d\mathbf{r}} \qquad (1)$$

B. API Algorithm

The API method entails: (1) Defining a central lobe where $|\gamma(\mathbf{u})| \geq \tau$; (2) Unwrapping the phase $\theta(\mathbf{u}) = \arg\gamma(\mathbf{u})$ on this lobe; (3) Estimating the global ramp $\hat{\mathbf{g}}$ via weighted least squares:

$$\hat{\mathbf{g}} \approx -\Big(\sum_{\mathbf{u}} |\gamma|\,\mathbf{u}\mathbf{u}^{\top}\Big)^{-1}\Big(\sum_{\mathbf{u}} |\gamma|\,\theta(\mathbf{u})\,\mathbf{u}\Big) \qquad (2)$$

(4) Constructing an initial support by half-scaling the central lobe mask to object coordinates.

III. RESULTS

Evaluating synthetic 2D datasets using 30 cycles of alternating HIO/ER, API+Patterson achieves the lowest phase error (RMS ≈0.085 rad) and best support overlap (IoU ≈0.615). Conventional random initialization yields much higher errors (RMS ≈1.96 rad). By deterministically de-ramping the seed, API eliminates global degeneracy.

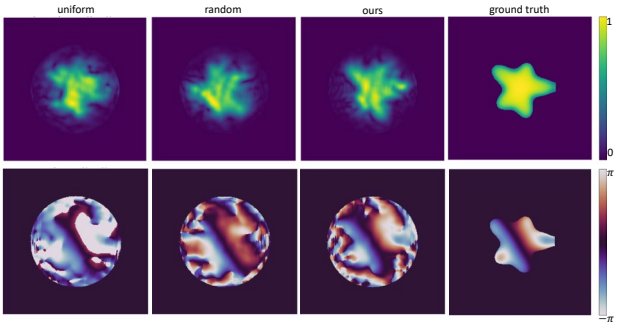


Figure 1: Reconstruction comparison using a loose circular support. API resolves more accurate object orientation and structural details compared to conventional initializations (uniform and random).

IV. CONCLUSION

API deterministically initializes phase retrieval by exploiting the autocorrelation phase to extract the amplitude-weighted mean gradient. It stabilizes and accelerates CDI/BCDI reconstructions, serving as a robust drop-in replacement for random initialization.

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Electric-Field-Driven Quantum Control of Exciton Motion in Semiconducting Carbon Nanotubes

Dong Yoon Shin[1,2], Devinda Udawattage[2], Seungyeop Lee[2], Jacob Fortner[1,2], Ziyi Wang[2], YuHuang Wang[2]

[1]Chemical Physics Program and [2]Department of Chemistry and Biochemistry, University of Maryland, College Park, Maryland 20742

I. INTRODUCTION

Excitons, the Coulomb-bound electron-hole pairs that govern the optical response of semiconducting single-walled carbon nanotubes (SWCNTs), have binding energies of 300 to 500 meV from strong one-dimensional confinement [1], and the chirality-defined near-infrared emission of species such as the (6,5) SWCNT makes them attractive for nanophotonics [2]. Static electric fields quench SWCNT photoluminescence (PL) [3] and redshift the E11 emission through the exciton Stark effect [4, 5], but they do not redistribute the exciton population along the tube. Here we report directional exciton transport in individual (6,5) SWCNTs at room temperature, driven by a time-varying field and set by the sign of the field's time derivative, dE/dt.

II. EXPERIMENTAL AND COMPUTATIONAL METHODS

(6,5)-enriched SWCNTs were spin-coated onto a parylene-C film on quartz and capped by a second parylene-C layer. Au microelectrodes with 10 μm gaps were patterned on top and covered by a final parylene-C layer that insulates the tubes from the electrodes, suppressing carrier injection, doping, and Joule heating. Voltage waveforms were applied while spatially resolved PL was recorded with a hyperspectral near-infrared imaging setup [6]. TDDFT on finite (6,5) tubes (about 4.5 nm) used Gaussian 16 at the B3LYP/3-21G level with natural transition orbital (NTO) analysis.

III. RESULTS AND DISCUSSION

A. Static-field benchmark

Under a static field, PL between the electrodes is quenched and the E_{11} peak redshifts, reproducing the known field quenching [3] and Stark shift [4, 5]. TDDFT reproduces both trends, and NTO analysis shows that the field pushes the electron and hole toward opposite tube ends; the reduced overlap lowers the oscillator strength (quenching) and the axial dipole lowers the transition energy (shift).

B. Directional transport

Under a symmetric triangular field between −1 and +1 V/μm (20 s period), the two ends of an aligned tube show anti-correlated PL oscillations (Fig. 1): one end brightens while the other dims, and the pattern reverses at each slope reversal. Switching occurs at the field maxima and minima, not at the zero crossings, which shows that the controlling variable is d*E*/d*t*, not *E*.

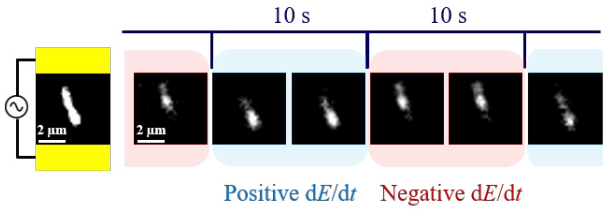


Figure 1: Dynamic exciton transport: frame-by-frame imaging of a single (6,5) SWCNT under a triangular electric field shows periodic, end-selective brightening synchronous with d*E*/d*t*.

C. Direction set by sign of dE/dt

Unipolar waveforms (0 to +1 and −1 to 0 V/μm) give the same end-selective response for the same slope sign despite opposite field polarity, so the direction depends only on the sign of d*E*/d*t*. This excludes static-field drift, dipole alignment, and dielectrophoresis. An asymmetric sawtooth produces a brief PL flash at one end, so the magnitude scales with |d*E*/d*t*|, and perpendicular tubes show no oscillation, confirming one-dimensional transport along the tube axis. This behavior is consistent with a dynamic excitonic dipole that couples to local field gradients [7], at fields about an order of magnitude below static-field studies.

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All-in-One Wearable Bioelectronics for a Continuous Assessment and Early Diagnosis of Acute Kidney Injury

Dr. Woon-Hong Yeo

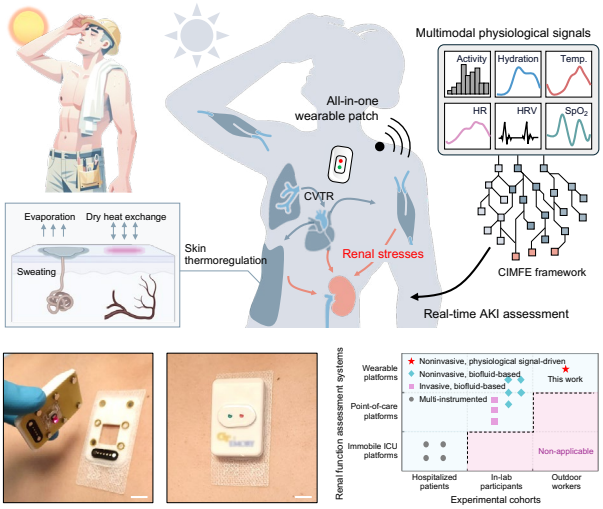
George W. Woodruff School of Mechanical Engineering, Wallace H. Coulter Department of Biomedical Engineering, Georgia Tech and Emory University School of Medicine, Atlanta, GA 30332, USA
Wearable Intelligent Systems and Healthcare Center, Georgia Tech, Atlanta, Georgia 30332, USA

I. INTRODUCTION

Outdoor workers are at a significantly higher risk of acute kidney injury (AKI). Efficient noninvasive monitoring of physiological changes plays a crucial role in the proactive assessment of AKI risk. Here, we introduce an all-in-one wearable platform that presents a class of translational technologies of multimodal sensors, multifunctional materials, snap-on modular electronics, and an AI-based predictive model for continuous renal function assessment and AKI risk. The wearable patch is designed to simultaneously measure temperature, skin hydration, cardiac activities, physical activities, and blood oxygen saturation, which detects continuous changes in serum creatinine, the clinical standard for diagnosing AKI. An in vivo study involving 110 outdoor workers demonstrates that the real-time collection of multiple physiological parameters combined with integrated AI can facilitate early diagnosis of AKI for prompt intervention.

II. RESUTLS AND DISCUSSION

This paper reports the development of an all-in-one wearable platform that integrates a wearable sensor for multimodal signal monitoring and an AI-based predictive model for continuous renal function assessment and AKI risk, specifically designed for outdoor workers. As shown in the figure, the all-in-one wearable patch is designed to simultaneously and noninvasively measure temperature, skin hydration, heart rate (HR), heart rate variability (HRV), physical activity, and blood oxygen saturation (SpO2), which facilitates continuous assessment of renal function and AKI risk. The all-in-one wearable patch comprises a multifunctional patch integrating flexible, low-profile sensors and a miniaturized smart sensor unit, which can be reversibly assembled via magnetic coupling. This integrated system offers high adhesion strength, sweat absorption, wireless connectivity, and reusability, enabling robust fixation, reliable data acquisition, and extremely user-oriented characteristics for outdoor workers. This work introduces a clinically-informed multi-level feature extraction (CIMFE) framework as a real-time, continuous renal function predictive model. This predictive model integrates a clinically-informed pretext task to learn deep-learning-derived features with statistical features, outperforming conventional AI-based predictive models that utilize raw multimodal time-series inputs to basic deep learning architectures.



III. CONCLUSIONS

The all-in-one wearable system presented here demonstrates a translational medical platform enhancing safety and saving lives in high-risk occupational environments. This robust signal monitoring system enables the deployment of a predictive ML framework for continuous renal function and AKI risk assessment, based on the in vivo test with an in-lab cohort of 29 participants and a real-world cohort of 110 outdoor workers. Remarkably, the CIMFE framework exhibits superior performance on this clinical task by learning physiology-informed deep representations through a novel PSI prediction task, which serves as a key indicator of physiological state, and by incorporating static features.

Silicon/Glass Interposer Metrology and Inspection by Shadowgraphy

ChaBum Lee[1] and Kuan Lu[1]
[1]J. Mike Walker '66 Department of Mechanical Engineering, Texas A&M University, College Station, TX, USA

I. SUMMARY

Through-glass vias (TGVs) and through-silicon vias (TSVs) are critical vertical interconnects in advanced 3D packaging, where geometric defects and sidewall roughness directly degrade electrical reliability and yield [1-2]. Conventional methods such as SEM and AFM require destructive preparation and offer limited throughput. This work presents a shadowgraphy approach for non-destructive TGV/TSV array metrology with sub-micron accuracy in diameter, depth, and sidewall roughness.

II. METHODOLOGY

The shadowgraphy system employs oblique-angle illumination to project via contours onto a single imaging plane (Figure 1). The TGV system uses 450 nm blue light, and the TSV system uses 1200 nm IR light to penetrate silicon.

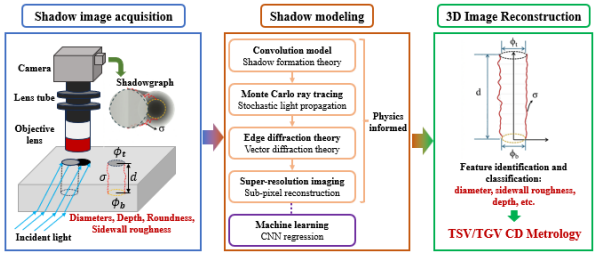


Figure 1: Shadowgraphy-based metrology framework for TGV/TSV inspection.

Top and bottom apertures appear as distinct shadow contours, with TGVs producing an additional waist contour. Diameter and depth are extracted via edge detection and circle fitting. For sidewall roughness, shadow edge gradient is modeled as a diffraction PSF encoding LER information [3], and MCRT simulation combined with CNN inverse mapping estimates roughness from gradient profiles.

III. RESULTS

Table 1 summarizes the measurement results on TGV (60/45 µm surface/waist diameter, 630 µm depth) and TSV (10 µm diameter, 90 µm depth) samples. Both achieve sub-micron diameter and depth accuracy against optical microscopy and SEM references. CNN-based LER estimation yields RMSE of 0.031 µm, consistent with SEM cross-section observations. Single-image acquisition enables simultaneous inspection of entire via arrays without cross-sectioning.

Table 1: Summary of measurement accuracy for TGV and TSV metrology.

	Ref.	RMSE (µm)	MADR (%)
TGV Dia.	OM	1.48	2.54
TGV Dep.	Nom.	0.87	0.13
TSV Dia.	OM	0.19	1.40
TSV Dep.	SEM	1.04	1.00
TSV LER	CNN pred.	0.031	-

IV. CONCLUSION

The proposed shadowgraphy framework enables non-destructive, array-scale TGV and TSV inspection from a single image, with sub-micron accuracy for both dimensional and roughness characterization. Future work will extend this methodology to other interconnect structures.

ACKNOWLEDGEMENTS

This research was supported by the National Science Foundation (2426512).

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Atmospheric Pressure Plasma Deposition for High-Performance PVDF-Based Piezoelectric Nanogenerator

Choon-Sang Park[1], Eun-Young Jung[2], and Heung-Sik Tae[2]
[1]Department of Electrical Engineering, Milligan University, USA
[2]Shcool of Electronic and Electrical Engineering, Kyungpook National University, South Korea,

I. SUMMARY

This work investigates the structrure and dielectric properties of poly(vinylidene fluoride) (PVDF) films for piezoelectric nanogenerators (PENGs) that is grown by atmospheric pressure plasma (APP) process. The fabricated PENGs exhibit an open-circuit voltage that increases from 4.92 to 10.3 V_{pp} with plasma processing time under periodic mechanical impact.

II. METHODS

Figure 1 shows the schematic diagram, a photo of the fabricated APP reactor, and the complete experimental setup used in this study. The APP reactor is a dielectric barrier discharge (DBD) configuration operated with floating ground. The discharge region consisted of a cylindrical glass guide tube (length 80 mm, outer diameter 34 mm) that housed a copper high-voltage electrode covered by a glass dielectric. The counter-electrode (the sample/copper substrate) was electrically floating. The substrate rested on a polytetrafluoroethylene (bluff-body) stand mounted on an electronic rotator to promote uniform exposure. The electrode–substrate separation defined the discharge gap and was adjusted within the reactor chamber to generate an intense, broadened glow-like discharge suitable for precursor fragmentation and film growth. Two argon streams were used and controlled independently. Main Ar flow (ranging from 1000 to 2500 sccm) was used to sustain the plasma discharge, setting the residence time, ambient entrainment, and discharge length. In parallel, a separate Ar stream of 500 sccm was bubbled through the PVDF/DMF solution to introduce vapor into the discharge/near-substrate region. The two streams were mixed at the gas-feeding tube, which feeds into the discharge zone; decoupling them allowed independent tuning of hydrodynamics and precursor supply during deposition

III. RESULTS

Currently, the developments tendency of piezoelectric nanogenerator, will be portable and stretchable electronic devices with light weight [1]. From this point of view, the PVDF and its copolymers have good attractive attention in field of piezoelectric nanogenerator device due to their advantages such as mechanical flexibility, lightweight, piezoelectricity, dielectric property, thermal stability, and high chemical resistance, and good biocompatibility [1,2]. Accordingly, we investigated the structure and dielectric properties of the deposited PVDF thin film by APP process. In summary, we examined the structural and dielectric characteristics of PVDF films by APP process. After plasma deposition, in FT-IR result, the plasma-deposited films show mostly two crystalline phases (α and β phases), which represents the peaks at 1288 and 1400 cm^{-1} for β-phase and the peaks at 765 and 975 cm^{-1} for α-phase, respectively. Based on the experimental results, these two peaks contributed to the enhancement in the dielectric coefficient of PVDF thin film.

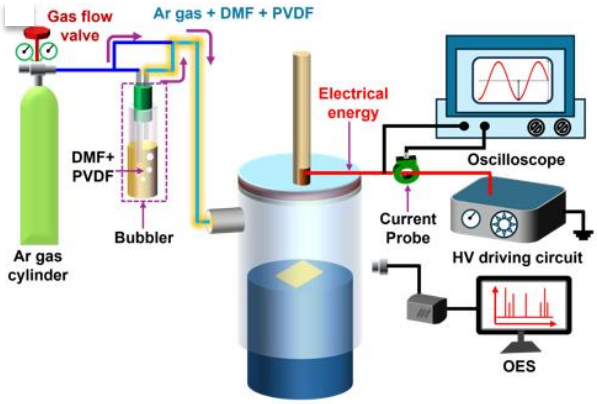


Figure 1: Schematic of the APP reactor and experimental setup.

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Mode conversion of hyperbolic phonon polaritons in van der Waals terraces

Byung-Il Noh[1], Siyuan Dai[1]

[1]Materials Research and Education Center, Department of Mechanical Engineering, Auburn University, Auburn, Alabama 36849, USA

I. SUMMARY

Electromagnetic hyperbolicity, characterized by opposite signs in the principal components of the permittivity tensor ($\varepsilon_i\varepsilon_j < 0$, where i, j = x, y or z), drives important advances in nanophotonics. These include the exceptionally high photonic density of states, unconventional light propagation, and access to deep sub-diffraction optics. Such advances have led to valuable functionalities like super-resolution imaging, efficient energy control, and extreme light manipulation. At the core of these advances and functionalities are high-momentum (high-*k*) hyperbolic polaritons—the nanometer-scale light-matter waves confined in hyperbolic materials. Following the Fabry-Pérot resonance condition, hyperbolic polaritons span multiple energy-momentum (ω-*k*) dispersion branches (Figure 1a, indexed by *l* = 0, 1, 2, …) with incremental momenta k and distinct mode profiles. These different-order hyperbolic polaritons can be studied using far-field Fourier Transform Infrared Spectroscopy on nano-patterned hyperbolic materials. Real-space near-field studies typically image the lowest-k zeroth-order (*l* = 0) hyperbolic polaritons as dominant single-period polariton fringes. While different-order hyperbolic polaritons have been probed, their distinct momenta and mode profiles make them relatively independent, lacking evident interaction, integration, or conversion.

In this work, we report mode conversions of different-order hyperbolic polaritons by breaking structure symmetry in van der Waals (vdW) terraces with engineered step-shape edges (Fig. 1). These mode conversions result from changes in polariton momentum *k* upon reflection at asymmetric step-shape edges, in contrast to conventional symmetric simple slab edges that tend to preserve both momentum and mode profile during reflection. Moreover, the mode conversions of different-order hyperbolic polaritons can be altered by varying the step sizes at the asymmetric edges. Our combined experimental and theoretical results uncover the distinct nano-optical phenomenon of polariton mode conversions by simple vdW engineering. The mode conversion offers a practical approach towards integrating previously independent different-order hyperbolic polaritons with ultra-high momenta for advanced polariton nano-optical functionalities.

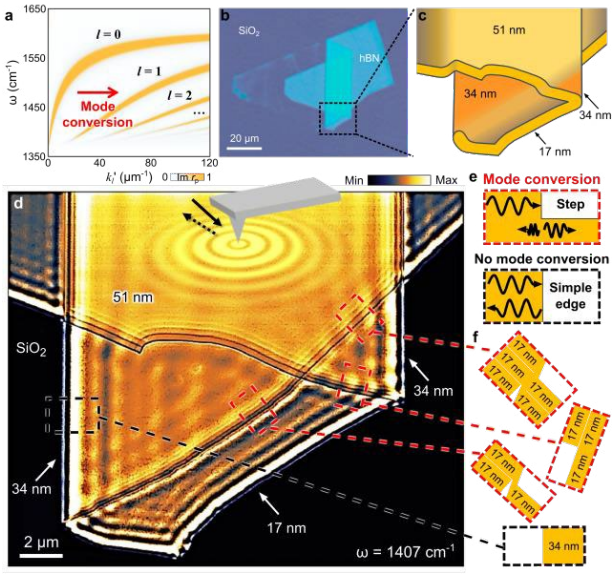


Fig. 1: Nano-infrared imaging of hyperbolic phonon polariton mode conversion in hBN terrace using scattering-type scanning near-field optical microscopy (s-SNOM).

ACKNOWLEDGEMENTS

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End-to-End Computer Vision Pipeline for Perforation Defect Detection and Classification in Industrial Imaging

Joanne Yun[1], Hasnaa Ouidadi[1], Khawlah Alharbi[1], Pengyu Zhang[1], Hantang Qin[1]

[1]Department of Industrial and Systems Engineering, University of Wisconsin-Madison, USA

jyun45@wisc.edu, ouidadi@wisc.edu, kaalharbi@wisc.edu, pzhang256@wisc.edu, hqin52@wisc.edu

I. SUMMARY

Quality control is essential for product consistency and reliability in modern manufacturing. This work presents an end-to-end computer-vision pipeline that automatically detects and classifies perforation defects in industrial imagery. A two-stage architecture combines a YOLOv11 detector that localizes individual perforation regions with a multi-label EfficientNet-B0 classifier that assigns one of four defect classes (DT0 non-defective, DT1 missing, DT2 touching, DT3 out-of-bounds). To address the scarcity of labeled data, active learning and bootstrapping select representative images for annotation, and an adaptive-thresholding pseudo-labeling stage expands the training set. The final classifier reaches F1-micro 99.08% on held-out test data, supporting process monitoring and preventive maintenance.

II. METHODOLOGY

A. Phase 1: Object Detection

Active learning with Laplacian-variance ranking is combined with random bootstrapping to mine a representative subset from a large pool of unlabeled images. Pseudo-labels are then generated by Gaussian adaptive thresholding (primary) with black-hat morphology and Otsu binarization (fallback), using dot-association and box-expansion rules; the result is refined manually in Label Studio. Four detectors (Faster R-CNN, Mask R-CNN, Deformable DETR, YOLOv11) are benchmarked to identify the most effective backbone for localization.

B. Phase 2: Region Classification

Each detected region is cropped and passed to a multi-label EfficientNet-B0 classifier that predicts DT0-DT3 per region using a sigmoid head supporting DT2/DT3 co-occurrence. Region predictions are aggregated at the image level: if any region flags DT1, DT2, or DT3, the image is labeled defective.

C. Two-Phased Training Strategy

Round 1 trains the classifier on the hand-labeled subset using progressive fine-tuning, 448 x 576 px inputs, weighted binary cross-entropy, and a 0.5 sigmoid threshold. Round 2 expands the training set with pseudo-labeled crops produced by the selected detector and refined in Label Studio.

III. RESULTS

Round 1, trained on the hand-labeled subset, reaches F1-micro 96.94%. Round 2, retrained on the pseudo-label expansion, reaches F1-micro 99.08% (+2.14 pt). YOLOv11 is the strongest detector with mAP@50 0.995 (mAP@50-95 0.918, recall 0.99), outperforming Faster R-CNN, Mask R-CNN, and Deformable DETR (Table I). End-to-end inference is approximately 0.24 s per image on an NVIDIA A100, suitable for production-scale throughput. The multi-label head also reveals DT2/DT3 co-occurrence patterns useful for process-level diagnosis.

Table I. Object Detector Comparison

Model	mAP@50	mAP (AP)	Recall / AR
Faster R-CNN	0.968	0.831	0.836
Mask R-CNN	0.975	0.836	-
Deformable DETR	0.974	0.861	0.909
YOLOv11	**0.995**	**0.918**	**0.990**

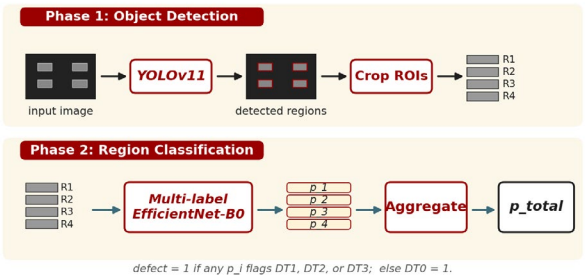


Figure 1. Two-phase pipeline: YOLOv11 detection + EfficientNet-B0 region classification

IV. CONCLUSION

This study presents an accurate and scalable two-stage vision system that both detects perforation defects and characterizes class-level patterns across an industrial dataset. Active learning, bootstrapping, adaptive-thresholding pseudo-labels, and progressive fine-tuning together deliver high accuracy with minimal hand-labeling, making the framework practical for industrial deployment. Future work targets real-time inline deployment on the production line, leveraging the ~0.24 s/image throughput together with edge-device optimization (quantization, TensorRT) to meet line-speed budgets.

ACKNOWLEDGEMENTS

The authors thank the QCRE 2026 organizers for providing the dataset.

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Infrastructure / Mobility / Robots

Value for Money Analysis of Public–Private Partnership and Public Sector Comparator for Building Project

Joseph J. Kim[1], Sri Ram Chowdary Arikapudi
[1] California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840
joseph.kim@csulb.edu

I. INTRODUCTION

Public infrastructure in the United States has traditionally been delivered through conventional public procurement, assessed using the Public Sector Comparator (PSC). Government agencies design, finance, construct, operate, and maintain facilities. While it provides strong public control and access to low-cost financing, it has been criticized for cost overruns, schedule delays, and challenges in long-term asset maintenance (FHWA 2016). Over the past two decades, Public–Private Partnerships (PPPs) have emerged as an alternative for complex, capital-intensive projects. PPPs integrate design, construction, financing, operations, and maintenance into a single long-term contract, often supported by performance-based availability payments. Studies in the U.S. and internationally show that well-structured PPPs can improve lifecycle performance, enhance cost certainty, and transfer specific risks to the private sector (ADB 2018). However, determining whether a PPP offers better value for money than traditional procurement remains challenging, as Value for Money (VfM) outcomes are highly sensitive to assumptions about financing costs, risk transfer, discount rates, operations and maintenance costs, and contract duration (FHWA 2016; Zhao et al. 2023). Therefore, this study evaluates the VfM achieved in delivering the Long Beach Courthouse project through a PPP model compared with what would have been realized under a traditional PSC approach.

II. RESEARCH METHODS

This study follows a four-step analytical approach: (1) compiling and analyzing project data; (2) constructing total service cost and PPP lifecycle cost models; (3) performing discounted cash-flow analysis using model-specific cost-of-capital assumptions; and (4) conducting sensitivity tests to assess how key variables affect VfM results.

III. ANALYSIS AND RESULTS

The completed PSC and PPP models show that, under this study's assumptions, PPP delivery does not produce positive VfM. Initial simplified estimates suggested a 4-6% PPP advantage, but they excluded the full cost of private equity and discounting. The detailed PPP model indicates that any efficiency gains are outweighed by the higher cost of private financing over the 35-year concession. This result is consistent with research identifying discount rates as a central driver of PPP VfM outcomes and noting that PPPs tend to be cost-effective only when public-sector risk is high. Although the PPP structure offers benefits in long-term asset conditions and performance certainty, it does not yield cost savings for the Long Beach project. Sensitivity testing confirms that the PPP weighted average cost of capital is the dominant factor, followed by operating-cost and concession-length assumptions, while capital-cost and risk-adjustment variations have limited influence. Under final model assumptions, PPP procurement remains more expensive than the PSC.

Table 1: Sensitivity Analysis

Parameter	Low VfM (M$)	High VfM (M$)	Change (M$)
Discount Rate (real)	426.67	468.54	41.87
OPEX	433.23	466.14	32.91
WACC - PPP	306.23	543.06	236.83

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Beyond Economic Returns: The Duality of AI Adoption on Data Breach Incidents

Jason Shin[1], Kyungmyung Jang[2]
[1]Mississippi State University, [2]Montclair State University

I. SUMMARY

This study investigates the dual impact of artificial intelligence (AI) adoption on firm-level data breach incidents by distinguishing between external and internal threats. While AI enhances operational efficiency and decision-making, it also introduces new cybersecurity challenges. Drawing on criminal opportunity theory and complexity theory, we argue that AI adoption simultaneously increases external data breaches by expanding attack surfaces and reduces internal data breaches by automating processes and limiting employee misconduct.

To test these relationships, we employ a staggered difference-in-differences (DID) approach using a large panel dataset of 123,468 firm-year observations from 2005 to 2024. The results indicate that AI adoption is associated with a significant increase in external data breaches, while it significantly reduces internal data breaches. These findings highlight the duality of AI adoption, revealing a trade-off between heightened external vulnerabilities and improved internal controls.

This study contributes to the information systems and cybersecurity literature by providing novel empirical evidence on the post-adoption consequences of AI. It also offers important managerial implications, suggesting that firms should complement AI investments with robust external cybersecurity measures while leveraging AI to strengthen internal governance mechanisms.

II. RESULTS

Table 1. Staggered DID Estimations of AI Adoption on Data Breaches

VARIABLES	Model (1) DV: External Breach	Model (2) DV: Internal Breach
AI Adoption	0.00622*	-0.00127*
	(0.00344)	(0.00073)
Constant	-0.01665	0.00376
	(0.01213)	(0.00768)
Observations	123,468	123,468
R-squared	0.09503	0.07872
Control Variables	Included	Included
Firm FE	YES	YES
Year FE	YES	YES

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Tabel 2. The Results of Event Study Regressions

	Model (3)	Model (4)
Variables	DV: External Breach	DV: Internal Breach
t_{-3}	0.00033	-0.00049
	(0.00347)	(0.00079)
t_{-2}	0.00598	-0.00008
	(0.00424)	(0.00070)
t_{-1}	0.00091	0.00347
	(0.00236)	(0.00361)
t_0	-	-
t_1	0.00920	0.00009
	(0.00804)	(0.00064)
t_2	0.00611	0.00020
	(0.00468)	(0.00074)
t_3	0.00650	0.00017
	(0.00691)	(0.00091)
Constant	-0.02807**	0.00387
	(0.01319)	(0.00784)
Control Variables	Included	Included
Observations	122,128	122,128
R-squared	0.09534	0.07926
Firm FE	YES	YES
Year FE	YES	YES

Notes. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. We used the prior year (i.e., 2011) of treatment begins as a reference variable.

Tabel 3. Staggered DID Estimations of AI Adoption on Data Breaches with CEM

VARIABLES	Model (5) DV: External Breach	Model (6) DV: Internal Breach
AI Adoption	0.00610*	-0.00126*
	(0.00355)	(0.00073)
Constant	-0.01677	0.00418
	(0.01499)	(0.00973)
Observations	104,541	104,541
R-squared	0.09934	0.08393
Control Variables	Included	Included
Firm FE	YES	YES
Year FE	YES	YES

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 1 shows that AI adoption increases external data breaches (β = 0.0062) while decreasing internal breaches (β = −0.0013).
Table 2 confirms no significant pre-treatment effects, supporting parallel trends.
Table 3 (CEM) yields consistent results, reinforcing the robustness of these findings.

Safe, Permeable and Quiet Highway Pavement Infrastructure for the States with Severe Freeze/Thaw Cycles

Hosin "David" Lee[1]
[1]University of Iowa

I. SUMMARY

The use of open-graded friction course (OGFC) has been declining, with states discontinuing the use due to increased raveling and reduced service life. The permeable friction course pavement (PFC), which is a new generation of OGFC designed to achieve good drainability by changing the gradation of OGFC. However, both OGFC and PFC have not proven to perform in the severe freeze/thaw environment. Therefore, most states in the Midwest did not or discontinued to build OGFC or PFC pavements because their designs adopted in warmer states were not adequate to maintain the expected performance. This paper discusses the most successful OGFC and PFC designs and their practices.

II. PROBLEM STATEMENT

While the use of OGFC and PFC mixtures in warm southern climates has been successful, it has not proven to have the same successes in the freeze/thaw environment of the Midwest. Most states in the Midwest did not use OGFC and PFC because their designs were not adequate to maintain the expected performance life of PFC mixes and the snow/ice removal issues. There are many OGFC and PFC asphalt mix designs available, however, there is no widely accepted mix design for the Midwest region with severe freeze/thaw cycles. Since the effectiveness of OGFC and PFC asphalt mixes greatly influence the durability and longevity of pavements, it is critical to develop an asphalt mix that will withstand severe freezing and thawing conditions.

III. BACKGROUND

OGFC has been used in the US since 1950's. In 1988, 27 states were using OGFC but 21 states stopped using it because of premature OGFC failures (Smith 1992). In 1998, 19 states were using the OGFC, 19 states discontinued to use it and 4 states had never used it (Huber 2000). Overall, most states in the Midwest were reluctant to consider OGFCs because of the snow/ice removal issues (Arambula-Mercado et al. 2024).

IV. CONCLUSIONS

The PFC achieved a good drainability while reducing the generation and propagation of traffic noise by changing the gradation of OGFC. PFCs also offer better ride quality based on the International Roughness Index (IRI), better vehicle handling due to the coarser surface texture, and the flexibility of application as a wearing surface over PCC or HMA (Arambula et al. 2013). There are many different mix designs available for both OGFC and PFC. However, there is no widely accepted mix design that can be used in the Midwest. This paper compares OGFC and PFC mixes and proposes an improved design that can withstand severe free/thaw cycles, which include the use of fiber stabilizers, modified binders, and tack coat, the increased air voids and aggregate size, and thinner layer thickness.

ACKNOWLEDGEMENTS

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Nudging Secure Behavior: Examining the Effects of Attentional Nudge Strategies on Phishing Email Detection Performance

Yebin Bae[1], Seeung Oh[2], Hye Young Kim[3], Si Woo Jang[4], Youngjae Im[5]
[1, 5] Department of Ergonomics Engineering, Dong Eui University, [2] Department of Engineering, South Carolina State University, [3]Department of Art + Visual Studies, Winston-Salem State University, [4]The Loomis Chaffee School

I. SUMMARY

Phishing emails pose a persistent cybersecurity threat that technical solutions alone cannot fully address. This study examined whether nudge-based design strategies can compensate for users' attentional limitations during phishing detection. Across 16 experimental conditions, nudges were applied to vulnerable email regions (body and footer) in a Latin-square, counterbalanced design. Results showed that informational nudges improved short-term detection rates, while default-setting and structurally guided nudges sustained long-term behavioral change. These findings suggest that nudge-based interface design reduces alert fatigue and reinforces overlooked cues, supporting a user–system collaborative security approach beyond conventional automation-centered detection.

II. METHODS AND RESULTS

A. Methods

This study designed 16 experimental conditions by applying nudge strategies to two vulnerable email regions, AOI3 (body) and AOI5 (footer), constructed by combining two email types (Netflix and Adobe) with four interface versions (Baseline, Friction, Information, and Presentation). Using a Latin square counterbalanced design, all participants were presented with 16 email stimuli and completed a behavioral response task (click, report, delete, or ignore) with response times recorded, along with a survey evaluation for each stimulus. The experiment was administered in approximately 15 to 20 minutes per participant.

B. Results

The baseline condition identified the cues, such as brand elements and urgency messages, that users naturally attend to without intervention, serving as a reference for evaluating nudge effects. Under nudge conditions, heightened attention to AOI3 and AOI5 was observed, with informational nudges improving short-term detection rates and default-setting and structurally guided nudges proving more effective in sustaining long-term behavioral change. Collectively, these findings demonstrate that nudge-based interface design enhances detection performance by reinforcing cues users are prone to overlook and by mitigating alert fatigue. This supports the potential for a user–system collaborative security strategy that advances beyond conventional automation-centered detection approaches.

III. ILLUSTRATIONS

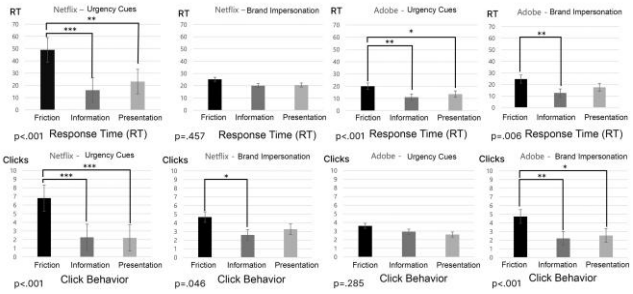


Figure 1. Comparison of Response Time (top) and Click Behavior (bottom) Across Netflix and Adobe Email Conditions

ACKNOWLEDGEMENTS

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FI-DARA: Adaptive Edge-Cloud Routing for Privacy-Preserving Health Monitoring

Michael Choi[1], Parth Borate[1]

[1]Department of Information and Decision Sciences, University of Illinois Chicago, Chicago, IL, USA

I. SUMMARY

Internet of Medical Things (IoMT) wearables enable continuous physiological monitoring, but cloud-only processing introduces emergency-time latency, exposes sensitive health data, and drains battery and bandwidth. We present FI-DARA, a three-tier framework that coordinates computation across edge, fog, and cloud to support low-latency response and privacy-preserving learning under resource constraints.

FI-DARA integrates three components: (i) an edge triage model producing a per-window urgency score; (ii) a federated learning protocol improving models across institutions without sharing raw data; and (iii) a reinforcement learning policy that adaptively places each window on edge, fog, or cloud based on urgency, battery, network, and tier load. The objective trades off latency, bandwidth, and edge energy.

II. METHODS

A. Edge Triage and Feature Extraction

ECG signals are streamed and segmented into 10-second windows at 100 Hz. Each window is reduced to a feature vector (mean, standard deviation, min, max, RMS), and a logistic regression classifier produces an urgency score in [0, 1] that flags abnormal cardiac activity for prioritized handling.

B. Federated Learning Across Sites

Multiple institutions train locally and share only model updates, not raw patient data. We aggregate updates with FedAvg [1] over simulated, non-IID sites that reflect inter-hospital heterogeneity, producing a global model that improves cross-site generalization while preserving privacy.

C. Adaptive Edge–Fog–Cloud Allocation

For each window, we construct a 5-dimensional state (urgency, battery, network, fog load, cloud load) and use a Deep Q-Network (DQN) to select one of three actions: process at the edge, offload to fog, or offload to cloud. The reward shapes a trade-off among latency, edge energy, and uplink bandwidth, so high-urgency windows are routed to achieve the fastest response. In contrast, low-urgency windows can be deferred to fog to save edge battery.

Fog and cloud tiers are emulated using controlled service delay and cost models that capture queueing and contention while preserving reproducibility. The agent is implemented in Stable-Baselines3 [2].

III. PRELIMINARY RESULTS

An end-to-end simulation was implemented using ECG data from the MIT-BIH [3] and PTB-XL [4] datasets, with the PhysioNet/CinC Challenge 2020 [5] reserved for cross-dataset evaluation. As shown in Table 1, the RL policy reduces average latency by roughly 5× relative to a non-RL baseline by routing the vast majority of windows to the edge. At the same time, preliminary edge-model F1 of 0.58 in-dataset rises to 0.80 under cross-dataset evaluation.

Table 1: System metrics — FI-DARA RL policy vs. baseline allocator.

Metric	FI-DARA	Baseline	Notes
Avg. latency	**0.076 s**	0.379 s	per ECG window
Edge usage	**~99%**	~13%	RL prefers edge
Fog usage	**low**	~87%	baseline prefers fog
Edge F1	**0.58**	—	PTB-XL,in dataset
Cross-set F1	**0.80**	—	PTB-XL → MIT-BIH

ACKNOWLEDGEMENTS

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Knowledge-Graph Integrated Agentic Physical/Shadow AI for Autonomous Ships: A Hybrid Approach with LLM and Ontology

Geon-Woo Kim[1], So-Won Choi[1], Eul-Bum Lee[1]

[1]Graduate Institute of Ferrous and Eco Materials Technology (GIFT), Pohang University of Science and Technology (POSTECH), 77 Cheongam-Ro, Nam-Ku, Pohang, 37673, Korea. Email: dreblee@postech.ac.kr

I. INTRODUCTION

The practical deployment of Maritime Autonomous Surface Ships (MASS) requires AI decisions that are safe, explainable, and compliant with international navigation rules. In autonomous vessels, the Physical AI perceives and assesses the operational situation from sensor inputs and actively performs physical control of the ship. In contrast, the Shadow AI operates within a digital-twin environment that mirrors the actual vessel, and plays a central role in autonomous navigation by verifying the behavior of the Physical AI and learning from previously unseen scenarios. This study proposes a Shadow AI model that integrates a maritime ontology, a knowledge graph (KG), GraphRAG, and an LLM.

II. METHODOLOGY

A. Maritime Ontology and KG

The proposed maritime-domain ontology encompasses COLREG Rules 5–19, vessel entities, encounter situations, marine environmental conditions, vessel maneuvering characteristics, and collision-risk indicators. It is grounded in the ISO 21838-2 basic formal ontology. Collected maritime knowledge assets are normalized as Subject–Predicate–Object (SPO) triples and assembled into a KG. The resulting KG semantically links the diverse encounter situations arising during navigation to their applicable COLREG provisions and recommended actions, thereby providing a knowledge base on which MASS can perform rule-based reasoning.

B. GraphRAG and LLM Reasoning

GraphRAG traverses KG relationships to retrieve COLREG provisions, encounter types, risk indicators, and historical cases relevant to the current navigational context, thereby providing grounding evidence to the LLM. Based on this evidence, the LLM generates an explanation covering situation awareness, applicable rules, risk assessment, and recommended actions. The generated output is validated against SHACL constraints for semantic consistency. Through this process, the Shadow AI presents—for every autonomous decision made during navigation—the applied rules, supporting provisions, risk assessment, and recommended actions in natural language, thereby ensuring the explainability of MASS operation.

C. Edge–Cloud Deployment

The proposed system adopts a two-tier edge–cloud architecture comprising shipboard edge and shore-based data center cloud components. At the edge, a lightweight ontology and a small language model support real-time inference under communication-constrained conditions. In the cloud, the full ontology, KG, GraphRAG, and LLM are used to analyze decision-gap intervals and retrain the Shadow AI.

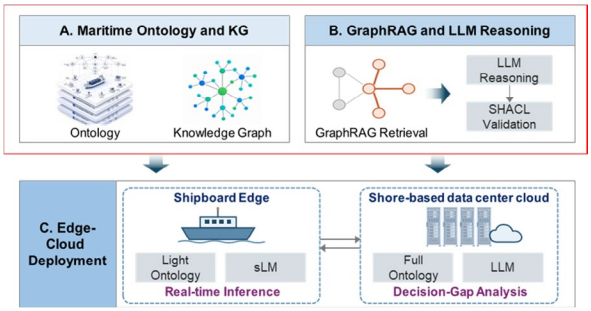


Figure 1: The development process of the ontology and LLM-based Shadow AI for MASS

III. CONCLUSIONS

The proposed system will be developed over the next four years, progressing from maritime-domain ontology and KG construction to the GraphRAG–LLM reasoning pipeline, edge–cloud integration, and real-vessel validation. Using an expert-reviewed COLREG QA dataset and an ontology triple-validation set, the final targets are set at 95% LLM-AI response accuracy and 95% ontology semantic accuracy. This work is expected to provide applicable technical evidence for MASS verification and certification, public maritime AI development, and IMO/ISO standardization discussions.

ACKNOWLEDGEMENTS

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Exploring the Electro-Tribological Behavior of Laser Cladded High Entropy Alloys

Dongyun Lee[1], Sougata Roy[2]
[1,2] Department of Mechanical Engineering, Iowa State University
2029 Union Dr. 1103 Black Engineering Bldg., Ames, 50010, U.S.

I. INTRODUCTION

Mobility systems are transitioning from internal combustion engines to electric motor–based systems[1]. However, as electrification progresses, new issues in drivetrain components, such as electro-pitting, have been reported on bearings [2].

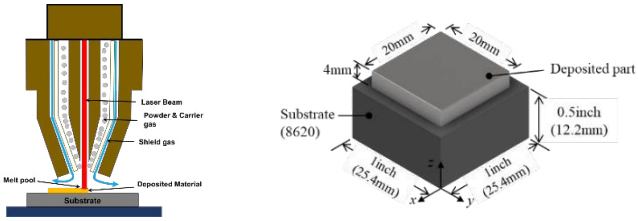
As a potential solution to mitigate bearing wear, high-entropy alloy (HEA) coatings have attracted attention. Among various HEA systems, CoCrFeNi-based alloys have been widely studied due to their excellent mechanical properties and wear resistance. However, the friction and wear behaviors of these alloys under sliding conditions with applied electric current have not yet been sufficiently investigated.

Therefore, the wear characteristics of CoCrFeNi(Al, Ti, Mo) were evaluated using reciprocating sliding wear tests under electrically applied conditions. By comparing the advantages and limitations of each alloy composition, this study aims to propose the potential applicability of HEA coatings for electrified drivetrain components.

II. MATERIALS AND METHODS

Directed Energy Deposition (DED) was performed using an MX-Lab. As shown in Figure 1(a), powders were fed from multiple hoppers and delivered into the laser-induced molten pool via a nozzle. Figure 1(b) shows that the samples were fabricated by depositing powders onto an AISI 8620 substrate to produce specimens.

Friction tests were conducted using a UT-750 tribometer (Ducom, India) equipped with a power supply that enables the application and measurement of electrical current and voltage. The experiments were performed under the conditions 5Hz, 10mm stroke, 42 min duration time, PAO4 lubrication and DC of 1.5 A. During the tests, the tribometer recorded the coefficient of friction (COF). Each test was conducted in duplicate to ensure reproducibility. Wear track measured via Zigo for wear volume analysis.



(a) Schematic of DED (b) Printed block dimension

Fig 1. L-DED printing

III. RESULTS

CoCrFeNi, Ti, and Mo alloys exhibited a reduction in the COF under electrified conditions. This phenomenon also led to a tendency toward reduced wear volume. However, in Mo alloy, the brittleness increases cracks, which promotes wear. In contrast, Al alloy exhibited a faster onset of two-stage friction behavior which the interval between the formation and breakdown of the protective oxide layer was shortened and increased thermal stress likely contributed to the increased wear.

IV. CONCLUSION

1) Electrically assisted sliding promotes the formation of oxide-based tribofilms in CoCrFeNi-based HEAs.
2) A combined alloying strategy using Al, Ti, and Mo may provide synergistic effects that improve wear resistance and structural stability of HEA coatings.

ACKNOWLEDGEMENTS

This research was supported by from Deere & Company.

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Optimal Camera Placement for 3D Surface Coverage

Sumin Hu, Volkan Isler
University of Texas at Austin

I. Problem Definition

Given a coarse 3D mesh of the environment (e.g., derived from a preliminary sparse scan or CAD model), we solve the problem of optimal camera placement for maximized visibility of a target scene. More formally, given a discretized scene surface $U = \{u_1, u_2, \ldots, u_n\}$ and candidate camera poses C, each pose $c \in C$ observes a visibility set $V(c) \subseteq U$. We select at most k poses to maximize covered surface area:

$$C^*_{\text{sel}} = \arg \max_{C_{\text{sel}} \subseteq C,\, |C_{\text{sel}}| \le k} \bigcup_{c \in C_{\text{sel}}} |V(c)|$$

II. Method

We reconstruct a scene using 2DGS [1] from images captured across diverse views, as shown in Figure 1(a). The resulting reconstruction serves as a proxy mesh for estimating visibility. For each mesh face f and camera pose c, we define $v_{f,c} \in \{0, 1\}$, where $v_{f,c} = 1$ when f is visible from c, and 0 otherwise. We then use a greedy camera selection strategy that incrementally selects the camera that reveals the largest number of previously unseen mesh faces:

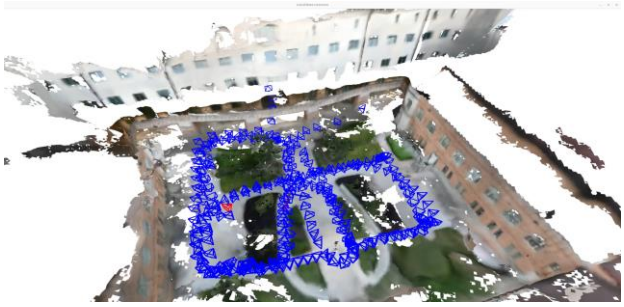
$$U_{\text{sel}} = \bigcup (c' \in C_{\text{sel}}) V(c')$$
$$c_{\text{next}} = \arg \max_{(c \in C \setminus C_{\text{sel}})} |V(c) \setminus U_{\text{sel}}|$$

III. Results

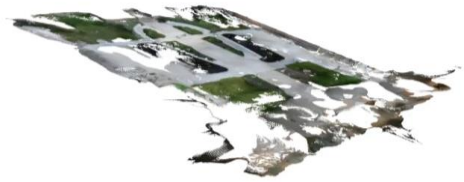
In this paper, we choose the floor of this environment as the target scene, as shown in Figure 1(b). Using the top 10 greedy cameras, we get a total coverage of 43.8% of the floor. Each camera has incrementally decreasing marginal gains in visibility. The cameras of those 10 views are shown in Figure 1(c).

IV. Limitation

Since the reconstructed meshes are the targets for visibility, if a region of the floor was not reconstructed, that area would not be available for visibility assessment.



(a) Candidate camera poses



(b) Floor extraction for visibility analysis



(c) Top 10 greedy views for maximum visibility

Figure 1: Simulation with 2D Gaussian Splatting at Anna Hiss Gymnasium (AHG) in UT Austin.

Acknowledgements

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Mixed Traffic Cooperative Platooning using Multi-Agent Reinforcement Learning

B. Brian Park[1], Zeyu Mu[1], Shangtong Zhang[1]
[1]University of Virginia

I. SUMMARY

This study proposes a hybrid multi-agent lane-change decision model to improve cooperative platooning among connected automated vehicles during early deployment, when CAVs are sparsely mixed with human-driven vehicles. The model uses a CNN-QMIX framework to process traffic information and support coordinated lane-change decisions despite varying numbers of CAVs in dynamic traffic. Traffic simulation results under different CAV market penetration rates show that the proposed approach outperforms rule-based models and increases cooperative platooning rates by up to 26.2%.

II. METHODOLOGY

We propose a novel framework utilizing a CNN-QMIX architecture. To overcome the traditional QMIX limitation of requiring a fixed number of agents, we employ Convolutional Neural Networks (CNNs) to process grid-mapped traffic snapshots. This allows the model to extract spatial features and make optimal decisions regardless of the dynamically fluctuating number of CAVs. The system utilizes Centralized Training with Decentralized Execution (CTDE), enabling CAVs to learn cooperative strategies globally but execute decisions independently based on local observations. For safe execution, this high-level decision-making model is paired with a low-level trajectory planner and a Model Predictive Controller (MPC) to ensure smooth and collision-free lane changes.

III. KEY FINDINGS

Extensive microsimulation testing (see Figure 1) proved that the CNN-QMIX framework significantly outperforms traditional rule-based models like MOBIL and a decentralized greedy method. At a sparse 12.5% market penetration rate, CNN-QMIX improved cooperative platoon rates by 110% compared to MOBIL and by 21.3% compared to the greedy baseline. Additionally, the model successfully balanced traffic and energy efficiency, increasing mean traffic speeds by up to 5.1% over MOBIL while reducing energy consumption by 16.1% at a 50% penetration rate (see Table 1).

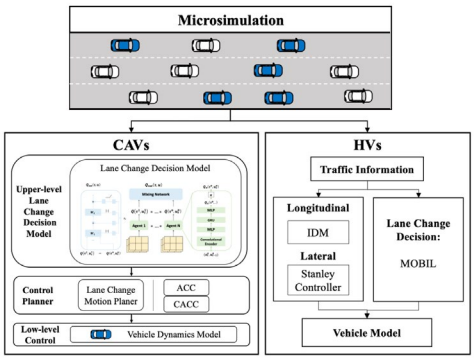


Figure 1: Simulation Framework

Table 1. Simulation Results

MPR	Method	Platoon Rate	Max Length	Time [s]	LC
12.5%	MOBIL	0.10	1.1	N/A	3.1
	Greedy	0.16	1.4	46	2.1
	Greedy (RLC)	0.18	1.5	74	2.7
	CNN-QMIX	0.21	1.9	52	2.7
37.5%	MOBIL	0.30	1.8	N/A	3.5
	Greedy	0.42	2.5	33	2.9
	Greedy (RLC)	0.43	2.8	49	3.6
	CNN-QMIX	0.53	3.4	35	3.7
50%	MOBIL	0.52	2.8	N/A	3.9
	Greedy	0.62	3.1	33	2.5
	Greedy (RLC)	0.65	3.2	38	3.1
	CNN-QMIX	0.72	4.9	29	3.0

IV. Conclusions

The proposed hybrid multi-agent reinforcement learning framework successfully maximizes cooperative platooning opportunities in early-deployment mixed traffic. By utilizing CNNs to manage varying agent numbers and integrating an MPC for physical safety constraints, the model offers a highly adaptable, safe, and efficient solution for automated vehicle coordination.

ACKNOWLEDGEMENTS

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Performance Assessment of Permeable Pavement under Intense Rainfall in U-Ecotron: A CFD-Based Approach

Seunghun Baek[1,5], Junsuk Kang[1,2,3,4,5]

[1]Department of Landscape Architecture and Rural Systems Engineering, Seoul National University, [2]Interdisciplinary Program in Landscape Architecture, Seoul National University, [3]Research Institute of Agriculture and Life Sciences, Seoul National University, [4]Interdisciplinary Program in Urban Design, Seoul National University, [5]Transdisciplinary Program in Smart City Global Convergence, Seoul National University, Seoul 08826, Republic of Korea

I. SUMMARY

As intense rainfall events become more frequent under climate change, evaluating permeable pavement performance under diverse rainfall conditions has become increasingly important for urban stormwater management. This study develops a CFD-based framework linked to the U-Ecotron climate-controlled facility to support performance evaluation of permeable pavement under intense rainfall, with the current stage focusing on reproducing rainfall input and water accumulation behavior inside the facility.

II. METHODOLOGY

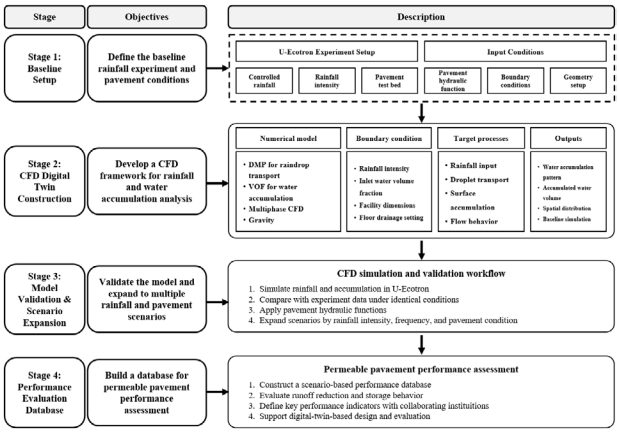


Figure 1. Schematic sequence of study

A. U-Ecotron Digital Twin

The U-Ecotron climate-controlled facility is modeled as a digital twin to simulate rainfall-driven flow behavior under controlled intense rainfall conditions and to support future permeable pavement performance evaluation using hydraulic performance functions and rainfall experiment data.

B. Rainfall Simulation

A multiphase CFD model is developed to represent rainfall transport through air and subsequent water accumulation on the facility floor. Raindrop transport is simulated using a DMP model, while accumulated water is represented using a VOF model. Rainfall inflow is imposed by prescribing the water volume fraction at the inlet based on rainfall intensity and inflow conditions.

C. Performance Evaluation

Future stages will incorporate permeable pavement hydraulic performance functions and facility experiment data for validation under identical boundary conditions. Multiple rainfall intensities, event frequencies, and pavement conditions will then be evaluated to construct a scenario-based database for runoff reduction and storage performance assessment.

III. EXPECTED RESULTS & FUTURE RESEARCH

Preliminary simulations indicate that the proposed framework can reproduce rainfall input and floor-level water accumulation within the U-Ecotron facility and quantify accumulated water through numerical monitoring. These results provide a basis for evaluating how permeable pavement conditions influence runoff reduction and storage behavior under intense rainfall. Future work will validate the model against facility experiment data, incorporate hydraulic performance functions, define performance indicators in consultation with collaborating institutions, and extend the framework to multiple rainfall scenarios and pavement conditions for digital-twin-based performance evaluation.

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A Semi-Markov Process Approach to Quantify Material Content Over Multiple Product Lifecycles with Application to a Hard Disk Drive

Yong Han Kim[1], Nehika Mathur[2], Ritbik Kumar[1], John W. Sutherland[1]
[1]School of Sustainability Engineering and Environmental Engineering, Purdue University, West Lafayette, IN 47907, USA
[2]National Institute of Standards and Technology, 100 Bureau Dr. Gaithersburg, MD 20899, USA

I. Abstract
Critical materials (CMs) are used in many electronic, defense, and emerging technologies, e.g., hard disk drives (HDDs). Identifying, tracking, and quantifying potentially recoverable CM from secondary sources is necessary to plan for long-term CM supply security. A Semi-Markov Process (SMP) model is employed to temporally quantify and characterize individual material flows in HDD lifecycles. The model addresses knowledge gaps by tracking individual materials in complex products subject to different end-of-use (EoU) pathways and integrates product lifecycle 'sojourn' times to estimate retained material quantities. The SMP shows promise as a novel approach to characterize individual material flows across complex product lifecycles.

II. Introduction
The need to store and efficiently process the vast amounts of high-quality data generated by technologies such as artificial intelligence (AI), cloud computing, and e-commerce is driving the need for server farms. Server farms are, simply put, collections of servers that function collectively to handle large volumes of data [1]. Servers contain several high-value materials (e.g., critical materials (CMs), including Rare Earth Elements (REEs)). The HDD sub-assembly comprises Rare Earth Permanent Magnets (REPMs) made from the REEs Nd, Pr, and Dy. The main function of an HDD is to provide long-term storage of data; therefore, the end-of-use (EoU) collection and management of used HDDs are particularly vital [2]. Given their material composition, combined with the fact that HDDs require special handling at EoU, a unique opportunity to maximize HDD value presents itself, thus making HDDs the focus of this study.

III. Method
An overarching goal of this work is to understand how much material content from an initial HDD is retained across successive "use" cycles, where the degree of retention is defined as the ratio of cumulative recovered mass (i.e., mass recovered over multiple cycles) to the initial mass. Understanding this aspect is important because evaluating how many times the initial material mass can be retained within the system over multiple cycles provides insight into material utilization efficiency and associated economic implications.

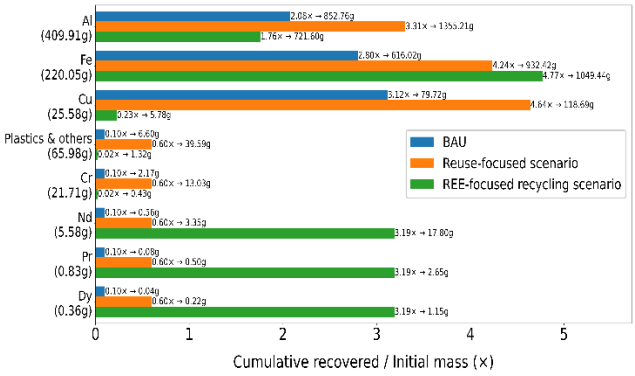


Figure 1: Material-wise cumulative recovered mass relative to initial mass

ACKNOWLEDGEMENTS
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Novel Electrochemical MIP Sensors for Monitoring Emerging Water Contaminants: PFAS and Odor Detection

Samuel Adjei-Nimoh[1], Lance-Nicolas Rances[1], Naoki Kanekawa[2], Eri Hasegawa[2], and Woo Hyoung Lee[1]*

[1]Department of Civil, Environmental, and Construction Engineering, University of Central Florida, Orlando, FL
[2]R&D Center, METAWATER Co., Ltd., Tokyo, Japan

I. Introduction

Per- and polyfluoroalkyl substances (PFAS) are persistent and toxic contaminants that require reliable monitoring at ultra-trace levels to comply with increasingly stringent regulatory standards. Geosmin (GSM) and 2-methylisoborneol (2-MIB), frequently detected during harmful algae bloom (HAB) events, are semi-volatile compounds responsible for taste and odor problems in drinking water systems. Conventional PFAS and semi-volatile detection methods provide high sensitivity but require expensive instrumentation and time-consuming analyses. This study presents a rapid and cost-effective electrochemical sensor based on a molecularly imprinted polymer (MIP) formed on a nickel oxide (NiO)-coated screen-printed carbon electrode (SPCE), for PFAS and odor detection in water sources [1, 2].

II. Materials & Methods

All electrochemical fabrication steps for the MIP/NiO-SPCE sensors were performed using the EmStat4X potentiostat (PalmSens, Houten, Netherlands), where ~100 µL of reagents were dropped on the working electrode (WE) of the commercially available SPCEs (C110, Metrohm, Herisau, Switzerland), following 7 simple steps, using electrochemical impedance spectroscopy (EIS) as a detection mechanism (**Figure 1**).

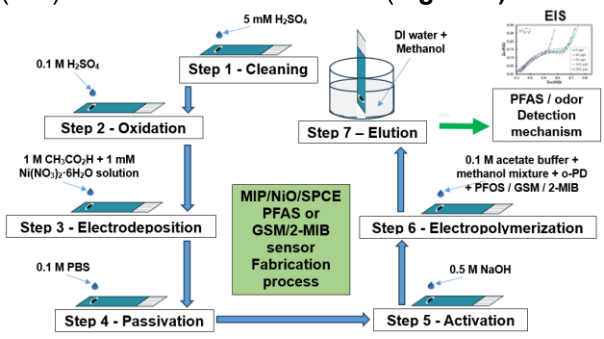


Figure 1. Schematic showing MIP/NiO/SPCE PFAS or odor sensor fabrication process.

III. Results

At ultra-low concentration range from 0 – 10 ppt, the MIP/NiO-SPCE PFAS had a limit of detection (LOD) of 0.67 and 1.86 ppt, with R^2 = 0.97–0.99 for PFOS and PFOA, respectively, which were well below the current U.S. EPA drinking water maximum contaminant limit (MCL) for PFOS (4 ppt). At PFAS concentrations of 0–100 ppt, the PFAS sensor had an LOD of ~20 ppt for both PFOS and PFOA, indicating the tunable nature of the MIP/NiO-SPCE sensors across different environmental matrices. For odor detection, the MIP/NiO-SPCE GSM sensor had a working range of 0–100 ppt, with an LOD of 4.6 ppt, well below the human detection threshold of 10 ppt. Overall, these results demonstrate a proof-of-concept for a low-cost electrochemical MIP/NiO-SPCE platform capable of detecting trace levels of PFAS and GSM, highlighting the potential of these sensors for rapid environmental monitoring in water systems.

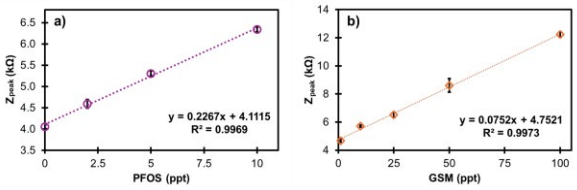


Figure 2. Typical calibration curves for PFOS and GSM using MIP/NiO-SPCE sensors.

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Automated System for Bridge Corrosion Detection and Severity Classification

Joseph J. Kim[1], Avi Patel[1], Vatsal M. Patel[1]
[1] California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840
joseph.kim@csulb.edu

I. INTRODUCTION

Steel bridges carry a large share of transportation load across the United States. More than 40% of all bridges are built from steel that corrode progressively when left unprotected. The *ASCE 2025 Report Card for America's Infrastructure* stated that the nation has 623,218 bridges, of which 49.1% are rated in fair condition, 44.1% in good condition, and 6.8% in poor condition (ASCE 2025). Notably 45% of these bridges have exceeded their 50-year design life. Manual inspection is time-consuming, subjective, and produces inconsistent condition ratings. Despite progress in AI and deep learning-based corrosion detection, several gaps remain, including (1) the size of datasets, (2) lack of pixel level instance segmentation, (3) transparent reporting of validation-test performance differences, and (4) connecting pixel-level segmentation outputs directly to the fair, poor, and severe conditions defined in the *AASHTO Manual for Bridge Element Inspection* and *FHWA Bridge Inspector's Reference Manual* (BIRM, FHWA 2023).

II. RESEARCH METHODS

The objective of this study is to develop and evaluate a YOLOv8-seg-based workflow for automated pixel-level detection and severity classification of corrosion in steel bridge images using inspection-relevant condition categories consistent with AASHTO and FHWA BIRM guidance.

III. ANALYSIS AND RESULTS

This study found that YOLOv8-seg can generate pixel-level corrosion masks in real time, which means it could realistically be paired with a drone and produce immediate condition ratings on-site.

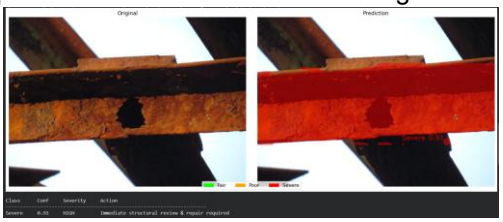


Figure 1: Severe corrosion prediction with confidence score of 0.91

The three-class output maps directly onto what the BIRM requires, so the model output would be usable by inspectors without a conversion step. This practical alignment with inspection standards is the most important finding of this study. Figure 1 shows an example of demonstrating the severe corrosion prediction with confidence score of 0.91. Table 1 presents the comparison of the results between this study and Ameli et al. (2024).

Table 1: Sensitivity Analysis

Parameter	This Study	Ameli et al. (2024)
Dataset size	514 images	514 images
Data source	Roboflow platform	DJI Mini drone + Nikon D750 camera
Annotation standard	AASHTO MBEI + FHWA BIRM	AASHTO + BIRM
Model	YOLOv8m-seg	YOLOv8m-seg + Mask R-CNN
Training platform	Google colab, Tesla T4 GPU	Google colab Pro, T4 GPU
Input image size	640x640 px	640x640 px
Training images	412 (80%)	412 (80%)
Validation images	90 (17.5%)	90 (18%)
Test images	12 (2.3%)	12 (2%)
Training epochs	150	250
Precision (test)	0.8832	0.853
Recall (test)	0.6877	0.647
F1 Score (test)	0.7731	0.730
mAP@50 (test)	0.8237	0.726
mAP@50-95 (test)	0.6534	Not reported

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Narrative Manufacturing
A Human-Centered Path from Automation to Mass Innovation

Changheon Han[1]
[1]School of Aeronautics and Astronautics, Purdue University, West Lafayette, IN, USA

I. OVERVIEW

Manufacturing automation is moving from isolated machine control toward systems that can plan, execute, and refine production workflows. As this capability grows, the central issue is not only how to keep humans inside automated loops, but how to define a higher-value human role when physical execution becomes increasingly autonomous.

This paper proposes Narrative Manufacturing: a paradigm in which people express desired products, functions, constraints, or operating contexts in natural language, and a Large Engineering Model for Manufacturing (LEM²) converts those narratives into engineering specifications, feasible process plans, and validated physical artifacts. The objective is to make manufacturing less dependent on ownership of specialized equipment and more available to individual creators, domain experts, and small teams.

II. CONCEPT AND TECHNICAL APPROACH

Narrative Manufacturing begins with intent. A user may describe what a component should accomplish, where it will operate, which materials or costs are acceptable, and which performance trade-offs matter. LEM² maps this input to candidate geometries, process routes, inspection requirements, and scheduling decisions across distributed cloud manufacturing resources. These resources may include additive manufacturing, machining, joining, robotic handling, metrology, and post-processing cells.

LEM² is not simply a conversational front end. It serves as a closed-loop engineering intelligence layer linking language, models, machines, and shop-floor evidence. Four capabilities are essential: multimodal interpretation of text, sketches, images, usage scenarios, and prior files; reasoning under physical, geometric, economic, and quality constraints; orchestration of heterogeneous software tools, machine protocols, and facility capacity; and adaptation from simulation, sensing, inspection, and operator feedback. In this sense, Narrative Manufacturing extends cloud manufacturing [1] and cyber-physical production systems [2] by adding an intent-driven creation layer.

III. BROADER IMPACTS AND RESEARCH AGENDA

This paradigm changes who can participate in production. Instead of separating consumers from producers, it creates a broad creator layer in which clinicians, technicians, educators, entrepreneurs, repair specialists, and citizens can initiate manufacturing without owning a factory. It also increases the importance of expert roles: platform engineers who build trustworthy LEM² models, data standards, verification tools, and secure interfaces; and operations teams who maintain shared facilities, handle exceptions, and protect safety, quality, and resilience.

If realized, Narrative Manufacturing could shorten the path from idea to artifact, support customized low-volume products, and widen participation in industrial innovation. Key research questions remain: LEM² must provide transparent and testable engineering reasoning; machines, materials, process data, and quality records must be interoperable; AI-generated designs and process plans require verification, certification, cybersecurity, and liability frameworks; and education must prepare people to frame problems, evaluate trade-offs, and collaborate with AI-mediated production systems. The long-term promise is a manufacturing ecosystem in which automation amplifies human imagination into reliable physical outcomes.

ACKNOWLEDGEMENTS

This research was supported by the Institute for Physical Artificial Intelligence (IPAI) Postdoctoral Fellowship Program.

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AI-Driven Pavement Crack Detection and Severity Classification

Joseph J. Kim[1], Mohit Ahir[1], Vatsal M. Patel[1]
[1] California State University, Long Beach, 1250 Bellflower Blvd., Long Beach, CA 90840
joseph.kim@csulb.edu

I. INTRODUCTION

Traditional site inspection relies on trained professionals who physically traverse sites, record observations manually, and synthesize findings into written reports. This approach is authoritative, contextually sensitive, and legally defensible, but is constrained by inspector availability, physical access limitations, fatigue, inspection frequency, and unavoidable inconsistency across individuals. AI-driven inspection systems address several of these constraints directly by offering continuous operation, consistent classification criteria, and access to physically hazardous or geometrically inaccessible locations. However, automated systems lack the contextual professional judgment required to interpret ambiguous conditions, consult engineering codes, or interact with contractors on site. The most effective deployment paradigm combines AI systematic coverage and anomaly detection with human professional interpretation, accountability, and decision authority (Kazeem et al., 2023). Pavement crack detection is among the most mature applications of computer vision in infrastructure inspection. Crack morphologies such as longitudinal, transverse, block, and diagonal shear each correlate with distinct structural conditions and failure mechanisms, making automated classification both technically feasible and practically valuable for maintenance prioritization (FHWA, 2003).

II. RESEARCH OBJECTIVE AND METHODS

The objective of this study is to develop and evaluate a pavement crack detection using a YOLOv8m-seg instance segmentation model. The model was trained on approximately 2,000 pixel-level annotated images across four retained classes (longitudinal, block, transverse, and diagonal shear) for 150 epochs with early stopping patience of 30, with the classification loss weight doubled to 2.0 to address class imbalance. Training completed in approximately 1.4 hours. Each detected crack is mapped to a severity level and recommended engineering action through a rule-based lookup table aligned with the FHWA specification for actionable maintenance decisions.

III. ANALYSIS AND RESULTS

AI-driven inspection systems demonstrate clear advantages over traditional manual inspection in systematic detection of surface defects at resolutions exceeding human visual capacity. Figure 1 shows sample detection output comparing the original field image with the model's predicted segmentation overlay with an 87% confidence score and a purple segmentation mask tracing the crack boundary. Table 1 presents the per-class segmentation mask metrics on the validation and test sets, respectively. The results support a human-AI inspection workflow.



Figure 1: Longitudinal crack detection

Table 1: Segmentation Performance by Crack

Crack type	Block	Diagonal shear	Longitudinal	Transverse
(a) Validation set				
Images	13	5	45	12
Precision	0.63	1.00	0.86	0.99
Recall	0.62	0.00	0.80	0.75
mAP50	0.58	0.16	0.83	0.84
mAP50-95	0.18	0.04	0.44	0.41
(b) Test set				
Images	6	1	21	10
Precision	0.64	1.00	0.53	0.69
Recall	0.83	0.00	0.76	0.89
mAP50	0.72	0.00	0.59	0.81
mAP50-95	0.38	0.00	0.24	0.37

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Mobile Routing System for Older Adults' Walking

John J. Sohn[1]
[1]Department of Civil and Environmental Engineering and Construction, University of Nevada, Las Vegas

INTRODUCTION

Walking is an essential form of exercise for older adults to maintain health, as well as a fundamental mode of transportation. However, older adults' walking is often limited by stressful experiences in the built environment due to environmental stressors (e.g., uneven surfaces). Prior studies have shown that reinforcing positive walking experiences can encourage walking activity through psychological mechanisms, such as improving their self-efficacy. Building upon this finding, it can be presumed that a mobile routing system that recommends routes with high walking utility (i.e., satisfaction) may serve as a promising intervention to enhance walking. Despite the potential of a routing system-based walking intervention, this approach has been discussed at a conceptual level, and its actual development and empirical effectiveness in promoting older adults' walking remain underexplored.

RESEARCH OBJECTIVES

To realize a mobile routing system-based walking intervention and evaluate its effectiveness, this study addresses two research objectives. First, it develops a computational model to predict older adults' preferred routes by considering walk time and built environment attributes, such as sidewalk condition. The model is designed to provide favorable built environment conditions (e.g., smooth sidewalks), while avoiding excessive travel time. Second, this study empirically evaluates whether the proposed mobile routing system can improve older adults' walking activity and overall walking experience.

METHOD

The overall procedure for developing the mobile routing system and evaluating its effectiveness in promoting walking activity consisted of two phases. First, a computational model was developed using stated preference (SP) survey data from older adults. An SP survey is a specific type of survey method that presents respondents with hypothetical scenarios and asks them to indicate their preferences among alternative options. According to utility theory, individuals tend to choose the option that provides the highest utility among the available alternatives. Based on this principle, SP surveys make it possible to understand how different combinations of built environment attributes and walk time influence individuals' route choices. Second, the effectiveness of the mobile routing-based walking intervention was evaluated using a within-subject experimental design. A total of 16 older adult participants completed a 7-day baseline period and a 7-day intervention period. The walking intervention was evaluated in three dimensions: walk time, distance, and steps. These dimensions were selected to examine whether the intervention produced meaningful changes in daily walking activity.

(a) (b)



Figure 1: (a) Example of a stated preference survey and (b) developed mobile routing system

RESULTS

Our proposed machine learning-based model for predicting preferred routes achieved a mean absolute error of 0.197. This prediction error falls within an acceptable range of human response variability. The field intervention results showed that the mobile routing application significantly improved older adults' walking activity ($p < 0.05$). Specifically, average daily walk time increased from 1469.67 seconds to 1684.67 seconds ($\beta = 217.57$, $p = 0.018$), average daily walk distance increased from 1,338.5 m to 1,539.5 m ($\beta = 189.96$, $p = 0.023$), and average daily walk steps increased from 2306 to 2626 ($\beta = 302.83$, $p = 0.039$).

ACKNOWLEDGEMENT

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Structural Reorganization of the Global Container Shipping Network under Geopolitical Risk: The Case of the Red Sea Crisis

Suyeon Park, Sang-yoon Lee
Graduate School of Logistics, Inha University

I. SUMMARY

This study analyzes the resilience of the global container shipping network under geopolitical risks in maritime transport. Focusing on the Red Sea Crisis triggered by attacks on merchant vessels near the Red Sea from November 2023 onward, we use approximately 1.6 million AIS-based port call records to construct monthly directed and weighted port-to-port networks and apply network analysis together with MRQAP regression. Preliminary results show that Suez-related port-pair connections and visits to the Suez chokepoint declined markedly, whereas the overall network exhibited a pattern of reorganization rather than a simple collapse marked by denser intra-community connections and stronger hub pairs. From the perspective of Complex Adaptive Systems (CAS) [4], these findings suggest the possibility of adaptive resilience through structural reorganization.

II. DATA & METHOD

Using AIS-based port call records [3], we construct monthly directed and weighted port-to-port networks [1],[2] over June 2023 to September 2024, divided into a base and a post period, and track network-level changes. To examine what drives these changes, the change in port-pair edge weight between the post and base periods (ΔW) was specified as the dependent variable, and an MRQAP model was estimated with BaseW, SuezExposure, SameRegion, SameCommunity, and HubPair as explanatory variables, testing whether these factors are systematically associated with changes in port-pair connections.

III. RESULTS

A. Network Analysis

The Suez-related edge share fell from 1.48% in November 2023 to 0.93% in December 2023 and stayed lower throughout 2024. Centrality of major hubs generally declined, though Singapore remained top-ranked across weighted degree, betweenness, and PageRank in both periods. Increased-weight edges were dispersed across multiple regions, whereas decreased-weight edges concentrated among Suez related pairs. At the same time, intra-community connections became denser.

B. MRQAP

The MRQAP results show negative coefficients for Suez exposure and base-period edge weight, and positive coefficients for same-community membership and hub-pair status. These results indicate a relative weakening of Suez-exposed edges, while existing community and hub structures were maintained or reorganized.

IV. PRELIMINARY IMPLICATIONS

The Red Sea Crisis reflects reorganization rather than collapse, leveraging existing hub and community structures [6]. This suggests that resilience should be understood not as a return to the pre-shock state, but as the maintenance of network function through structural reorganization [5].

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Basic Sciences

Light-Front Helicity

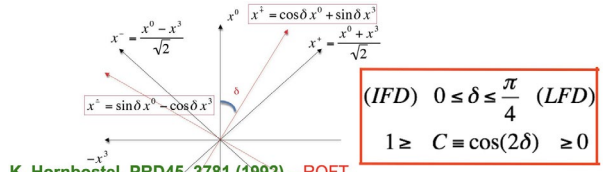
Chueng-Ryong Ji
North Carolina State University

I. SUMMARY

The interplay between quantum orientation entanglement and Wigner rotation plays a fundamental role in understanding the behavior of spin angular momentum in quantum states. To analyze the quantum orientation entanglement of the relativistic helicity states, we contrast the Jacob-Wick helicity and the light-front helicity and examine the relative angle between the particle's momentum direction and the spin orientation for the helicity states interpolated between the instant-form dynamics and the light-front dynamics. In particular, we identify the critical interpolation angle that bifurcates the dynamical branches between the instant-form dynamics and the light-front dynamics and discuss the underlying orientation entanglement in the interpolating helicity amplitudes.

II. MOTIVATION

For the study of relativistic particle systems, Dirac proposed three different forms of the relativistic Hamiltonian dynamics in 1949: i.e. the instant ($x^0 =0$), front ($x^+ = (x^0 + x^3)/\sqrt{2} = 0$), and point ($x_\mu x^\mu = a^2 >0, x^0 > 0$) forms. Among these three forms of dynamics proposed by Dirac, the two forms of dynamics, IFD and LFD, can be linked to each other. I discuss the advantage of interpolating IFD and LFD in particular for the discussion of the helicity.



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Fig. 1: Interpolation between IFD and LFD

III. ILLUSTRATION

Under the rotation around 180 degree, it is interesting to note the orientation entanglement phase factor appears in |1,0> state, namely |1,0> → - |1,0> while |0,0> → |0,0>. The boost of the spin state provides the helicity which must be invariant under the kinematic transformation in the given form of the dynamics as exemplified in Fig. 2.

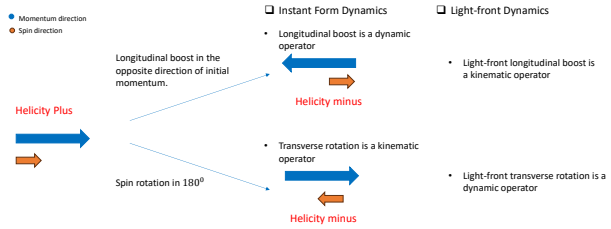


Fig.2: Orientation entanglement effect under rotation of spin in contrast the boost of the momentum to flip the helicity of the state in the instant form dynamics.

We find the critical interpolating angle between IFD and LFD as shown in Fig. 3.

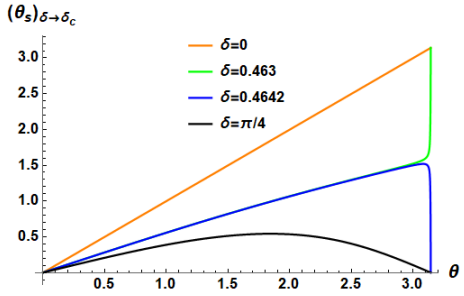


Fig. 3: Critical interpolation angle

IV. CONCLUSION

We identified the critical interpolation angle that bifurcates the dynamical branches between the instant-form dynamics and the light-front dynamics reflecting the underlying orientation entanglement in the interpolating helicity amplitudes.

ACKNOWLEDGEMENT

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Practical T_1 Analysis for Quadrupolar Solid-State NMR Experiments

YeonJun Choi[1], Rui Li[1], and Joseph H. Ross Jr.[1, 2]
[1]Department of Physics and Astronomy, Texas A&M University, College Station, TX 77843
[2]Department of Materials Science and Engineering, Texas A&M University, College Station, TX 77843

I. INTRODUCTION

NMR Spin-lattice relaxation of quadrupolar nuclei in solids, which provides an important probe for atomic-scale dynamics, for example in ferroelectrics and battery materials,[1,2] is often governed by both magnetic and electric-field gradient (EFG) fluctuations.[3,4] These processes generate multi-exponential recovery curves for which conventional quantitative T_1 analysis is often impossible. Except for special cases, no analytic solution is known, so developing effective analysis schemes is a significant need. To address this, we developed straightforward numerical functions representing the recovery curves for I = 5/2, 7/2, and 9/2 nuclei, based on effective single- and stretched-exponentials. The results provide practical guidance for extracting reliable T_1 values from solid-state NMR experiments.

The relaxation dynamics result from a set of coupled population rate equations in the high-field limit. Three standard parameters affect the results: the magnetic relaxation rate W^M, and the quadrupolar Δm = 1 rate W_1^Q and Δm = 2 rate W_2^Q, which can be derived from magnetic and EFG spectral densities associated with material dynamics.[5,6] After generating numerical recovery curves for selective saturation of central and satellite transitions, the results were analyzed using exponential and stretched-exponential curves of the form[7] $\Delta S(t) \propto exp[-(t/T_1)^\beta]$. This form is well known in NMR for comparing non-exponential T_1 relaxation in other contexts. For combined magnetic and quadrupolar relaxation, the results were also compared with the commonly assumed additive approximation, $1/T_{1,sum} = 1/T_{1,M} + 1/T_{1,Q}$.

II. KEY RESULTS

For quadrupole-only relaxation, we show that central-transition recovery remains close to single-exponential behavior over a broad range of W_1^Q/W_2^Q. In the experimentally most relevant range $W_1^Q/W_2^Q \approx$ 1–4, the stretching exponent β stays near unity, for which our exponential results are particularly effective. Strong deviations occurring for extreme W_1^Q/W_2^Q values make the stretched analysis functions more significant.

We also find that satellite-transition recovery curves are particularly well modeled by the exponential function. We also show that their strong dependence on W_1^Q/W_2^Q makes them particularly well suited for extracting all relaxation parameters when these transitions are experimentally accessible.

When magnetic and quadrupolar mechanisms have comparable size, the fitted effective rate $1/T_{1,eff}$ is larger than the common simple additive estimate $1/T_{1,sum}$. On the other hand the stretched-exponential function gives rates closer to the additive limit than single-exponential fitting and is therefore a useful practical approach for such cases.

III. CONCLUSIONS

Our results provide an efficient means to analyze central-transition T_1 recovery curves, especially when W_1^Q/W_2^Q is not extreme. Our satellite transition results may also constrain the quadrupolar relaxation parameters particularly well, and we provide guidelines and fitting parameters for systems with comparable magnetic and quadrupolar relaxation strengths. Stretched-exponential fitting provides a practical and systematic approximation when a full multi-exponential analysis is not possible. Preliminary versions of this approach have also been used effectively to analyze dynamics of NiTiHf and NiTiZr shape-memory and strain-glass materials.[8]

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Low-energy tail of the spectral density for a particle interacting with a quantum phonon bath

Donghwan Kim[1, 2], Bertrand I. Halperin[3]

[1]Oden Institute for Computational Engineering and Sciences, The University of Texas at Austin, Austin, Texas 78712, USA, [2]Department of Physics, The University of Texas at Austin, Austin, Texas 78712, USA, [3]Department of Physics, Harvard University, Cambridge, Massachusetts 02138, USA

I. SUMMARY

We present two approximation methods that capture the leading behavior of the low-energy tail of the momentum-dependent spectral density $A(\mathbf{k}, E)$ and the tunneling density of states $D(E)$ for an injected particle, such as an electron or an exciton, interacting with a phonon bath at a non-zero initial temperature T, including quantum corrections arising from the non-zero phonon frequencies.

II. APPROXMIATION METHODS AND RESULTS

We consider a one-dimensional model of particles and phonons on a lattice. The particles are linearly coupled to the phonons. We invert the Laplace transform and obtain $A(\mathbf{k}, E)$ as well as $D(E)$ from the imaginary-time analysis.

A. Imaginary Time-Dependent Hartree (ITDH) Approximation

We consider a situation where the particle is injected into a specified coherent state of the phonon system. The thermal average of the correlation function $C(\tau)$ is obtained, in principle, by integrating the result over all possible initial phonon coherent states, weighted by a thermal distribution. However, in the low-energy tail, one can obtain a good first approximation by focusing only on those initial states near the maxima of the integrand—this is the essence of the ITDH approximation.

B. Fixed-Wave-Function (FWF) Approximation

This approximation assumes that the wave function of the injected particle evolves instantaneously to a wave function which then is independent of time, while the phonon system continues to evolve due to interaction with the particle. The densities of states calculated within FWF approximation are shown in Figure 1. For a one-dimensional continuum model of a particle interacting with acoustic phonons, nuclear quantum effects are observed as $\alpha = T/\omega_{\kappa_H}$ approaches 0. In the classical phonon limit, the dominant behaviors of both the ITDH and FWF approximations in the low-energy tail reduce to the previous result for a particle in a random potential with a Gaussian statistical distribution.

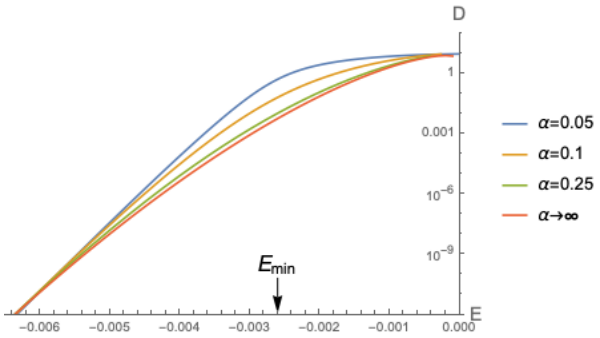


Figure 1: Densities of states $D_{\mathrm{FWF}}(E)$ within FWF approximation for different $\alpha = T/\omega_{\kappa_H}$ values achieved by varying nuclear mass density ρ for fixed $T = 1.25 \times 10^{-4}$, and the particle-phonon coupling $\gamma = 0.5$.

ACKNOWLEDGEMENTS

The authors are indebted to Eric J. Heller for discussions on possible applications of the coherent state description of phonons. B.I.H. gratefully acknowledges John J. Hopfield for introducing him to the problem of the low-energy tail of optical absorption in various insulators.

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Reconstruction of Atomic-Scale Electronic Structures via Active Learning-Driven Scanning Tunneling Spectroscopy Mapping

HyeongChan Suh[1], Menge Liu[1]

[1]Department of Physics, The University of Texas at Dallas, Richardson, Texas 75080, United States

I. SUMMARY

Scanning Tunneling Spectroscopy (STS) mapping is an indispensable tool for characterizing local density of states (LDOS) at the atomic scale; however, acquiring high-resolution spatial maps across a full energy range is severely bottlenecked by exorbitant acquisition times. This prolonged measurement process inherently introduces critical limitations, such as tip instability and thermal drift, which compromise data integrity. To address these challenges, we introduce a novel machine learning model that provides comprehensive STS mapping data by utilizing Scanning Tunneling Microscopy (STM) topography and a dI/dV image obtained at a specific bias voltage. Our proposed model integrates an active learning framework that not only guides optimal data acquisition but also efficiently generates synthesized STS mapping data. By drastically reducing the time required for data collection, this model realizes an unprecedented acceleration in STM analysis, offering a powerful tool for high-throughput surface characterization.

II. ILLUSTRATIONS

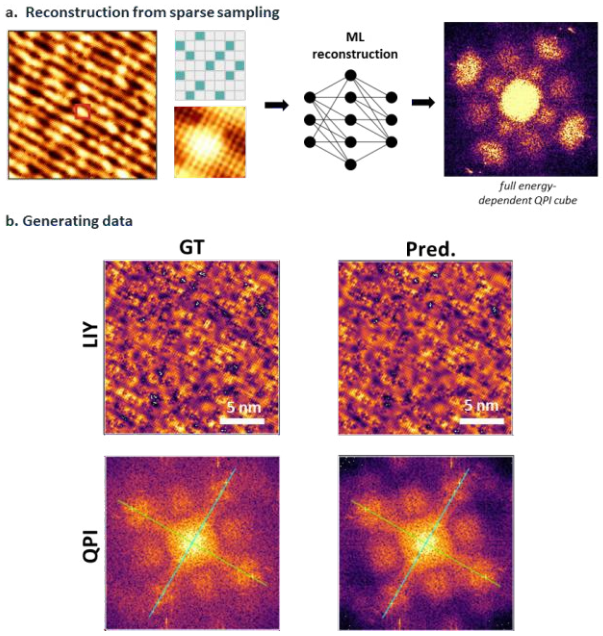


Figure 1: AI-assisted reconstruction of QPI patterns from sparse measurements. (a) ML-reconstruction workflow mapping sparse real-space sampling to a full energy-dependent QPI cube, minimizing data acquisition time while preserving core physical properties. (b) Comparison of generated (simulated) data showing large-scale real-space topography (top, 5 nm scale bar) and corresponding Fourier-transformed q-space profiles (bottom) with highlighted symmetry axes.

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Search for associated production of a Higgs boson and of two vector bosons via vector boson scattering

Philip Chang[1]
[1]University of Florida

I. SUMMARY

We present the first search for the production of a Higgs boson (H) in association with two vector bosons (V = W, Z) via vector boson scattering (VBS), using proton-proton collision data collected by the CMS experiment at $\sqrt{s}$ = 13 TeV during 2016–2018, corresponding to an integrated luminosity of 138 fb^{-1}. This channel provides a novel probe of the quartic VVHH coupling, parametrized by the modifier κ_{2V}, complementary to Higgs pair production searches, and also κ_{2W}, κ_{2Z}.

II. Analysis Strategy

Events are required to contain two forward jets with a large pseudorapidity separation, consistent with the VBS topology, together with a large-radius jet from a boosted H → b$\bar{b}$ decay and 0, 1, or 2 charged leptons from the vector boson decays. Six orthogonal channels are defined—all-hadronic (fully and semi-boosted), single-lepton, and dilepton (opposite-sign WW, opposite-sign Z, and same-sign)—to maximize signal acceptance. Boosted H and hadronic V candidates are tagged with the mass-decorrelated ParticleNet algorithms. Backgrounds are estimated from data using a matrix ("ABCD") method, with dedicated neural-network and boosted-decision-tree discriminators trained to be orthogonal to the VBS selection variables. Signal and background yields are extracted from a simultaneous binned maximum-likelihood fit across all regions.

III. ILLUSTRATIONS

No significant excess over the standard model (SM) prediction is observed. Assuming SM values for all other couplings, VBS VVH production is excluded at 95% confidence level for κ_{2V} outside the observed (expected) interval $0.40 < \kappa_{2V} < 1.60$ ($0.34 < \kappa_{2V} < 1.66$), among the most stringent constraints to date from CMS data. The individual WWHH and ZZHH couplings are also constrained to the observed ranges $0.17 < \kappa_{2W} < 1.84$ and $-0.37 < \kappa_{2Z} < 2.38$, and a two-dimensional exclusion in the κ_{2W}–κ_{2Z} plane is derived, substantially improving on prior VHH constraints and establishing VBS as a new probe of the quartic gauge-Higgs interaction.

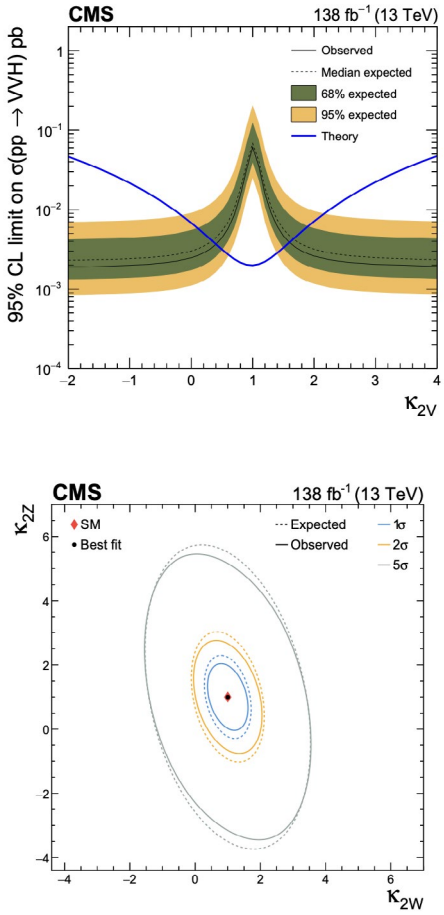


Figure 1: ABC

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Ultrafast Phase Transformation Studies using X-ray Free-Electron Lasers

Hyunjung Kim

Center for Ultrafast Phase Transformation, Department of Physics, Sogang University, Seoul 04107, Korea

I. INTRODUCTION

Phase transformations underpin the functional properties of a vast range of materials, from quantum and energy materials to soft-matter systems. Many of these transitions are governed by structural and electronic rearrangements that unfold on femtosecond-to-picosecond time scales and across nanometer length scales. We develop and apply advanced X-ray scattering techniques, combining coherence and shot-pulse characteristics with the high flux available from X-ray free-electron laser (XFEL) sources, to capture these processes directly in space and time. This presentation offers a concise overview of our research directions and recent activities.

II. RESEARCH OVERVIEW

A. Ultrafast Dynamics at XFELs

The recent advances in X-ray free-electron lasers (XFELs) have enabled a few-to-tens-of-femtoseconds time resolution in ultrafast structural dynamics, owing to the unique characteristics of X-rays. XFEL enables the acquisition of critical information about intermediate states or pathways during phase transformation, whereas many existing techniques measure only the initial and final states.

We develop time-resolved Bragg coherent X-ray imaging and time-resolved dark-field X-ray microscopy at the X-ray Scattering & Spectroscopy (XSS) and Nano Crystallography and Imaging end stations, respectively, at the PAL-XFEL, where the 3rd hard X-ray free electron laser facility in the world. We perform optical-pump/X-ray-probe experiments to combine diffraction-based imaging techniques.

B. Ultrafast Phase Transition in Perovskite oxides

We present direct observations of the initial generation of carrier-induced lattice distortions and the relevant strain evolution in perovskite-oxide nanocrystals. The ultrafast lattice distortions induced by photoexcitation are measured by time-resolved Bragg coherent X-ray diffraction imaging with an optical laser pump and an X-ray pulse probe.

C. Ultrafast Surface Disordering and Shock wave generation

Using time-resolved dark-field X-ray microscopy at an XFEL, we investigate ultrafast response of laser-excited Cu(111) thin films. Depending on the tilted twin boundaries, we observed near-surface lattice disordering via electron–lattice coupling and a supersonic elastic shock wave generation.

III. SUMMARY AND OUTLOOK

By combining ultrafast XFEL experiments, coherent X-ray imaging, and purpose-built instrumentation, we observed the fundamental pathways of phase transformations across the relevant length and time scales. We anticipate that the continued growth of XFEL facilities and upgraded synchrotron facilities will open new opportunities to observe non-equilibrium phenomena in quantum, energy, and functional materials, and we welcome collaboration with the broader Korean and international research community represented at UKC 2026.

ACKNOWLEDGEMENTS

This work was supported by the National Research Foundation of Korea (RS- RS-2021-NR059920).

Purely GHZ-like entanglement is forbidden in holography

Monica Jinwoo Kang

Mitchell Institute for Fundamental Physics and Astronomy, Department of Physics and Astronomy, Texas A&M University, College Station, TX 77843, U.S.A

I. INTRODUCTION

Entanglement is a fundamental feature of quantum systems and plays a geometric role in holography. The Ryu-Takayanagi formula relates the entanglement entropy of a boundary region A to the area of a minimal surface Γ_A in a higher-dimensional spacetime, $S(A) = \frac{\mathcal{A}(\Gamma_A)}{4G_N}$. Thus, the organization of entanglement in the boundary quantum field theory is directly reflected in the emergent bulk geometry.

Most of our understanding of this relation is bipartite: one divides a system into a region and its complement. Holographic states, however, naturally contain many interacting subsystems, whether they are distinct boundaries of a multiboundary wormhole or several regions of a single boundary. This raises a more refined question: does semiclassical geometry admit every possible pattern of multipartite entanglement?

We show that two complementary signals of tripartite entanglement obey a new holographic inequality. Generalized Greenberger-Horne-Zeilinger states violate this inequality, implying that a time-reflection-symmetric holographic state cannot have purely GHZ-like entanglement. Semiclassical geometry therefore constrains not only the amount of entanglement, but also its internal organization.

II. MULTIPARTITE ENTANGLEMENT

For two subsystems, the mutual information $I(A : B) = S(A) + S(B) - S(AB)$ measures their total correlation. For three subsystems, ordinary entropies can be combined into the triple information $I_3(A : B : C) = S(A)+S(B)+S(C)-S(AB)-S(AC)-S(BC)+S(ABC)$. General quantum states can have either sign of I_3, whereas holographic states satisfy $I_3 \leq 0$. For a pure state on ABC, however, $S(ABC) = 0$ and $S(AB) = S(C)$, $S(AC) = S(B)$, $S(BC) = S(A)$. Hence $I_3 = 0$ identically. The holographic entropy cone therefore cannot distinguish different structures of pure tripartite entanglement. Such structures are already inequivalent for three qubits: $|\mathrm{GHZ}\rangle = (|000\rangle + |111\rangle)/\sqrt{2}$, $|W\rangle = (|001\rangle + |010\rangle + |100\rangle)/\sqrt{3}$. Both states are genuinely tripartite entangled, but they are not related by local unitary transformations and behave differently when one party is removed. Hence, tripartite entanglement entropy cannot be unique.

The first signal is the residual information, or Markov gap, $R^{(3)}(A : B) = S_R(A : B) - I(A : B)$, where S_R is the reflected entropy obtained from the canonical purification of ρ_{AB}. A nonzero $R^{(3)}$ certifies genuine tripartite entanglement, although it may vanish on some tripartite-entangled states.

The second signal is the genuine multi-entropy, $GM^{(3)}(A : B : C) = S^{(3)}(A : B : C) - \frac{1}{2}\big[S(A)+S(B)+S(C)\big]$. Both signals vanish for states containing only bipartite entanglement, but they respond differently to a generalized GHZ state $|\psi_{\mathrm{gGHZ}}\rangle = \sum_i \lambda_i |iii\rangle$. For this family, $R^{(3)}_{\mathrm{gGHZ}} = 0$, $GM^{(3)}_{\mathrm{gGHZ}} = \sum_i |\lambda_i|^2 \log \frac{1}{|\lambda_i|} > 0$ for any nontrivial superposition. Their comparison therefore tests whether purely GHZ-like entanglement is compatible with holography.

III. THE HOLOGRAPHIC CONSTRAINT

Consider a pure holographic state on three boundary regions A, B, C, dual to a time-reflection-symmetric bulk spacetime. We use the proposed geometric descriptions of the reflected entropy $S_R(A : B) = \mathcal{A}(\gamma_{A:B})/(2G_N)$, for $\gamma_{A:B}$ the minimal cross-section of the entanglement wedge of AB, and multi-entropy $S^{(3)}(A : B : C) = \mathcal{A}(W_{A:B:C})/(4G_N)$, with $W_{A:B:C}$ the minimal brane web separating all three regions.

Since the full state is pure, the Ryu-Takayanagi surface $\Gamma_C = \Gamma_{AB}$ separates C from AB. Within the entanglement wedge of AB, $\gamma_{A:B}$ separates A from B. Their union is therefore an admissible three-way brane web. Minimality of $W_{A:B:C}$ gives $\mathcal{A}(\Gamma_C) + \mathcal{A}(\gamma_{A:B}) \geq \mathcal{A}(W_{A:B:C})$. Using the holographic area formulas and purity, this becomes

$$\frac{1}{2} R^{(3)}(A : B) \geq GM^{(3)}(A : B : C).$$

A generalized GHZ state has $R^{(3)} = 0$ but $GM^{(3)} > 0$, and therefore violates the inequality. Such a state cannot by itself describe a time-symmetric semiclassical bulk. GHZ-like components are not forbidden altogether, but they must be accompanied by other tripartite structures producing sufficient residual information to satisfy the bound.

IV. SUMMARY AND OUTLOOK

This is the first holographic inequality that nontrivially constrains pure three-party states. It shows that reproducing the correct entropies across every bipartition is not sufficient for a semiclassical gravitational dual: the type of multipartite entanglement also matters. The derivation assumes the proposed brane-web prescription and time-reflection symmetry. Extending it to time-dependent spacetimes and developing the broader hierarchy suggested by our four-party generalization remain important problems

ACKNOWLEDGEMENTS

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Poloidal Dynamics of DNA Minicircles

Tony Lemos[1] & **Harold Kim[1]**
[1]School of Physics, Georgia Institute of Technology

I. SUMMARY

DNA is often pictured as a straight double helix, but inside cells it is frequently packaged into small looped structures. Because DNA's mechanical properties depend on its sequence, different DNA sequences can prefer different looping directions. However, these preferences are difficult to measure experimentally. Using a novel approach, we investigated the preferred looping direction of DNA using DNA minicircles (Figure 1), tiny DNA rings formed by joining the ends of a linear DNA molecule. These minicircles favor a particular inside-out, or poloidal, orientation that reflects the preferred looping direction of the corresponding linear DNA.

II. RESULTS

We constructed DNA minicircles containing a molecular tag positioned at different locations around the DNA helix. By attaching a protein marker to the tag and imaging individual molecules with atomic force microscopy (AFM), we determined whether different regions of the DNA tended to face toward the inside or outside of the minicircle. We applied this method to two DNA sequences that theory predicted would adopt distinct poloidal orientations.

The results revealed clear sequence-dependent differences. The protein marker appeared at different positions around the minicircles for the two sequences, indicating that each sequence favored a different poloidal orientation.

Computer simulations independently predicted the same behavior and closely matched the experimental observations. Together, these findings provide the first direct experimental evidence that DNA sequence can determine the preferred poloidal orientation of DNA minicircles, offering new insight into the structure and dynamics of circular DNA.

III. OUTLOOK

We will next design DNA minicircles with non-Gaussian poloidal dynamics, such as bimodal switching behavior or asymmetric poloidal motion. These unique dynamics may enable the development of DNA-based devices with novel functional properties.

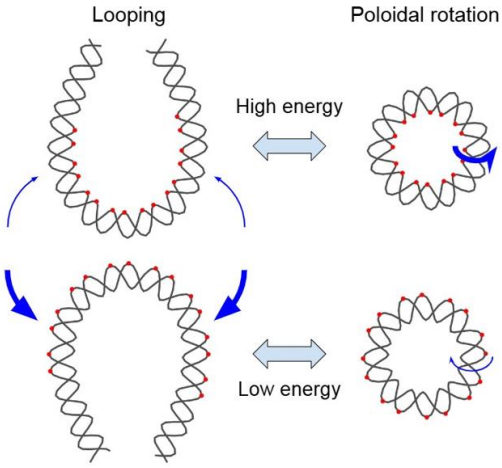


Figure 1: Analogy between linear DNA looping and poloidal rotation of circular DNA.

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Coherent terahertz radiation from laser-wakefield acceleration

Ki-Yong Kim[1]

[1]Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland 20742, USA

I. INTRODUCTION

The terahertz (THz) band of the electromagnetic spectrum (1 THz = 10^{12} Hz)—bridging the microwave and infrared domains—has traditionally been regarded as a particularly challenging frontier in photonics. However, rapid progress in THz source and detector technologies is transforming the field, making the THz range increasingly accessible for both fundamental studies and practical applications in spectroscopy, imaging, sensing, and communications [1]. In particular, the emergence of strong-field THz sources is opening access to new regimes of light-matter interaction, enabling THz-driven nonlinear spectroscopy, ultrafast phase transitions, high-harmonic generation, charged-particle acceleration, and THz-induced tunneling ionization.

All of these emerging applications rely on strong THz sources, and a variety of high-energy THz sources have been developed. These include difference-frequency generation and optical rectification of ultrafast laser pulses in nonlinear crystals, single- and two-color laser mixing in gases, coherent transition radiation (CTR) from ultrashort electron bunches, and laser-plasma interactions in liquids and solids. Notably, tens of millijoules of THz energy were obtained from metal foils irradiated with ~60 J picosecond laser pulses, and joule-level THz radiation has been produced from petawatt (PW) laser-solid interactions.

Laser-wakefield acceleration (LWFA) offers another promising route to high-energy THz generation. Relativistic electron bunches, produced by LWFA, emit THz radiation as they exit the plasma-vacuum boundary via CTR. In general, coherent THz emission occurs when the source (electron bunch) dimensions are comparable to or smaller than the emitted THz wavelength; under this condition, the fields radiated by individual electrons add coherently, and the radiated energy scales with the square of the total charge.

Early experiments with 10-TW-class lasers produced sub-100 nJ THz pulses, consistent with the CTR model. However, a recent experiment at 100-TW laser power generated ~4 mJ of THz radiation; such a high THz output cannot be explained by the conventional CTR model alone, and a coherent acceleration radiation (CAR) model was proposed to account for this regime [2]. In the CAR model, THz waves are produced by relatively low-energy (~MeV) but high-charge (~nC) electrons undergoing strong acceleration and scattering (wave breaking) near the back of plasma bubbles. This occurs continuously over the entire plasma length, producing coherent, conical, radially polarized broadband THz emission [2, 3].

II. THZ GENRATION AND DETECTION

We experimentally characterized THz radiation emitted from LWFA driven at 100-TW laser power. Simultaneous measurements of the laser energy, electron-bunch charge, and THz energy reveal a quadratic dependence of the THz energy on both charge and laser energy. This behavior indicates coherent collective emission in the generation process and provides a useful scaling law for THz output. Microbolometer-based beam profiling shows a relatively large THz beam divergence (~0.2 rad). Single-shot THz interferometry further shows that the emitted THz pulse is sub-picosecond in duration and broadband. Combining the beam-profile and interferometric measurements, the THz spectrum is expected to span approximately 1–20 THz. Together, these results support coherent acceleration radiation as the dominant mechanism for THz generation in 100-TW LWFA.

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How molybdenum disulfide (MoS_2) modulates actin assembly dynamics and fibroblast cell viability

Ellen H. Kang[1,2,3], Bryan Demosthene[1,4], Tristen Gerren[1], Dylan Jeff[1,2], Taylor V Douglas[1,2], Tamar Y Yishay[4], Robert Steward[4], Saiful Khondaker[1,2]

[1]NanoScience Technology Center, [2]Department of Physics, [3]Department of Materials Science and Engineering, [4]Burnett School of Biomedical Sciences, University of Central Florida, Orlando, Florida, USA

I. SUMMARY

The actin cytoskeleton is an active biological network that changes in response to the cell's microenvironment allowing for vital functions such as cell motility, division, and maintaining cell morphology. Molybdenum disulfide (MoS_2) is a 2D transition metal dichalcogenide nanomaterial utilized in various biomedical applications due to its biocompatibility, electrochemical, and mechanical properties at the nanoscale. The use of MoS_2 in these applications increases the need to determine how these specific nanomaterials influence biological molecule structure and functions. While previous studies have shown the effects of MoS_2 nanomaterials at the cellular level, it is not well established how MoS_2 directly influences the actin cytoskeleton.

In this study, we investigate the effects of MoS_2 nanoflakes on actin cytoskeletal dynamics in the cell and determine how MoS_2 modulates actin filament assembly kinetics. Using total internal reflection fluorescence microscopy, we determined how varying concentrations of MoS_2 nanoflakes influence the elongation rate of individual actin filaments. We studied changes in NIH-3T3 mouse fibroblast viability, morphology, and spreading in response to MoS_2 nanomaterials. Our results showed an increase in cell spreading without a significant change in cell viability after MoS_2 treatment. These results indicate that the MoS_2 nanoflakes can modulate the actin cytoskeleton without inducing adverse effects on the cell depending on the concentration, leading to safer uses of MoS_2 nanomaterials in various biomedical applications.

II. RESULTS

A. Effects of MoS_2 *on actin filament elongation rates*

To determine how MoS_2 influences actin filament assembly rates in vitro, we polymerized actin filaments in the presence of varying concentrations of MoS_2 nanoflakes using a functionalized flow cell and acquired time lapse images of actin filament assembly in real time using TIRF microscopy. Actin filaments grew steadily up to 10 minutes. From the time-lapse images, individual filaments were selected and used to generated kymographs that displayed the actin filament growth over time. Time lapse images showed growth on one end of the filament, indicative of the filament barbed end. Representative filaments were chosen to show the slope of actin filament elongation in each condition. When MoS_2 nanoflake concentration increased, there was a significant increase in average elongation rates of individual filaments. However, at high concentrations above 100 μg/mL, the average filament elongation rates were shown to recover to similar levels as control.

B. Effects of MoS_2 *on NIH-3T3 mouse fibroblast cell viability*

To determine the effects of the MoS_2 nanoflakes on the cytoskeleton *ex vivo*, we cultured NIH-3T3 mouse embryo fibroblasts to determine changes in viability and morphology after treatment with varying concentrations of MoS_2 nanoflakes. We evaluated the effects that MoS_2 nanomaterials had on the viability of NIH3T3 cells using a WST-1 assay. Cells were plated into a 96 well plate and triplicate measurements were taken of cell viability after 24- and 48-hours in the absence (control) and presence of MoS_2 nanomaterial. Cells were observed to have similar readings of cell viability in MoS_2 treated samples as was seen in control samples. This indicates that the MoS_2 samples are not cytotoxic to NIH-3T3 fibroblasts at the tested concentrations.

ACKNOWLEDGEMENTS

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Emerging Areas (Entertainment Technology & STEAM-centered Social Sciences)

Temporal Shifts of Key Factors for Volunteer Retention in Local Mentoring Programs using Machine Learning Approach

Juyoung Lee[*1], **Sunghyun Kim**[1], **Saumya Diwan**[1]
[1]Emory University, Atlanta, GA

I. SUMMARY

We propose a machine learning framework to identify which program factors drive volunteer mentor retention—and when those factors matter most.

Using twelve years of longitudinal data from JUMP (Korea), we show that retention is shaped by temporally distinct predictors: early-program dynamics are governed by peer relationships, whereas teaching effectiveness dominates mid-to-late program phases.

II. INTRODUCTION

Despite well-documented benefits of mentoring for both mentors and mentees, retention of college student volunteers consistently declines over time. Prior work has evaluated program outcomes without systematically analyzing when specific factors become critical. We address this gap by combining ensemble machine learning (feature importance) with Kaplan–Meier survival analysis (temporal dynamics) on a large-scale longitudinal dataset.

III. METHODS

A. Dataset

12-year retrospective cohort (2012–2024) from 37 JUMP mentoring platforms: 3,277 CSV files, 9,300 respondents. Weekly mentor activity reports and post-program satisfaction surveys were standardized to a 5-point scale.

B. Features

Five feature categories — Teaching Outcomes (LM), Volunteer Organization Communication (CC), Peer Mentor Relationship (PR), Personal Circumstances (TO), and Activity Time (TM) with their mean/SD/weekly-Δ yielded 15 total predictors.

C. Models

Random Forest and XGBoost predicted retention. Kaplan–Meier survival analysis with log-rank tests and Cox proportional hazards examined when each top feature most critically influenced dropout.

IV. RESULTS & DISCUSSION

Ensemble models substantially outperformed baseline: Random Forest R^2=0.622 (MAE=10.8), XGBoost R^2=0.560 (MAE=10.9) vs. Linear Regression R^2=0.040 (MAE=18.0), $p<0.001$. Feature importance ranked LM > FR > PR ≈ CC.

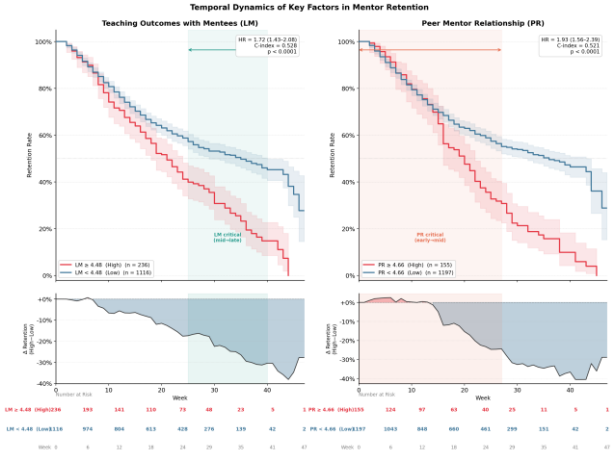


Figure 1. Retention curves for LM and PR.

Survival analysis revealed that these factors are not uniformly important across time. PR separates groups most sharply in the early–mid program (wk 1–27): mentors with low peer relationships drop out significantly earlier. LM becomes the dominant predictor from mid-program onward (wk 25–40), suggesting perceived teaching impact sustains long-term commitment once early social bonds are established.

Counterintuitively, below-average CC scores correlated with higher retention—autonomy, rather than close managerial oversight, appears to foster sustained engagement.

ACKNOWLEDGEMENTS

Supported by the 2024 JUMP Research Contest Grant, funded by the Center for Social Value Enhancement Studies (CSES) and Brian Impact.

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University Complexity and the Decoupled Role of Universities in U.S. Regional Innovation Systems

Sooyeon Lim[1,2]
[1]Georgia Institute of Technology,
[2]Seoul National University

I. SUMMARY

Regional innovation policy assumes universities mirror local industry. Using USPTO patents for 51 U.S. states (2013–2023), this study places university portfolios (UniC) in the same complexity space as state knowledge complexity (KCI). University complexity is far less geographically differentiated—about one-fifth the dispersion and weakly correlated—indicating a stable knowledge layer only partially shaped by local industry, which motivates a three-regime typology and a dynamic Florida case.

II. DATA AND METHOD

Granted USPTO utility patents (PatentsView, December 2024) for the 50 states and Washington, D.C. over 2013–2023 are classified at the four-digit CPC subclass level. Of 1,738,487 patents, 73,536 (4.23%) are assigned to universities, identified by validated top-down pattern matching; multiple assignees are handled by full counting.

For each state–technology pair the Revealed Comparative Advantage is binarized, and the Method of Reflections [1] yields KCI (states) and TCI (technologies) from the same matrix, placing both on a common scale. UniC is defined as the TCI-weighted average of a state's university portfolio, and IndC as the analogous measure for non-university patents. The University Complexity Premium is UCP = UniC − KCI, the position of universities relative to the state average.

III. Results

KCI ranges from +4.17 (California) to −1.35 (Michigan), with σ = 1.000, while UniC spans only +0.72 to −0.16 (σ = 0.215). The two correlate only weakly (r = 0.380), in sharp contrast to IndC, which tracks KCI closely (r = 0.815). Yet IndC shows larger dispersion despite about 22 times more patents, so the narrow UniC spread is a distributional pattern, not a sample-size artifact (Fig. 1).

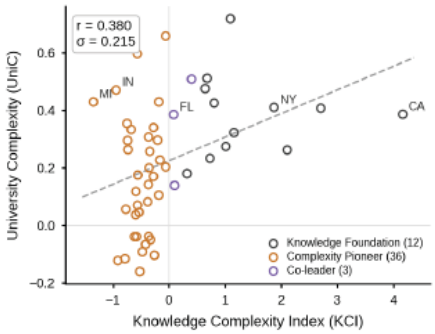


Figure 1: University complexity (UniC) versus regional complexity (KCI) across 51 U.S. states, by regime.

The sign combination of KCI and UCP sorts the 51 states into three regimes (Table 1): Knowledge Foundation, high-KCI hubs where industry exceeds universities; Complexity Pioneer, below-average industry but above-average universities; and Co-leader, both above average.

Regime	n	KCI	UniC	UCP
Knowledge Foundation	12	+1.44	+0.38	−1.06
Complexity Pioneer	36	−0.50	+0.16	+0.66
Co-leader	3	+0.19	+0.34	+0.15

Florida moves from Complexity Pioneer (2013–2017) to Co-leader (2018–2023) as KCI (−0.05 → +0.12) and UniC (+0.31 → +0.46) rise together while UCP is essentially unchanged.

ACKNOWLEDGEMENTS

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FitMindMove: Multi-Dimensional Hybrid Model Selection for Behavioral Health AI Systems

Saahoon Hong1[1], Hea-Won Kim[1], Terry Choi[2], Dongwoo Shin[2]
[1]Indiana University Indianapolis, [2]A TO Z Service Inc

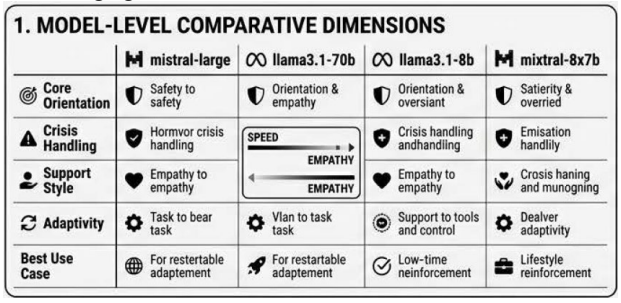
I. SUMMARY

FitMindMove is an AI-driven behavioral health platform supporting SUD recovery through personalized chatbot engagement, voice interaction, and clinician dashboards with real-time analytics. Its modular, model-agnostic architecture dynamically routes interactions across AI models to optimize safety, empathy, and guidance, ensuring adaptive, ethical, and clinically aligned support in real-world care settings.

II. HYBRID MODEL SELECTION PROCESS

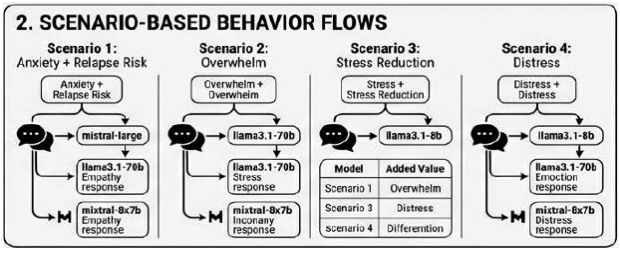
A. Multi-Dimensional Model Evaluation Framework

The model comparison for FitMindMove employed a multi-dimensional, scenario-based framework assessing safety, empathy, response structure, adaptivity, transparency, and speed. Distinct model strengths emerged, including safety-focused (mistral-large), empathy-driven (llama3.1-70b), structured guidance (llama3.1-8b), and lifestyle-oriented (mixtral-8x7b), reflecting varied clinical and user engagement needs.



B. Scenario Testing and Performance Trade-offs

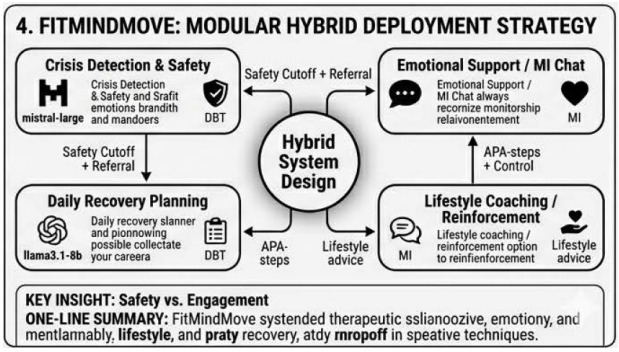
Scenario-based evaluations (e.g., relapse risk, emotional distress) highlighted trade-offs between safety, engagement, and actionability.



Performance analysis demonstrated that no single model adequately satisfies all behavioral health requirements, necessitating a balanced approach.

C. Hybrid Architecture and Model Orchestration

Findings support a modular, hybrid AI architecture that dynamically routes tasks—such as crisis detection, emotional support, and recovery planning—to the most appropriate models. This approach optimizes clinical safety, user engagement, and actionable guidance in real-world behavioral health settings.



III. CONCLUSIONS

The findings indicate that a single-model approach is insufficient for behavioral health applications. Instead, a modular, hybrid AI architecture is required, where models are strategically deployed based on task demands such as safety monitoring, emotional support, structured recovery planning, and lifestyle coaching. This comparison highlights that LLMs operate along a continuum (from safety-driven to empathy-driven, and from structured to holistic support), emphasizing the importance of dynamic model orchestration to balance clinical safety, user engagement, and actionable guidance in real-world behavioral health settings.

ACKNOWLEDGEMENTS

Funded by Intrepid Phoenix Ventures and Indiana Applied Research Institute, supporting FitMindMove AI recovery platform (2025 awards).

Female International Students in STEM: Distinctive Cultural Assets

Jae Hoon Lim, Yao Zhao, & Yuting Chen
University of North Carolina at Charlotte

I. SUMMARY

This qualitative research explored the adaptation and acculturation process of two sub-groups of international female students. Our analysis, focusing on the similarities and differences between the two groups, elucidated each group's unique cultural assets and adaptation strategies situated in the post-pandemic American higher education and STEM workforce environment.

II. INTRODUCTION AND THEORETICAL MODEL

A. Introduction

STEM disciplines have long been criticized for their low representation of women and, as a result, have actively recruited women's talent at all levels. With the growing presence of international students and faculty members in STEM fields, female international students in STEM have emerged as a noteworthy subgroup. These individuals embody multiple overlapping marginalities and are likely to have distinctive experiences that set them apart from other international students reported in previous studies.

B. Theoretical Model

Yosso's theory of community cultural wealth (CCW) served as the theoretical framework. This model highlights the distinctive intrapersonal dispositions and community-embedded resources that explain the professional success and upward mobility of traditionally marginalized community members in American society.



Figure 1: Yosso's Community Cultural Wealth Model

III. METHODS

This study is a qualitative case study (Hancock et al., 2021) conducted in a large urban research institution located in the Southeast. The sample includes 14 international female graduate students enrolled in multiple engineering programs. Participants completed at least one semi-structured interview lasting 40-75 minutes in 2025-2026. The research team applied within-case and cross-case analyses and identified key patterns and relationships consistent across all participants, as well as noteworthy variations between the two groups, Southeast Asians and Chinese students.

IV. FINDINGS

Our qualitative analysis showed that all participants faced a similar set of challenges during their first year, including adapting to new cultural and academic norms in US higher education and developing essential life skills to manage daily survival. Building and tapping into various capital (e.g., familial, social, & navigational) are common among all participants. Still, Chinese students tend to exhibit greater self-reliance/self-accountability, using internal coping mechanisms before seeking external resources or support. In contrast, South Asian students tended to adopt a community-based approach, proactively seeking information, resources, and connections through their established ethnic community and campus networks.

ACKNOWLEDGEMENTS

This study was partially supported by UNC Charlotte Scholarship of Teaching and Learning grant.

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Analyzing Mentoring Ecosystems in Engineering Research Centers

Presenter Name[1], Co-Author Name[2]
[1]Affiliation, [2]Affiliation

I. SUMMARY

Mentoring in research centers involves multiple stakeholders whose relational dynamics extend beyond traditional dyadic models, yet methodological approaches for studying these ecosystems remain underdeveloped. This study presents a two-phase, sociogram-informed qualitative method designed to examine how mentees within a National Science Foundation (NSF) Engineering Research Center (ERC) experience their mentoring relationships. Grounded in the STEM Mentoring Ecosystem (STEM-ME) framework [1], this approach integrates semi-structured interviews with participant-generated sociograms, visual representations of each individual's mentoring network, to produce a layered understanding of mentoring roles, perceived influence, and cross-network patterns. This work foregrounds the methodological contribution, with future work extending the approach to mentor-reported data for cross-population comparison.

II. METHODOLOGICAL APPROACH

A. Phase 1

In the first phase, single case analysis was conducted for each mentee (n=13). Semi-structured interviews were conducted alongside participant-generated sociograms. The sociograms served a dual analytical purpose: they prompted participants to narrate their relationships through visual reference during the interview, and they strengthened the researcher's interpretive capacity when analyzing transcript data. Using a deductive lens informed by the STEM-ME framework, a mentoring network was refined for each participant based on their sociogram, interview transcript, and interviewer reflection notes. As a result, key mentors were classified into four stakeholder categories informed by the STEM-ME framework: advisors, environmental stewards, external professionals, and peers.

B. Phase 2

In the second phase, cross-case analysis was conducted to identify relational patterns across mentee participants. The aforementioned categories were ranked by perceived influence in a comparative table that captured whom mentees identified as most impactful and the nature of those mentoring roles. The STEM-ME framework was then contextualized within the ERC to visualize how salient mentoring relationships reflected the broader theoretical structure. This cross-case analysis enabled a systematic comparison of mentoring structures across individual ego-networks, revealing both shared and divergent patterns in how mentees experienced support within the same institutional environment.

III. CONTRIBUTIONS AND IMPLICATIONS

This work contributes to research methods in engineering education by demonstrating how visual tools can deepen qualitative inquiry beyond traditional thematic coding. The method positions participant-generated sociograms as both a data collection instrument and an analytical lens, bridging individual narrative and structural understanding. The two-phase design also offers a transferable, replicable structure for researchers seeking to study mentoring ecosystems, that showcases cross-case comparison. Future work will extend the analysis to mentor data as a verification and enrichment of understanding mentoring dynamics at the ERC, which will make practical implications for other institutions in examining and cultivating mentoring structures that support multi-institutional collaboration and learning.

ACKNOWLEDGEMENTS

This material is based upon work supported by [Redacted for Review].

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Utilizing a Video Game to Examine Engineering Team Communication

Fatemah Shehab, Benjamin Ahn
Department of Engineering Education, The Ohio State University

I. SUMMARY

This study investigates team communication among graduate engineering students playing the video game "Overcooked" by extracting communication metrics from audio-video recordings using Python. The examined metrics include turn-taking frequency, word count, speech duration, and gesture. These metrics show how graduate students communicate during team activities and provide insights into how their communication affects team outcomes, thereby highlighting the importance of communication in teamwork tasks.

II. INTRODUCTION

Graduate engineering students engage in collaborative structures such as research groups, competition teams, and course-based projects. In these structures, communication is a key component of collaboration.

The goal of this study is to use the video game "Overcooked" on the Nintendo Switch to capture communication metrics from engineering graduate students working in teams and to predict team outcomes. In this video game, players work together in a restaurant setting, preparing dishes for customers. The game uses a star and coin system to evaluate the team's performance within the time limit. Recording players while they play the game allows observation of their communication methods alongside their team's performance. The research question for this study is: To what extent do communication metrics (e.g., turn-taking, word count) predict a team's outcome (i.e., scores that reflect their effectiveness as a team)?

III. METHOD

Audio-video recordings were collected from 3- to 4-person teams as they played the game. The same task was administered to all teams to ensure that differences in communicative patterns reflect team dynamics rather than variation in task difficulty.

Recordings were processed in Python to produce time-stamped, speaker-attributed audio segments. These segments were used to extract the total duration, proportional share of talk, and turn-taking frequency for each team member. Video recordings were processed to count the number of hand movements and pointing actions players made to plan and distribute tasks prior to and during the game. The metrics were then analyzed using descriptive statistics and correlation analysis to examine the overall distribution of interaction patterns across teams and to identify which metric correlates with the stars metric (i.e., team performance).

Table 1 shows an example of the metrics extracted for Player A on a team. Turn taking represents the conversational exchanges between Player A and another player. Turn taking total is the total number of turn-taking instances between Player A and the rest of the players. Word count represents the total number of words Player A uttered. Gestures are the number of times Player A gestured toward the screen. Finally, speech duration is the total time Player A spoke during the observation.

Table 1: Example of extracted data for Player A

Player	Turn-taking	Turn-taking total	Word Count	Ges-tures	Speech duration (minutes)
Player A	15	22	315	3	2.25

IV. RESULTS AND CONCLUSION

Based on the preliminary investigation, the best strategy to achieve the highest team performance scores is to share tasks with others and keep them informed when a task is completed, so others can complete their tasks. In other words, the total number of turn-taking instances in speech during the game contributed to achieving high team performance. Furthermore, active gesturing, which translates to discussion of the division of tasks before the game begins and to creating a plan, improves team performance. The findings align with previous research on the importance of turn-taking and team efficiency. In summary, this paper assists universities in preparing graduate students for their team interactions. Furthermore, it moves teamwork research in engineering beyond perception-based measures and toward behavioral data.

Child Executive Function Predicts Neurophysiology Indicators of Emotion Regulation: Insights from Frontal Alpha Asymmetry and Respiratory Sinus Arrhythmia

Yelim Hong[1], Laura Quiñones-Camacho[1], Martha Ann Bell[2]
[1]The University of Texas at Austin
[2]Virginia Tech

I. SUMMARY

This study examines how children's executive function (EF) relates to two neurophysiological indicators of emotion regulation (ER). By integrating electroencephalography (EEG) and electrocardiogram (ECG) measures of ER, we explore the dynamic interplay between EF and children's emotional responding, offering insights into bolstering EF may foster resilience by enhancing the neurobiological capacity for regulation.

II. CURRENT STUDY

A. Background

Emotion regulation in childhood is fundamental to long-term well-being. Executive functions (EF; neurocognitive abilities, such as working memory, inhibitory control, and cognitive flexibility) facilitate goal-directed behavior and support ER. Although stronger EF correlates with more effective ER, less is known about whether EF is reflected in children's neurophysiological regulation during emotional challenges. The present study integrates two complementary biomarkers of ER:

- Frontal alpha asymmetry (FAA): Measured via EEG, FAA reflects differences in alpha activity between the left and right frontal regions. Greater left frontal asymmetry is linked to approach behaviors and adaptive regulation, whereas right frontal asymmetry reflects avoidance and withdrawal.
- Respiratory sinus arrhythmia (RSA): Measured via ECG, RSA is an index of parasympathetic cardiac control via the vagus nerve. RSA captures heart rate variability linked to breathing. Reductions in RSA from baseline to task (i.e., vagal suppression) signal effective physiological regulation during emotional arousal.

While FAA reflects neural mechanisms of top-down regulation, RSA captures parasympathetic regulation of physiological arousal. Integrating these biomarkers is essential, as they reflect a comprehensive picture of regulatory system. Thus, the present study utilizes a multimodal approach to examine how child EF shapes the neural (FAA) and physiological (RSA) processes underlying experiences of negative emotions at ages 6 and 9.

B. Methods

Participants were 241 children assessed at ages 6 and 9 as part of a longitudinal study. Children completed three EF tasks (Stroop task; Digit span; Dimensional Change Card Sort). They also completed age-appropriate emotion-eliciting tasks (frustration, disappointment) while EEG and ECG were collected: Not Sharing and Wrong Gift at age 6, and Locked Box and Broken Gift at age 9.

C. Results

Multilevel analyses revealed that at age 6, higher EF was associated with attenuated RSA withdrawal during frustration. At age 9, higher EF predicted greater relative left FAA across both emotional contexts and showed a marginal association with attenuated RSA withdrawal during disappointment. These findings underscore the role of EF in supporting the neurobiological underpinnings of ER. By age 9, children with stronger executive abilities exhibited more adaptive neural and autonomic responses to emotional challenge, suggesting that cognitive control facilitates the effective modulation of physiological arousal and approach-related motivation. These results highlight the value of integrating cognitive and neurobiological perspectives to understand how children learn to manage negative emotions.

ACKNOWLEDGEMENTS

We would like to thank the participants and the staff in the laboratories at Virginia Tech and UNC Greensboro. The research was supported by a grant from the Eunice Kennedy Shriver National Institute of Child Health and Human Development.

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How Does Feedback Influence Standard-Setting Ratings in Medical Certification Assessments?

Chansoon (Danielle) Lee, Kelly Rewley, Jerome Clauser
American Board of Internal Medicine

I. SUMMARY

This study explores the effect of feedback on content experts' standard setting ratings in medical certification assessments using a mixed-methods approach. Findings from the quantitative and qualitative analyses suggest that providing feedback (e.g., the panel's projected pass rate) significantly impacts ratings in ways that may undermine the content-based nature of the process.

II. INTRODUCTION

In licensure and certification settings, assessing competence requires setting performance standards to distinguish competent from non-competent candidates. Typical standard-setting processes involve multiple rounds in which content experts receive feedback on their ratings and are given the opportunity to revise their ratings. This iterative process is intended to reduce bias and improve internal consistency. However, content experts may use feedback information mechanically, leading to standards that are norm-referenced rather than content-referenced.

III. METHODS

Data were collected from standard settings for 11 medical certification assessments. The sample consisted of 321 panelists across all assessments with approximately 30 panelists per assessment. A simple linear regression analysis was conducted to examine whether convergence toward the feedback pass rate, which was provided after the practice rating session and before the operational rating session, predicted the pass rate based on operational ratings. Specifically, the difference between the practice pass rate and the feedback pass rate was used to predict the magnitude of rating change from the practice to the operational pass rate. Data were pooled across examinations for the final analysis. Additionally, pre- and post-operational-rating surveys were conducted for three exams to better understand how panelists interpreted and used the feedback in the operational ratings.

IV. RESULTS

As shown in Figure 1, practice-feedback differences significantly predicted practice-operational differences, $\beta = 0.89$, $SE = 0.04$, $t(319) = 20.14$, $p < .001$, explaining 56% of the variance in the outcome (Adjusted $R^2 = .56$). The survey responses also indicated that the feedback might influence panelists' rating decisions. Some examples of panelists' responses are presented in Figure 2. These examples illustrate how panelists compared their ratings with the feedback and subsequently adjusted their ratings, highlighted in red. The presentation will provide additional details and discuss the implications of these findings.

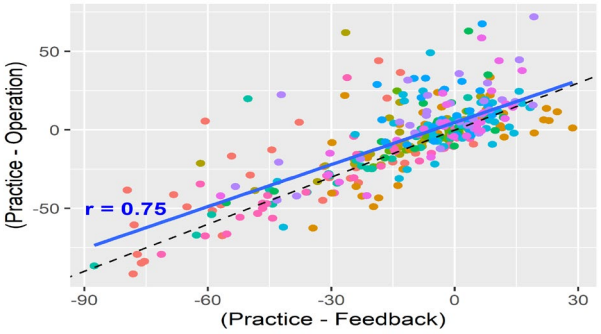


Figure 1: Relationship between Practice-Feedback and Practice-Operational Pass Rate Differences

Question: *How did the feedback (the panel's projected pass rate) influence your rating process?*
"Helped me see what I designed as the pass rate compared to my peers."
"My ratings seemed slightly easier than the group as a whole."
"It was helpful to see that I may have been a bit of an outlier with the group."
"I re-adjusted my rating process to be less stringent."
"My feedback showed that I was pretty easy on the borderline examinee. I'm pretty sure I was harder on them during the longer session.

Figure 2: Examples of Survey Responses

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Technological Changes in U.S. Prisons: Contraband, AI, and Institutional Security

Hyesun Kim
President of KOSCA, Professor of criminal justice
Worcester State University

I. SUMMARY

This study examines recent technological changes in U.S. prisons, with particular attention to the rise of artificial intelligence (AI) and its implications for prison management, inmate life, institutional security, and safety.

II. TECHNOLOGICAL ADVANCEMENT

A brief historical overview suggests that, by the late twentieth century, correctional systems were already moving away from paper-based reporting, manual recordkeeping and searches, and physical mail inspection toward computerized tracking, electronic monitoring, and technology-assisted administration, reflecting a broader institutional shift toward efficiency. In the following decades, prisons adopted additional communication and control technologies, including video visitation and tablet-based services. These tools fundamentally altered how inmates maintained outside relationships and accessed educational and recreational resources (Coppola, 2016). As prison management systems have become more technologically sophisticated, incarcerated people have also adopted new technologies to obtain contraband. The expansion of contraband cell phones, drone deliveries, digitized communications, and hidden electronic devices has transformed the problem from a largely physical security issue into an ongoing technological challenge for correctional institutions. Research by the National Institute of Justice (2023) indicates that contraband cell phones have been linked to violence, underground economies, criminal coordination, and threatening prison safety and security. In addition, drone deliveries and digitized communication have made interdiction more complex, costly, and difficult to standardize. AI has emerged as a powerful tool for monitoring prison communications, scanning digitized mail, flagging suspicious language, detecting hidden contraband, and performing intelligence functions inside correctional institutions (Iverson, 2022).

III. NEW CHALLENGES IN CORRECTIONS

This study argues that these technological changes reshape prison life at multiple levels. For administrators, AI and security technologies provide earlier threat detection and proactive interdiction, but they also require substantial financial investment, staff training, and continuous adaptation (Peterson et al., 2022). For inmates, these systems widen access to services but simultaneously intensify surveillance, reduce privacy, and transform everyday social interactions. Therefore, recent technological changes in prisons represent a fundamental reorganization of control, risk, and safety. Failing to manage these tools effectively can compromise security and deepen mistrust between staff and inmates, exacerbating institutional strain. By analyzing the interaction between inmate technological adaptation and AI-based correctional control, this study highlights the complex challenges confronting contemporary prison systems.

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Prompt Engineering and Human–AI Grading Agreement

Jesse Ha, Elliot Hu-Au, Asja Alic
Montclair State University

I. SUMMARY

Artificial intelligence (AI) has emerged as a promising tool for reducing educator workload through automated assessment; however, questions remain regarding the reliability and trustworthiness of AI-generated scores. This study examined how prompt engineering strategies influence agreement between human graders and large language models when evaluating free-response assessments.

A total of 196 undergraduate students enrolled in a statistics course completed free-response assessment questions. Human ratings were compared with scores generated by ChatGPT 5.5 using multiple prompting conditions.

II. METHODS

Student responses were scored using a four-point rubric developed through multiple inter-rater reliability (IRR) sessions. Agreement between human and AI scores was evaluated using Cohen's kappa, Pearson correlations, exact agreement, agreement within one rubric category (±1), and quadratic weighted Cohen's kappa (κw). Weighted kappa was included because rubric scores represented ordinal categories.

III. RESULTS

Prompting strategy influenced human–AI agreement. Traditional Cohen's kappa values ranged from .126 to .372 across ChatGPT 5.5 conditions. However, weighted agreement values were substantially stronger, ranging from κw = .387 to κw = .697. Agreement within one rubric category exceeded 94% across all prompting conditions, indicating that most disagreements reflected adjacent scoring levels rather than fundamentally different evaluations of student performance.

III. DISCUSSION

A key finding of this study is that conclusions regarding AI grading performance depend substantially on the agreement metric selected. Traditional Cohen's kappa suggested only fair agreement between human and AI raters, whereas quadratic weighted Cohen's kappa indicated moderate-to-substantial agreement across several prompting conditions. Because educational rubrics typically represent ordered categories, disagreements between adjacent score levels are often less consequential than disagreements spanning multiple categories. The weighted analyses therefore provide a more nuanced understanding of AI-assisted grading performance and suggest that many human–AI disagreements reflect differences in severity rather than fundamentally different evaluations of student understanding. These findings highlight the importance of selecting reliability measures that align with the nature of educational assessment data.

Table 1: Weighted Human–AI Agreement

Condition	Weighted κw
Instant Few-Shot	.697
Thinking Few-Shot	.620
Instant Rubric	.621
Extended Thinking Few-Shot	.591
Extended Thinking Rubric	.501
Thinking Rubric	.387

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AI-Based Automated Scoring for Police Shooting Targets

Hyoungah Park[1], Changmi Son[2]
[1]Saint Peter's University, [2]Korea National Police Agency

I. SUMMARY

This study introduces a deep learning-based automated scoring system for evaluating police shootings. The system integrates YOLOv11m-seg for score-area segmentation and YOLOv11s for bullet-hole detection. A dataset of 5,100 slow-fire target images was used for training and evaluation. On 100 test targets (994 bullet holes), the system detected 988 hits, achieving a 99.4% hit detection rate, with scoring results comparable to manual evaluation. The system reduced processing time by about 70% and the workforce by 60%.

II. INTRODUCTION

While effective shooting training is essential for police performance, manual target scoring remains labor-intensive and inconsistent. A single training session at the Seoul Metropolitan Police Agency involves approximately 4,000 targets and requires substantial time and manpower. Scoring accuracy may also be affected by limited expertise, parallax errors, and subjective interpretations of line-breaking hits. This study proposes an AI-based system to enable more objective and efficient evaluation.

III. METHODOLOGY

A. Data

A total of 5,100 slow-fire target images were annotated using CVAT. The dataset includes score-area segmentation masks (10 classes) and bullet-hole bounding boxes. A semi-automatic labeling approach was used, and the automatic annotations were refined through manual verification. The dataset was split into training (4,000), validation (1,000), and test (100) sets.

B. Model Implementation and System Integration

The proposed system uses YOLOv11m-seg for area-based score segmentation and YOLOv11s for bullet-hole detection. The pipeline includes QR-based target identification, segmentation, detection, and scoring. Each bullet hole is represented by its center, and a 9-mm-diameter region determines the score based on overlap, with higher scores prioritized. To enhance detection robustness, an iterative strategy is implemented that lowers the confidence threshold if the number of detected hits falls below the expected count.

IV. RESULTS AND EVALUATION

Table 1 summarizes the model performance for score-area segmentation and bullet-hole detection. Both models showed high precision and recall in controlled conditions.

Table 1: Model Training Performance Metrics

Category	Prec.	Rec.	mAP50	mAP50-95
Score Area	1	0.998	0.995	0.99
Bullet Hole	0.992	0.983	0.994	0.811

The system was evaluated on 100 test targets containing 994 bullet holes. Of these, 988 hits were detected, resulting in a 99.4% detection-based accuracy. The scoring results were comparable to the manual evaluation, despite minor human inconsistencies. As shown in Table 2, the average processing time per target decreased from 5 min to 1.5 min, and the required personnel decreased from 5 to 2.

Table 2: Efficiency Comparison: Manual vs. Automatic Scoring System

Category	Accuracy	Time Required	Personnel
Manual	99.5%	5 min	5 persons
AI System	99.4%	1.5 min	2 persons

V. CONCLUSION AND LIMITATIONS

This study presents an AI-based automatic scoring system for police shooting targets. The proposed system achieved high detection accuracy, produced scoring results comparable to manual evaluation, and improved efficiency in time and manpower. However, overlapping bullet holes remain a challenge, especially in closely clustered hits. Future work will focus on improving detection accuracy for overlapping bullet holes and further increasing the system's overall reliability.

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Preservice Teachers' Responsive Mathematics Teaching with AI-Powered Student Emulating Agents

Dabae Lee[1], Corey Webel[2] Sheunghyun Yeo,[3] Burcu Alapala,[4] Rebekah Hanak[5]
[1]Kennesaw State University, [2, 4,5] University of Missouri, [3]Daegu National University of Education

I. INTRODUCTION

Responsive teaching emphasizes attending to and building upon students' ideas, fostering deeper understanding and engagement (Radoff et al., 2018; Robertson et al., 2015). This method requires teachers to interpret students' thinking in the moment and adapt their instructional strategies accordingly. Teachers use questioning skills to elicit and extend their mathematical thinking. Effective questioning assesses student understanding and stimulates critical thinking and active engagement, thereby cultivating deeper learning. By posing effective questions, educators can identify learners' misconceptions, guide discussions, and tailor instruction to support student learning. Responsive teaching is a critical yet underdeveloped skill for many elementary preservice teachers (PSTs) (Jacobs & Empson, 2016; NCTM, 2014).

Practice-based teacher education emphasizes approximating key teaching practices in low-risk environments, existing simulations are often resource-intensive or limited in scope (Grossman et al., 2009). Recent advances in artificial intelligence (AI) offer new potential for scalable, authentic approximations of practice (Lee et al., 2025). In particular, AI has introduced new avenues for enhancing responsive teaching practices (Christensen & Knezek, 2025; Zhang et al., 2025). AI-powered agents (chatbots), for example, offer promising tools for simulated interactive teaching scenarios, allowing PSTs to develop and refine their responsive teaching skills in a low-risk environment (Lee et al., 2025; Lee & Yeo, 2022; Son et al., 2024). These chatbots can mimic student responses, enabling teachers to practice formulating questions, interpreting students' answers, and adjusting their instructional strategies in real-time. By engaging in AI-powered simulations, teachers can experience a range of student interactions, receive immediate feedback, and reflect on their questioning skills and instructional decisions (Cao et al., 2023). This experiential learning approach enhances teachers' responsive teaching skills and prepares them to navigate the complexities of real classroom dynamics effectively.

This study explored the questioning patterns that PSTs exhibited when engaging with text-based AI conversational agents representing different children with specific mathematical conceptions. Drawing on the prior work in practice-based teacher education and fraction learning, we designed and implemented interactive modules including simulated interactions with a virtual student and virtual mentor.

Our research question follows: What questioning patterns do PSTs exhibit when engaging with AI agents representing different children with specific mathematical conceptions?

III. RESEARCH DESIGN

We employed a quantitative content analysis design (Neuendorf, 2017) to investigate the questioning patterns exhibited by PSTs during interactions with two AI chatbots representing different children with specific mathematical conceptions on equal sharing tasks. Content analysis systematically classifies and quantifies questioning behaviors across structured chatbot interactions, enabling the identification of significant patterns.

A within-subjects design was used, in which each PST interacted with the two chatbot personas - Gabriel and Noah embedded in websites (Figure 1). Each chatbot simulated a different child conception, allowing for comparisons of questioning strategies elicited in different teaching situations. You can include a maximum of 1 figure and 1 table as needed. Figure caption should be below the figure; table caption should be above the table.

ACKNOWLEDGEMENTS

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Omitted for space.

Apendix
UKC 2026 Program

Plenary Speakers



William D. Phillips

Nobel Laureate in Physics

NIST Fellow and Distinguished University Professor

Dr. William D. Phillips is a Nobel Prize-winning physicist and NIST Fellow at the U.S. National Institute of Standards and Technology (NIST), as well as a Distinguished University Professor of Physics at the University of Maryland. He was awarded the 1997 Nobel Prize in Physics for the development of methods to cool and trap atoms using laser light, a breakthrough that transformed modern atomic physics and quantum science.

Dr. Phillips founded NIST's Laser Cooling and Trapping Group and pioneered techniques that have become fundamental to cold-atom research worldwide. His work has contributed to advances in quantum technologies, precision measurement, and atomic clocks, which serve as the foundation of global timekeeping systems.

Through his scientific discoveries, education, and public engagement, Dr. Phillips continues to inspire new generations of scientists while advancing the frontiers of quantum physics.

A New Measure: the Quantum Reform of the Modern Metric System

The metric system, officially the "***International System of Units***", has its roots in the French revolution. Today we have experienced the greatest revolution in measurement since the French revolution. The quantum nature of sub-microscopic atomic matter now provides new definitions of the kilogram, ampere, kelvin, and mole. These quantities are defined by fixing values for the most fundamental quantum constant, Planck's constant; the quantum of electric charge; Boltzmann's constant; and Avogadro's number. I will explain how this is possible, why it was necessary, and speculate about future changes in the SI that may take advantage of features of the Second Quantum Revolution.

Plenary Speakers



Chris A. Malachowsky

Co-Founder and Fellow,
NVIDIA

Chris Malachowsky founded NVIDIA in 1993 and has more than 30 years of industry experience. He serves as a member of the executive staff and a senior technology executive for the company.

Malachowsky has been instrumental in managing, defining and driving the company's core technologies as it has grown from a startup to the global leader in visual and parallel computing. As an executive at NVIDIA, he has led numerous functions, including IT, operations and all facets of the company's product engineering. Most recently, he was responsible for NVIDIA's world-class research organization, which is chartered with developing the strategic technologies that will help drive the company's future growth and success. Prior to NVIDIA, Malachowsky held engineering and technical leadership positions at HP and Sun Microsystems. A recognized authority on integrated-circuit design and methodology, he has authored close to 40 patents. He holds a BSEE degree from the University of Florida and an MSCS degree from Santa Clara University. Both schools have honored Malachowsky with Distinguished Alumnus awards.

Malachowsky serves on the boards of the Computer History Museum and Hiller Aviation Museum, in Silicon Valley, and the Los Angeles County Museum of Art's Art & Technology Lab. Beyond his technical accomplishments, Malachowsky has also received an Emmy for a film he helped produce that won Best Documentary in 2009.

Expanding Access, Building the Future

AI FOR GOOD
AI is a foundational shift, not just another tool — as consequential as electricity, as transformative as the internet; we are still in the earliest innings What happens to this country if most Americans never get a real chance to participate in the AI era?

The UF experiment as proof of concept – every department, every discipline, not just technical majors had AI across every curriculum Scaling the model: the "***New Frontier***" 50-State Compute Initiative AI's potential in science at the intersection of disciplines — AI + medicine, climate science, materials science; breakthroughs will come from interdisciplinary convergence, and universities are where that happens

GOOD FOR AI
AI as a once-in-a-generation chance to rebuild and expand opportunity, not just for the privileged few Good AI doesn't happen by accident — it requires the right people, structures, and commitments Industry + Government + Academia working together (SCSP Taskforce on the Future of Work; state AI institutes; university partnerships) Diverse, global talent is what makes AI good — the AI era will fail if it only draws from a narrow slice of humanity Korean-American scientists and engineers represent exactly the cross-disciplinary, globally-connected profile the field needs Korea's indispensable role in AI infrastructure — HBM memory, advanced semiconductor packaging; US-Korea R&D collaboration is not peripheral, it's load-bearing What "good" means for AI policy: accessible, equitable, shaped by people who understand both the technology and its human implications

The Question Worth Asking
What happens when everyone has the tools to think bigger, build faster, and solve problems we used to think were out of reach? That's the actual race. You don't win it by restricting access — you win it by expanding it The next breakthroughs will come from rooms like this one Call to action: be the builders, the bridges, the curious ones — there's more to build, more states to reach, more students to empower

Plenary Speakers



Ji-Hyun Lee

Professor, Department of Biostatistics, University of Florida;

Associate Director and Division Director for Cancer Quantitative Sciences, University of Florida Health Cancer Institute

Dr. Ji-Hyun Lee is a cancer biostatistician whose research focuses on clinical trials, cancer prevention and treatment, immunotherapy, artificial intelligence, and the analysis of large-scale health data. She has authored more than 210 peer-reviewed publications and provides statistical leadership for numerous federally funded cancer research projects.

In 2025, Dr. Lee served as the 120th President of the American Statistical Association, becoming the first Korean-American and first East Asian to hold the position in the organization's history. She also established the first Statistical Advisory Panel at Nature Medicine to strengthen methodological rigor and reproducibility in biomedical research.

Through her research, leadership, and mentoring, Dr. Lee advances the role of statistics and data science in improving human health and supporting evidence-based decision making.

Food, Medicine, and Belief: Scientific Evidence in the Age of Uncertainty

As a biostatistician working in cancer research, I have spent much of my career studying how evidence shapes medical decisions when the stakes are high. In this talk, I will share examples from my own research to illustrate how modern science navigates uncertainty, belief, hope, and rapidly evolving data. I will discuss a randomized clinical trial evaluating neutropenic diets in patients with blood cancer, observational studies examining ivermectin and cancer outcomes using large-scale electronic health records, and ongoing work on mRNA-based cancer vaccines and immunotherapy. I will also reflect on how data science, AI, and large-scale health data are creating new opportunities (and new challenges) for generating and interpreting medical evidence. As scientific information becomes easier to produce, questions about causation, uncertainty, and human judgment may become even more important. Ultimately, the goal of science is not simply to generate more data, but to help people understand what the evidence truly shows.

2026 KSEA Awards



Eun-Suk Seo

Professor
University of Maryland
College Park, MD

Outstanding Contribution to KSEA Award (presented by KSEA and MSIT)

Dr. Eun-Suk Seo is a Professor at the University of Maryland, College Park, MD. She obtained her B.S. and M.S. in Physics from Korea University in 1984 and 1986, respectively. She subsequently earned her Ph.D. in Physics from Louisiana State University, Baton Rouge, LA, in 1991.

Dr. Seo has established a legacy of research leadership and field-defining contributions. She has authored approximately 200 peer-reviewed journal articles and more than 300 conference proceedings papers, amassing over 26,000 citations with an h-index of 67. Demonstrating sustained international recognition, she has delivered 213 invited talks worldwide, which includes twelve in the year 2025 alone. Her cumulative research funding exceeds $30 million. Through this robust funding, over 100 students have been trained in her laboratory, extending the intellectual reach of her program as many now contribute to academia, national laboratories, and industry.

Throughout her distinguished career, Dr. Seo has received numerous prestigious accolades. She was the recipient of the Presidential Early Career Award for Scientists and Engineers from the White House in 1997. She received the NASA Group Achievement Award from the National Aeronautics and Space Administration in both 2006 and 2011. In 2008, the National Science Foundation awarded her the Antarctica Service Medal of the United States of America. She was elected as an American Physical Society Fellow in 2010. Additionally, she was honored with the Scientist of the Year Award by KSEA and KOFST in 2015 and was named the Korean-American Day Honoree by the Korea Economic Institute in Washington DC in 2017.

Dr. Seo's contributions to the KSEA represent some of her most noteworthy achievements. Her extensive leadership across major scientific associations includes her involvement in the Korean-American Aerospace Science and Technology Association (KASSTA). She has dedicated significant service as the 46th President of the Korean-American Scientists and Engineers Association (KSEA) , the 4th President of Korean-American Women in Science and Engineering (KWiSE), and the 29th President of the Association of Korean Physicists in America (AKPA). Furthermore, she holds a position on the Board of Directors of the Korea–U.S. Science Cooperation Center (KUSCO).

2026 KSEA Awards



Ji-Hyun Lee

Professor, Department of Biostatistics, University of Florida;

Associate Director and Division Director for Cancer Quantitative Sciences, University of Florida Health Cancer Institute

Scientist of the Year Award (presented jointly by KSEA and KOFST)

Dr. Ji-Hyun Lee is a distinguished biostatistician whose career has strengthened the role of statistics in biomedical science and expanded the visibility of Korean-American scientists in international scientific leadership.

In 2025, Dr. Lee served as the 120th President of the American Statistical Association (ASA), the world's largest statistical society, founded in 1839. She became the first Korean-American and first East Asian to hold this office in the organization's history. In this role, she championed the importance of statistical science in addressing societal and biomedical challenges. She previously served as President of the Caucus for Women in Statistics and Data Science, reflecting her commitment to mentorship, inclusion, and service.

Dr. Lee has authored more than 210 peer-reviewed publications in leading journals, including Nature, Cell, and the Journal of Clinical Oncology. She is co-first author of a Phase III randomized clinical trial that influenced clinical perspectives on dietary management in immunocompromised cancer patients. She has also contributed to studies demonstrating that mRNA COVID-19 vaccines can enhance anti-tumor immune responses, advancing next-generation cancer immunotherapy. In addition, she is a co-inventor of an emerging machine learning approach that uses brain imaging patterns to predict tumor characteristics and improve the identification of pseudoprogression, advancing efforts toward non-invasive cancer characterization. She currently contributes statistical leadership to multiple NIH-, NCI-, and PCORI-funded cancer research projects as lead biostatistician, core director, and co-investigator.

Dr. Lee established the first statistical advisory panel at Nature Medicine, bringing together 57 statisticians to strengthen rigor and reproducibility in biomedical research. She also initiated the ASA Clinical Trials Certification Program to bridge the gap between statistical education and clinical research practice.

Dr. Lee is a dedicated mentor and educator. She has mentored numerous graduate students and early-career scientists and co-authored 궁금하면 과학이야, a book written to encourage young Korean women to pursue STEM careers.

Dr. Ji-Hyun Lee exemplifies scientific excellence, leadership, and service to the broader scientific community. Through her scholarship, mentorship, and international leadership, she has helped expand the visibility of Korean-American scientists while supporting and inspiring future generations of researchers.

2026 KSEA Awards



Young-Shin Jun

Anna McKelvey Professor
McKelvey School of Engineering
at Washington University

Engineer of the Year Award (presented by KSEA and KOFST)

Dr. Young-Shin Jun is Professor of Energy, Environmental & Chemical Engineering at Washington University in St. Louis (WashU). She earned her B.S. and M.S. in Environmental Science and Engineering from Ewha Womans University, and her S.M. and Ph.D. from Harvard University. After postdoctoral research at the University of California-Berkeley/Lawrence Berkeley National Laboratory, she joined WashU in 2008 and was promoted early to both Associate and Full Professor.

Dr. Jun is recognized for her pioneering contributions to mineral nucleation and water-solid interfacial processes, translating nanoscale phenomena into scalable, sustainable technologies for water, energy, and resource recovery. A highly influential leader bridging the scientific communities of the United States and South Korea, she chaired the symposium "***Achieving Carbon Neutrality***" at the 2023 US-Korea Conference (UKC) in Dallas. Since 2013, she has served as the McDonnell International Scholars Academy Ambassador to Seoul National University and has fostered educational and research collaborations with leading Korean universities and research institutions.

Dr. Jun is a globally recognized leader in environmental and chemical engineering. Her innovations in three major thrusts—energy-related CO_2 systems, critical mineral recovery for a circular economy, and advanced nanomaterials for clean water—are transforming how society stores carbon, secures critical elements, and delivers safe drinking water. Her research advances CO_2 capture, utilization, and storage and CO_2-enabled energy systems. She has developed several patented technologies for recovering critical minerals and nutrients from unconventional resources, along with photothermal membrane systems for clean water production.

Dr. Jun's scholarly impact is demonstrated by 159 peer reviewed publications and four granted patents. She has received numerous honors, including the 2011 U.S. NSF CAREER Award, the 2020 James Lee Award, and the 2025 IUPAC Distinguished Women in Chemistry or Chemical Engineering Award. She was named a 2015 Kavli Fellow by the U.S. National Academy of Sciences, a 2016 Frontiers of Engineering Fellow by the U.S. National Academy of Engineering, a 2018 Fellow of the Royal Society of Chemistry, a 2019 Fellow of the American Chemical Society (ACS), and a 2024 Fellow of the American Association for the Advancement of Science. As chair of the ACS Committee on Science, she identifies and advances the frontiers of chemical science. She has mentored 119 students and supported K-12 STEM education since 2008.

2026 KSEA Awards



John Jungwoo Ha

Founder & Chief Executive Officer
Bear Robotics, Inc.

Entrepreneur of the Year Award (presented by KSEA and Maeil Business Newspaper)

Dr. John Jungwoo Ha is the Co-Founder and Chief Executive Officer of Bear Robotics, a global Physical AI company building full-stack autonomous robotics platforms that enable intelligent automation across hospitality, healthcare, logistics, manufacturing, and other commercial and industrial environments. Under his leadership, Bear Robotics has evolved beyond a service robotics company into a robotics platform company, integrating AI software, autonomous mobility, fleet management, cloud infrastructure, and operational intelligence to power the next generation of Physical AI applications.

Dr. Ha earned his bachelor's degree in Computer Science from Seoul National University and his Ph.D. in Computer Science from The University of Texas at Austin. Prior to founding Bear Robotics, he held engineering and research roles at technology startups and served as a Research Scientist at Intel and a Technical Lead at Google. He also gained firsthand experience operating a restaurant, providing unique insight into frontline operational challenges and shaping his vision for practical robotics solutions. In addition, he served as an Adjunct Professor at KAIST, helping bridge academic research and industry innovation.

Since co-founding Bear Robotics in 2017, Dr. Ha has led the company's growth into one of the world's largest deployed Physical AI and autonomous robotics platforms. Bear Robotics develops both robotic hardware and AI-driven software infrastructure, creating a full-stack ecosystem that enables robots to operate, learn, and collaborate effectively in dynamic real-world environments. Unlike many robotics companies focused primarily on prototypes or limited deployments, Bear Robotics operates at scale, with more than 15,000 robots deployed globally across thousands of customer locations. Today, the company's technology is deployed in more than 20 countries and 46 U.S. states, supporting mission-critical workflows across hospitality, healthcare, retail, logistics, and industrial sectors.

Dr. Ha has published numerous research papers in artificial intelligence, machine learning, and computer systems, and his leadership has helped earn global recognition for Bear Robotics, including the iF Design Award, International Design Awards (IDA), Kitchen Innovation Award, and Hospitality Innovation Planet (HIP) Award.

As a pioneer in Physical AI, he is focused on bridging the gap between AI breakthroughs and large-scale commercial adoption, building the infrastructure that enables intelligent robots to become an integral part of the future workforce.

2026 KSEA Awards



Sung-Sil Moon

Senior Research Microbiologist, CDC
President, KWiSE

Outstanding Community Service Award

Dr. Sung-Sil Moon is a scientist, mentor, and community builder whose seventeen years of sustained service to KSEA represent the very spirit of excellence. While maintaining a distinguished research career at the Centers for Disease Control and Prevention (CDC), she has dedicated herself to building institutions and advancing women in STEM—from young students in Atlanta to postdoctoral researchers across two continents.

As a Senior Research Microbiologist at the CDC, Dr. Moon leads critical vaccine development for rotavirus and has contributed significantly to global emergency responses for COVID-19, Ebola, and Monkeypox. Her professional credibility, recognized by honors such as the CDC Honor Award and the NCIRD Director's Award for Innovation, serves as the foundation for her influential community leadership.

As President of KWiSE Headquarters, Dr. Moon strengthened national networks and established enduring pathways for female scientists. Under her leadership, KWiSE launched the Young Scientist Scholarship and the Outstanding Woman Scientist Award. She has also been the driving force behind the Women in STEM Forum at the U.S.–Korea Conference (UKC), elevating it into a flagship program. In 2025, her role as UKC Poster Director further demonstrated her commitment to supporting early-career researchers with professional care.

Her impact on mentorship is perhaps most evident in the KWiSE–WISET Global Mentoring Program, which in 2025 served 168 mentees. Through structured curricula in career and leadership development, Dr. Moon has provided guidance that many credit as pivotal to their professional trajectories.

Since 2008, Dr. Moon has also been a cornerstone of the KSEA Georgia Chapter. She established a dedicated KWiSE Award for top-performing female students in the KSEA Math Competition, encouraging young girls in the Atlanta region to pursue STEM with confidence. Furthermore, as a member of the UKC 2025 Organizing Committee, she successfully engaged local political and business leaders to expand KSEA's visibility across the southeastern United States.

Dr. Sung-Sil Moon exemplifies outstanding community service: consistent, creative, and genuinely dedicated to others. From the laboratory bench to the conference stage, she continues to advance KSEA's mission with humility and purpose.

2026 KSEA Awards



North Carolina Chapter
Sung-Ju Kim

Associate Professor
School of Social Work
North Carolina State University

Outstanding Chapter and Chapter President Award

Dr. Sung-Ju Kim is a tenured Associate Professor at North Carolina State University's School of Social Work and an affiliated faculty member in the School of Public and International Affairs, specializing in nonprofit management, philanthropy, and civil society. He holds a Ph.D. from Indiana University and a Master of Social Administration from Case Western Reserve University, and has published extensively in peer-reviewed journals on topics including nonprofit management, philanthropic giving, and NGO education across East Asia and the West. He has served various nonprofit organizations both in South Korea and the U.S. and Korean-American professional communities, including KSEA (President of the KSEA North Carolina Chapter (2023–2026), nonprofit director and advisor since 2017), Korean Nonprofit and Philanthropy Researchers Association (KNPRN, Founder and executive director, 2008–2024); KASWEA, SPIA, the Beautiful Foundation, and others.

2026 KSEA Awards



Georgia Chapter
Jae-Kyung Lee

Associate Professor
University of Georgia

Outstanding Chapter and Chapter President Award

The Korean-American Scientists and Engineers Association has continued to expand its regional impact through scientific conferences, mentorship programs, outreach initiatives, and professional networking activities that support the Korean-American STEM community across Georgia and the southeastern United States. Under the leadership of Dr. Jae-Kyung Lee as Chapter Pres-ident in 2025, the chapter successfully organized the joint KSEA–KWiSE Southeast Chapter Con-ference, bringing together more than 50 participants from universities and research institutions across the region to strengthen interdisciplinary collaboration and engagement between the KSEA and KWiSE communities. The chapter also played an active role in regional preparation and participation in the U.S.–Korea Conference (UKC) 2025, promoting involvement of faculty, postdoctoral researchers, and students in national KSEA programs and increasing the chapter's visibility within the broader KSEA network. Additional chapter activities included executive committee meetings, membership drives, postdoctoral networking events, student and young professional outreach programs, and the successful organization of the 2026 National Math and Science Competition (NMSC), which hosted 90 student participants. These activities reflected the chapter's strong commitment to scientific exchange, mentorship, leadership development, and STEM outreach.

Dr. Jae-Kyung Lee is an Associate Professor in the Department of Physiology and Pharmacology at the University of Georgia College of Veterinary Medicine, with affiliated appointments in the Neuroscience Ph.D. Program and the Regenerative Bioscience Center. Her research focuses on neuroinflammation and neurodegenerative diseases, including Parkinson's disease, Alzheimer's disease, and Lewy body disorders, with particular emphasis on immune regulation and α-synuclein pathology. Her research has been supported by the National Institute of Neurological Disorders and Stroke and the Michael J. Fox Foundation for Parkinson's Research.

Prior to serving as Chapter President, Dr. Lee contributed as a Vice President in 2024, helping organize seminars and networking events that promoted scientific exchange and professional collaboration among Korean-American researchers across academia and industry. She has also demonstrated a sustained commitment to mentorship and community service through the KWiSE–WISET Global Mentorship Program, serving as a mentor for four consecutive years (2021–2024) and supporting approximately 50 mentees annually from Korea and the United States through career guidance and research mentorship. In recognition of her scientific achievements, leadership, and service within the Korean-American scientific community, Dr. Lee received the Korean-American Women in Science and Engineering, honoring both her contributions to neuroimmunology research and her dedication to mentoring the next generation of scientists.

2026 KSEA Awards



Woo Jong "Kevin" Kim

Senior Associate, SOCOTEC US

Young Generation Leadership Award (presented by KSEA and KOFST)

Mr. Woo Jong "Kevin" Kim is recognized for his outstanding leadership and sustained contributions to the Korean-American Scientists and Engineers Association (KSEA), particularly in advancing the growth, engagement, and development of the Young Generation (YG) community.

Over the course of his involvement with KSEA, Mr. Kim has demonstrated a remarkable trajectory of leadership, beginning as a student leader and continuing through chapter and national roles. From serving as Student Chapter President to Young Professional Director, Chapter Vice President, and currently as a Council Member of the New York Metropolitan Chapter, he has consistently dedicated himself to strengthening the foundation and future of the organization. His leadership reflects not only continuity but also a deep commitment to cultivating the next generation of KSEA members. At the national level, Mr. Kim has played a pivotal role in shaping YG initiatives and programs. As Young Generation Director and as Chair of IMPACTs, he led efforts to design and deliver impactful programming that connects students and early-career professionals with emerging technologies, career pathways, and professional networks. Under his leadership, these initiatives have expanded opportunities for engagement and learning, while reinforcing KSEA's mission to support the growth of young scientists and engineers.

Mr. Kim's contributions are distinguished by his focus on building a strong and sustainable YG pipeline. He has been instrumental in developing structured mentorship and professional development programs, strengthening member engagement and retention, and fostering meaningful collaboration across generations within KSEA. His efforts have helped create an inclusive and supportive environment where students and young professionals can connect, grow, and contribute to the broader community. Beyond his formal roles, Mr. Kim is widely recognized for his dedication to mentoring emerging members and promoting a culture of service and leadership. His ability to connect individuals, inspire participation, and build lasting relationships has significantly enhanced the vitality and cohesion of the YG and YP community. For his exemplary leadership, vision, and enduring commitment to the advancement of KSEA's Young Generation, Mr. Woojong Kim is a most deserving recipient of the 2026 Young Generation Leadership Award.

Hanwha Group

2026 Distinguished Sponsor Award

Hanwha Group is recognized for its steadfast dedication to advancing STEM education and empowering the next generation of innovators. Since 2021, the organization has been a vital benefactor of KSEA's National Math and Science Competition, contributing $70,000 annually for total sponsorship of $350,000 to date. In addition to this foundational support, Hanwha Group proudly partnered with KSEA to inaugurate the KSEA Mathematics Olympiad. By annually awarding $3,000 scholarships to ten top finalists (total of $30,000 per year), Hanwha grants these bright students the opportunity to attend prestigious national math camps across the United States. In profound appreciation of their philanthropic leadership and investment in young talent, the Committee is proud to recognize Hanwha Group.

2026 KSEA Honors



Kang-Wook Lee

Retired from IBM T.J. Watson Research Center

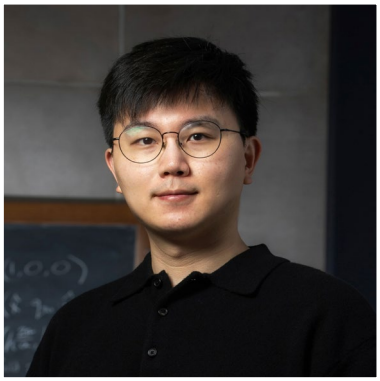
2026 Distinguished Service Membership (DSM)

Dr. Lee had a distinguished career, having worked for IBM T.J. Watson Research Center (1988-2018) and receiving 3 IBM Outstanding Technical Achievement Awards, Tenth Plateau IBM Invention Achievement Awards as well as 2 IBM Research Division Awards and 7 other IBM recognition awards for contributions. He received his Ph.D. from Rutgers University (Organic Chemistry) in 1982 and BS from Seoul National University (Applied Chemistry) in 1974. He served Korean Navy Officer & Naval Academy Instructor (해군사관학교 교관) for 1974-1977. He was an awardee of the 2021 Outstanding Contribution to KSEA award presented jointly by KSEA and the Ministry of Science & ICT.

During his tenure as the KSEA's 37th President, he chaired the UKC2008 with a great success in fund-raising as well as scientifically superb programs. He led to have both the Bylaws and Policies amended enabling E-voting and establishing two VPs. Dr. Lee's service record within KSEA is unparalleled in both depth and breadth. His cumulative service activities reflect decades of continuous engagement at the chapter, regional, and national levels. More importantly, his service has been transformative rather than merely participatory. One of Dr. Lee's most enduring legacies is his foundational role in KSEA's educational outreach. As the founding chair of the first KSEA New York Metro Math & Science Olympiad (KMSO) in 1994, he helped establish a flagship program that has now continued for more than three decades and inspired similar national programs, including the National Math & Science Competition (NMSC). His vision for engaging students and parents helped anchor KSEA's mission firmly within the broader Korean-American community. Dr. Lee has also been a central architect of KSEA's Young Generation (YG) programs. From early regional YG activities in the late 1990s to the eventual creation of the Young Generation Leadership Forum (YGLF) and its evolution into today's YGTLC (Ygnite), his ideas, proposals, and fundraising efforts laid the groundwork for programs that now serve hundreds of young scientists and engineers annually.

Dr. Kang-Wook Lee exemplifies the very essence of the Distinguished Service Member Award. He serves with humility, works tirelessly behind the scenes, and approaches every responsibility with a deep sense of stewardship. His contributions have shaped KSEA's programs, strengthened its institutions, and inspired generations of members.

2026 KSEA Young Investigator Grants



Jong Yeon Lee

Assistant Professor
University of Illinois
Urbana-Champaign

2026 KSEA YIG Award in Science

Dr. Jong Yeon Lee is an Assistant Professor at the University of Illinois, Urbana-Champaign. He received his B.S./M.S. in Physics and Mathematics from the California Institute of Technology, Pasadena, in 2015. He earned his Ph.D. in Physics from Harvard University in 2020, under the supervision of Professor Ashvin Vishwanath.

Dr. Lee has received numerous accolades, including the AKPA Outstanding Young Researcher Award in 2022, the Gordon and Betty Moore Fellowship in Kavli Institute of Theoretical Physics, Santa Barbara, for 2020-2023, and the 2015 Richard P Feynman Prize. His prolific publication record exceeds 30 papers published in high impact journals including solo author paper in Phys. Rev. Lett. in 2025. He has given over 40 invited talks at very prestigious venues.

Dr. Lee's research is distinguished by its ability to turn abstract ideas from quantum information into concrete conceptual advances and experimentally relevant tools for open quantum systems. On the experimental front, he developed efficient decoding observables that make measurement-induced phase transitions accessible on existing platforms by linking entanglement criticality to classical post-processing protocols. On the theoretical front, he discovered strong-to-weak spontaneous symmetry breaking, a new phenomenon in open quantum systems that has opened a significant new research direction and drawn broad attention in the field. In particular, his theory offers a bottom-up route from microscopic dynamics to transport laws such as diffusion and sound, directly connecting microscopic models to measurable quantities in quantum devices. Furthermore, he has established an information-theoretic framework for nonequilibrium phases of matter, providing new ways to characterize phases ranging from quantum error-correcting codes under decoherence to noisy quantum resource states. Together, these advances provide algorithmic, diagnostic, and theoretical tools that bridge fundamental quantum information theory and the practical development of next-generation quantum technologies.

2026 KSEA Young Investigator Grants



Junsoo Kim

Assistant Professor
Department of Mechanical Engineering
Northwestern University

2026 KSEA YIG Award in Engineering

Dr. Junsoo Kim is an Assistant Professor in the Department of Mechanical Engineering at Northwestern University. He received his B.S. and M.S. degrees in Mechanical & Aerospace Engineering from Seoul National University, Republic of Korea, in 2011 and 2013, respectively. He earned his Ph.D. in Materials Science & Mechanical Engineering from Harvard University in 2022, under the supervision of Professor Zhigang Suo.

Dr. Kim has received several Honors and Awards, including the Kavli Frontiers of Science Fellow (2024) from the National Academy of Sciences, Scialog Fellow (2024) from the Research Corporation for Science Advancement, two Scialog Awards (2024 and 2025), and the Haythornthwaite Foundation Research Initiation Grants (2025). His prolific publication record is significant over 38 papers published in top journals including Nature, Science, Advance Materials, Proceedings of the National Academy of Sciences, Matter, and Chemical Reviews.

Dr. Kim's research to reinforce the durability of soft materials has great potential to address grand challenges in our society such as polymer pollution and health care. The impact of his study reaches fundamental science in soft matter, engineering of soft biomedical devices, and even traditional materials such as tires. In the past five years, he identified a novel design principle to greatly improve the fracture resistance of hydrogels and rubbers by engineering the molecular structure of polymer networks. He also showed how to apply this principle to various types of soft materials such as industrial polymers and natural polymers. Dr. Kim is a rising research star and leading scholar in the fracture of soft materials, a topic area that has drawn a large amount of interest due to its far-reaching impact and interdisciplinary characteristics.

Program at a Glance

<table>
<tr><th>Time</th><th>8/4/2026
(Tue)</th><th>8/5/2026
(Wed)</th><th>8/6/2026
(Thu)</th><th>8/7/2026
(Fri)</th><th>8/8/2026
(Sat)</th></tr>
<tr><td>7:00-8:00</td><td colspan="5">Breakfast</td></tr>
<tr><td>8:00-
10:00</td><td rowspan="2"></td><td rowspan="5">SEED</td><td>Opening / Plenary I</td><td>Plenary II,
Fireside chat with
Chris A. Malachowsky</td><td>TG
Symposiums/
FIRE</td></tr>
<tr><td>10:00-
10:15</td><td colspan="3">Break</td></tr>
<tr><td>10:15-
12:00</td><td>Signature Symposiums</td><td>Sponsor Forums</td><td>Closing /
Plenary III</td></tr>
<tr><td>12:00-
1:00</td><td rowspan="7">SEED</td><td colspan="3">Lunch</td><td rowspan="7"></td></tr>
<tr><td>1:00-3:00</td><td>Distinguished
Sponsor Forums</td><td>KSEA Forums</td></tr>
<tr><td>3:00-3:15</td><td colspan="3">Break in the Exhibit Hall</td></tr>
<tr><td>3:15-5:00</td><td>KSEA
Forums</td><td>IES
opening</td><td>TG
Symposiums</td><td>FIRE</td><td>IES</td></tr>
<tr><td>5:00-6:45</td><td rowspan="2">Sponsor
Welcome
Reception
&
Dinner
Invitation
Only</td><td>TG
Symposiums</td><td>FIRE</td><td>IES</td><td>Posters</td><td colspan="2">IES SPC</td></tr>
<tr><td>7:00-9:00</td><td colspan="2">Gala Dinner</td><td colspan="2">Networking Dinner</td></tr>
</table>

Room Information

Thursday, August 6, 2026								
Room/Time	7:00-8:00	8:00-10:00	10:15-12:00	12:00-1:00	1:00-3:00	3:15-5:00	5:00-6:45	7:00-9:00
International Ballroom I	Sponsor Booth / IES Global R&D Demo							
International Ballroom II			Signature Symposium - Space					
International Ballroom III	Breakfast			Lunch			Bio I (1 of 2)	
National Ballroom A		Opening / Plenary I	Signature Symposium - AI					Gala Dinner
National Ballroom B								
National Ballroom C								
Royal Melbourne						IES		
Royal Dublin	IES Startup Demo							
Augusta A					Hyundai Motors Chung Mong Koo Foundation Forum		IT, Quantum & Semiconductors	
Augusta B							Infrastructure, Mobility & Robots	
Champions-Gate			Signature Symposium - Semiconductors		Innopolis Forum		FIRE	
Olympic					NRF	Joint Science Policy and Diplomacy Forum	Bio I (2 of 2)	
Colonial A					TIPA	KEIT Forum	Emerging Areas	
Colonial B					KOR-US Quantum	KWiSE - WISET Women Forum	Basic Sciences	
Congressio-nal A			Ewha womans University Community Meeting (11:00-1:00)				Agriculture, Food, Nutrition	
Congressio-nal B				Korea University Community Meeting(12:00-2:00)		NST Forum	Energy, Materials & Resources	
Oakmont A					Yonsei University Community Meeing(2:00-3:30)		Aerospace & Ocean	
Oakmont B						KIAT-K TAG		
Suite#245		Hanyang University Interview						

*Please note that the room assigned above is subject to change.

Friday, August 7, 2026								
Room/ Time	7:00-8:00	8:00-10:00	10:15-12:00	12:00-1:00	1:00-3:00	3:15-5:00	5:00-6:45	7:00-9:00
International Ballroom I	Sponsor Booth							
International Ballroom II				Poster Prep (12:00-5:00) Poster Session (5:00-6:45)				
International Ballroom III	Breakfast			Lunch				
National Ballroom A, B, C		Plenary II						Networking Dinner
Royal Melbourne			Gyeongsang National Univ.			IES (3:15-5:00) IES SPC (5:00-6:45)		
Augusta A			Innopolis Forum			IT, Quantum & Semiconductors		
Augusta B			Rural Development Admin.		KWiSE - WISET Women Forum	Infrastructure, Mobility & Robots		
Champions-Gate			SNU Forum	YGF Forum		FIRE		
Olympic					Future Tech	Bio II		
Colonial A			KIAT			Emerging Areas		
Colonial B			Sookmyung Women's University (SMWU)			Bio I		
Congressio-nal A			Catholic Kwandong & Kangwon National Univ.	R&D Leadership Forum		Agriculture, Food, Nutrition		
Congressio-nal B			KHIDI	Univ. Leadership Forum		Energy, Materials & Resources		
Oakmont A			IES Global R&D			Aerospace & Ocean		
Oakmont B						Basic Sciences		
Suite#245		Hanyang University Interview						

*Please note that the room assigned above is subject to change.

Saturday, August 8, 2026					
Room/Time	7:00-8:00	8:00-10:00	10:15-12:00	12:00-1:00	1:00-2:00
International Ballroom II					
International Ballroom III	**Breakfast**				
National Ballroom A			**Closing / Plenary III**		
National Ballroom B					
National Ballroom C					
Royal Melbourne A, B					
Augusta A		**IT, Quantum & Semiconductors**			
Augusta B		**Infrastructure, Mobility & Robots**			
ChampionsGate		**FIRE**			
Colonial A		**Emerging Areas**			
Colonial B		**Bio I**			
Congressional A		**Agriculture, Food, Nutrition**			
Congressional B		**Energy, Materials & Resources**			
Oakmont A		**Aerospace & Ocean**			
Oakmont B		**Basic Sciences**			
Olympic A, B		**Bio II**			

*Please note that the room assigned above is subject to change.

Plenary Schedule

Thursday, August 6, 2026			
8:00–10:00 am	**Opening Ceremony** **(Chaired by Prof. Gloria Kim & Prof. Jin W Choi)** • KSEA Introduction Video • National Anthems (Korea and USA) - Dr. Sharon Baik • Opening Remarks - Yong-Kyu Yoon, President, Korean American Scientists and Engineers Association (KSEA) • Welcoming Remarks - Oh Nam Kwon, President, Korean Federation of Science and Technology Societies (KOFST) - Won-Hwa Hong, President, KUSCO/National Research Foundation (NRF) • Congratulatory Remarks - In Kyu Park, Vice Minister for Science, Technology and Innovation Ministry of Science and ICT - Darren Michael Soto, U.S. representative for Florida's 9th district - Andy Kim, U.S. Senator, New Jersey (Video) - Joon Ho Lee, Consul General of the Republic of Korea in Atlanta - Matt Swanson, President and Chief Executive Officer of SelectFlorida - Alexander N. Cartwright, President, University of Central Florida - J. Scott Angle, Senior Vice President, University Florida • Introducing Dignitaries & Sponsor Representatives • Award Ceremony I - Outstanding Contribution to KSEA Award Presented by MSIT - Scientist of the Year Award Presented by KOFST - Engineer of the Year Award Presented by KOFST - Young Generation Leadership Award Presented by KOFST **Plenary Lecture I** - Dr. William D. Phillips, 1997 Nobel Prize in Physics for developing methods, NIST Fellow, Distinguished University Professor at the University of Maryland, College Park "***A New Measure: the Quantum Reform of the Modern Metric System***" • **Group Photo**		National Ballroom
10:00–10:15 am	Break		
10:15–12:00 pm	**UKC 2026 Signature Symposium** • AI Forum Chair: Young-Kee Kim, Professor, University of Chicago • Space Forum Chair: Eun-Suk Seo, Professor, University of Maryland • Next Generation Semiconductor Forum Chair: Jin W Choi, Professor, Michigan Tech University		National Ballroom, International Ballroom and Champions Gate
12:00–1:00 pm	Lunch		International Ballroom
1:00– 3:00 pm	Distinguished Sponsor Forums		
3:00 – 3:15 pm	Break		
3:15 – 5:00 pm	KSEA Forums (KWiSE-WISET Forum/ Science Policy & Diplomacy Forum)		IES Opening
5:00 – 6:45 pm	Fostering Innovation with Rising Expert (FIRE)	Technical Group Symposiums	IES

Thursday, August 7, 2026		
7:00 – 9:00 pm	**UKC Gala Dinner** (MC - Ms. Stella Kim) • Dinner • Opening Remarks - Yong-Kyu Yoon, President, Korean-American Scientists and Engineers Association (KSEA) • Welcome Remarks - Oh Nam Kwon, President, Korean Federation of Science and Technology Societies (KOFST) • Congratulatory Remarks - In Kyu Park, Vice Minister for Science, Technology and Innovation Ministry of Science and ICT **Awards Ceremony II** (Honors and Awards Committee Chair Prof. IL Minn) - Young Investigator Grant Award in Science - Young Investigator Grant Award in Engineering - Distinguished Membership Award - Distinguished Sponsorship Award - Entrepreneur of the Year Award - Outstanding Community Service Award - Outstanding Chapter and Chapter President Award (2) • Music Performance Rohan Reid Jazz Trio	National Ballroom

Friday, August 7, 2026				
8:00–10:00 am	**Plenary Session** **(Chaired by Prof. Soyoon Kum & Prof. Harold Kim)** • KSEA-KUSCO Graduate Scholarship Award • Research Vision Talks • Hee Kwon Jung, President, Korea Innovation Foundation (Innopolis) "***Innovation Ecosystem of INNOPOLIS***" • Ricky Kim, Chief Operating Officer (COO), Open Healthcare ***"Riding the Next K-Wave: K-Dx"*** • Seung-Wook Baek, Director/Program Manager, National Research Foundation of Korea (NRF) on behalf of Korea-US Quantum Technology Cooperation Center ***"The Quantum Race: Unlocking the Invisible"*** • Jaeyoon Kim, Third General Manager of Research Department, Kongju National University ***"Kongju National University's Glocal University 30 Initiative: Advancing Regional Innovation through Global Partnerships"*** **Plenary Lecture II** - Chris A. Malachowsky, Co-Founder, Fellow, and Senior Technology Executive of NVIDIA ***"Expanding Access, Building the Future"*** Fireside Chat with Chris A. Malachowsky			National Ballroom
10:00–10:15 am	Break			
10:15–12:00 pm	Sponsor Forums			Various
12:00–1:00 pm	Lunch			International Ballroom
1:00– 3:00 pm	KSEA Forums (University Leadership Forum/ R&D Leadership Forum/KWiSE Forum/ KOFST Next Generation Alumni Forum)			Various
3:00 – 3:15 pm	Break			
3:15 – 5:00 pm	Technical Group Symposiums	Fostering Innovation with Rising Expert (FIRE)	IES	Various

Saturday, August 9, 2026			
5:00 – 6:30 pm	Poster Session	IES Startup Pitch Competition	
7:00 – 9:00 pm	Networking Dinner		National Ballroom
8:00–10:00 am	Technical Group Symposiums		Various
10:00–10:15 am	Break		
10:15–12:00 pm	**Plenary & Closing** **(Chaired by Dr. Jinho Park & Prof. Hyun Dong Kim)** • **Plenary Lecture III** - Dr. Ji-Hyun Lee, Former President, American Statistical Association, Professor, University of Florida ***"Food, Medicine, and Belief: Scientific Evidence in the Age of Uncertainty"*** • **Award Ceremony III** - IES Award - UKC 2026 Poster Award • UKC 2026 Raffle Announcement • UKC 2027 Announcement, Ohbong Kwon, President-Elect of KSEA • Closing Remarks, Yong-Kyu Yoon, President of KSEA		National Ballroom

Signature Symposium

AI Signature Symposium

Thursday, Aug 6 10:15am – 12:00pm National Ballroom

Chair



Young-Kee Kim

Albert A. Michelson Distinguished Service Professor of Physics, University of Chicago



In Kyu Park

Vice Minister for Science, Technology, and Innovation, MSIT

Speakers



Rebbeca Willet

Worah Family Professor of Statistics and Computer Science
Faculty Director of AI, Data Science Institute
The University of Chicago



Sowjanya Gollapinni

Senior Scientist, Los Alamos National Laboratory
Co-Spokesperson, DUNE Experiment

Panelists



Oh Nam Kwon

President of the Korean Federation of Science and Technology Societies (KOFST)



William Phillips

Nobel Laureate in Physics
Fellow, NIST
Distinguished University Professor, University of Maryland



Youngsuk "YS" Chi

Chairman, Elsevier
Director, Corporate Affairs at RELX



Sangig Rho

Executive Vice President, ACRYL Inc.

The AI Signature Symposium: The Genesis Mission highlights a transformative U.S. national initiative launched in November 2025 and led by the U.S. Department of Energy (DOE). The Genesis Mission brings together national laboratories, academia, industry, and government partners to harness artificial intelligence for breakthroughs in energy dominance, discovery science, and national security.

This symposium showcases how AI, high-performance computing, and experimental science are converging through the Genesis Mission to accelerate innovation at an unprecedented scale.

It also provides a platform to discuss ways to strengthen U.S.–Korea collaboration in AI, fostering deeper partnerships that advance shared scientific and technological priorities.

Time		Title and Speaker
10:15		**Opening Remarks** Young-Kee Kim
Part I: Presentations **About The Genesis Mission**	10:20	**Introduction of the Genesis Mission** Young-Kee Kim
	10:30	**Perspectives from National Laboratories** Sowjanya Gollapinni (LANL)
	10:50	**Perspectives from Academia** Rebbeca Willet (University of Chicago)
Part II: Panel Discussions **Strengthening the Korea-U.S. Partnerships in AI: Opportunities and Pathways**	11:10	• Moderator - Young-Kee Kim / Panelists - Oh Nam Kwon (KOFST), William Phillips (NIST, University of Maryland), Youngsuk (YS) Chi (Elsevier), Sangig Rho (ACRYL Inc). Sowjanya Gollapinni (LANL), Rebbeca Willet (University of Chicago)
11:55		**Closing Remarks and Group Photo**

*Please note that the schedule mentioned above is subject to change based on unforeseen circumstances.

AeroSpace Signature Symposium

Thursday, Aug 6 10:15am – 12:00pm International Ballroom

Chair



Eun-Suk Seo

President of KASSTA
Professor of Physics
University of Maryland

Speakers



Soyeon Yi

Astronaut, GBD at SPEX, Incl

Shaping the future of Space

The AeroSpace Signature Forum offers a comprehensive perspective on the future of space through advances in human spaceflight, soft robotics, aerospace engineering, and next-generation space computing. Bringing together leading experts from academia, industry, and national laboratories, the forum highlights innovative technologies and interdisciplinary approaches that are redefining the capabilities of space systems and enabling the next era of exploration beyond Earth orbit. The forum is designed to inspire new partnerships and strategic collaborations while providing a forward-looking view of how scientific discovery and engineering innovation can collectively expand humanity's presence and capabilities in space.



Dae Young Lee

Professor,
Department
of Aerospace
Engineering, KAIST



Eun Jung Chae

Professor, Dept. of
Mech. and Aerospace
Engineering,
California State
University, Long Beach



Kyongsik Yun

Technologist, NASA Jet
Propulsion Laboratory

- KASSTA - Korean American AeroSpace Science and Technology Association

Time	Title and Speaker
10:15	**Opening Remarks** Eun-Suk Seo (Chair) **Welcoming Remarks** Yong-Kyu Yoon (President of KSEA) **Congratulatory Remarks** - In Kyu Park (Vice Minister for Science, Technology and Innovation, Ministry of Science and ICT) - Chang-Jeon Hwang (Vice-President of Korea Aerospace Research Institute, KARI)
10:25	**Healthcare Challenges of Space Flight** Soyeon Yi (Astronaut, GBD at SPEX, Inc.)
10:45	**Reliability through Softness: A Soft Robotics Approach to Space Exploration** Dae Young Lee (Department of Aerospace Engineering, KAIST)
11:05	**Aerodynamic Performance of the Next Generation Aircraft/Spacecraft** Eun Jung Chae (Department of Mechanical and Aerospace Engineering, California State University, Long Beach)
11:25	**Next-Generation Space Processors: HPSC and Hybrid Co-Processor Architectures** Kyongsik Yun (Technologist, NASA JPL)
11:45	**Concluding Remarks, Awards and Photos**

*Please note that the schedule mentioned above is subject to change based on unforeseen circumstances.

Next-Generation Semiconductors Signature Symposium

Thursday, Aug 6 10:15am – 12:00pm ChampionsGate

Imagining Tomorrow's Semiconductor Technologies

The Signature Symposium on Semiconductors will explore emerging trends, opportunities, and challenges shaping the future of semiconductor technologies and the global semiconductor ecosystem. The forum aims to bring together experts from academia, industry, government, and research organizations to exchange ideas on innovation, manufacturing, advanced materials, packaging, supply chains, workforce development, and future applications enabled by semiconductor technologies. Through invited talks and a panel discussion, the forum seeks to encourage collaboration, foster innovation, and promote strategic partnerships that will help advance the next era of semiconductor research, development, and commercialization.

Chair



Jin W. Choi

President of KEEE
Professor of Electrical and Computer Engineering
Michigan Technological University

Speakers



Jinho Ahn

Executive Vice President for Research,
Hanyang University



Dae-Seok Byeon

President of
Korea Advanced Nano Fab Center, KANC



Rockwell Hsu

Technical Leader of Engineering,
Cisco System, Inc



Charles Arvin

Director Integration Development,
Advanced Packaging, Skywater

Time	Title and Speaker
10:15	**Welcoming Remarks and Introduction** Jin W. Choi (Symposium Chair)
10:20	**From Imagination to Reality: The EUV Lithography Journey through Open Innovation** Jinho Ahn (Executive Vice President for Research, Hanyang University)
10:45	**Innovation and Imagination of Compound Semiconductors Accelerating the Penta-Singularity Era** Dae-Seok Byeon (President, Korea Advanced Nano Fab Center, KANC)
11:10	**Meeting System Requirements for High-Speed Signaling in Scalable AI Data Centers: Design Challenges and Manufacturing Considerations** Rockwell Hsu (Technical Leader, Engineering, Cisco Systems, Inc.)
11:35	**Panel Discussion** Moderator: Jin W. Choi

*Please note that the schedule mentioned above is subject to change based on unforeseen circumstances.

Technical Clusters

Cluster

Aerospace/Ocean	**C-3**	Chair: Martin Byung-Guk Jun (Purdue University) Co-Chairs: Cha Bum Lee (Texas A&M University), Chang-Hwan Choi (Stevens Institute of Technology)
Agriculture/Food/Nutrition	**B-2**	Chair: Sung Woo Kim (North Carolina State University) Co-chairs: Jooyeoun Jung (Oregon State University), Soonkyu Chung (University of Massachusetts Amherst)
Biology/Biotechnology/Health	**B-1 / B-3 / C-1**	Chair: James Moon (University of Michigan) Co-Chairs: Chun Gwon Park (Sungkyunkwan University) Youngjae Chun (University of Pittsburgh) Jung Soo Suk (University of Maryland)
Energy/Materials/Resources	**C-2/ C-4**	Chair: Jaewon Lee (University of Missouri, Columbia) Co-Chairs: Hyun-Tae Hwang (University of Kentucky) Sungwoo Nam (University of California, Irvine), Inseok Chae (Texas Tech University)
IT/Quantum/Semiconductors	**C-6 / C-7**	Chair: Mingon Kang (University of Nevada, Las Vegas) Co-Chairs: Sam Chung (City University of Seattle), Jungkwun Kim (University of North Texas)
Infrastructure/Mobility/Robots	**C-5 / C-8**	Chairs: Ryan Choi (Eastern Michigan University), JuHyeong Ryu (West Virginia University) Co-Chair: Seokgi Lee (Youngstown State University), Eul-bum Lee (POSTECH)
Basic Sciences	**A-1 / A-2 / A-3**	Chair: Harold Kim (Georgia Institute of Technology) Co-Chairs: Bumjung Kim (New Jersey City University), Soeun Kim (Azusa Pacific University)
Emerging Areas (Entertainment Technology & STEAM-centered Social Sciences)	**D-1**	Chair: Hyoungah Park (Saint Peter's University) Co-Chairs: Jung Han (K-EnterTech Hub), Danielle Lee (American Board of Internal Medicine), Benjamin Ahn (The Ohio State University)

UKC 2026 features eight interdisciplinary technical clusters that bring together researchers, industry leaders, and innovators across diverse fields of science and technology. These clusters highlight emerging research areas, foster cross-disciplinary collaboration, and provide a platform for exchanging ideas that drive innovation and global impact.

Technical Symposium Groups

Technical Group A-1	**Physics (PHY)**	Chair: Harold Kim (Georgia Tech) Co-Chairs: Wonhee Ko (University of Tennessee, Knoxville), K.C. Kong (University of Kansas)
Technical Group A-2	**Chemistry (CHM)**	Chair: Kyo Young Han (University of Central Florida) Co-chairs: Hoi Sung Chung (National Institutes of Health), Kwang Seob Jeong (Korea University)
Technical Group A-3	**Math/Applied Math/Statistics (MAS)**	Chair: Soeun Kim (Azusa Pacific University) Co-Chair: Seongho Song (University of Cincinnati), Daewa Kim (University of Delaware)
Technical Group B-1	**Medical and Pharmaceutical Science (MPS)**	Chair: Soojin Yoo (University of Texas - Rio Grande Valley) Co-Chair: Hungoo Lee (Johns Hopkins School of Medicine)
Technical Group B-2	**Food, Agriculture, Ecology and Nutrition (FAN)**	Chair: Sung Woo Kim (North Carolina State University) Co-chairs: Jooyeoun Jung (Oregon State University), Soonkyu Chung (University of Massachusetts Amherst)
Technical Group B-3 / C-1	**Biological and Biomedical Sciences (Biology, Molecular Biology, Cognitive Science, Botany, Zoology, Biomechanics, etc.)/Bioengineering and Biomedical Engineering (BME)**	Chair: James Moon (University of Michigan) Co-Chairs: Young Bin Choy (Seoul National University), Youngjae Chun (University of Pittsburg)
Technical Group C-2	**Chemical, Textile, Energy, and Nuclear Engineering (CHE)**	Chair: Hyun-Tae Hwang (University of Kentucky) Co-Chair: Jaewon Lee (University of Missouri), Tae-Sik Oh (Auburn University)
Technical Group C-3	**Mechanical, Aerospace and Naval Engineering (MAN)**	Chair: Eon Soo Lee (New Jersey Institute of Technology) Co-Chairs: Hongseok Choi (Clemson University), Junsoo Kim (Northwestern University)
Technical Group C-4	**Materials Science and Engineering, Nanotechnology (MSE)**	Chair: Sung Woo Nam (University of California, Irvine) Co-Chairs: Soon-Yong Kwon (Ulsan National Institute of Science & Technology), Chang-Yong Nam (Brookhaven National Laboratory)
Technical Group C-5	**Civil and Environmental Engineering, Architecture (CEA)**	Chair: JuHyeong Ryu (West Virginia University) Co-Chairs: Eul-Bum Lee (POSTECH), Boo Hyun Nam (Kyung Hee University)
Technical Group C-6	**Electrical and Computer Engineering (ECE)**	Chairs: Jin W. Choi (Michigan Technological University) Co-Chairs: Jeongwon Park (University of Nevada at Reno), JungKwun Kim (University of North Texas)
Technical Group C-7	**Computer and Information Sciences (CIT)**	Chair: Sam Chung (City University of Seattle) Co-Chairs: Jaerock Kwon (University of Michigan-Dearborn), Taejin Kim (City University of Seattle)
Technical Group C-8	**Industrial and Systems Engineering Management Sciences and Decision Science (IMD)**	Chair: Hyesung Park (Georgia Gwinnett College) Co-Chair: Ji-Hung (Ryan) Choi (Eastern Michigan University), Hyo Kyung Lee (Korea University)
Technical Group D-1	**Social Sciences (Anthropology, Economics, Political Science, Sociology, Public Policy, etc.), Psychology, Digital Arts, STEM Education, and Other Sciences (SSP)**	Chair: Hyoungah Park (Saint Peter's University) Co-Chairs: Jung Han (K-EnterTech Hub), Danielle Lee (American Board of Internal Medicine), Benjamin Ahn (The Ohio State University)

Poster Session Chair

Hyo-Joo Han Georgia Gwinnett College

Innovation and Entrepreneurship Symposium (IES) Group

Jeho Park Claremont McKenna College

Aerospace / Ocean

The Aerospace and Ocean Cluster Technical Symposium explores emerging technologies that are transforming aerospace, space exploration, ocean engineering, and autonomous systems. As humanity expands its presence beyond Earth while addressing increasingly complex challenges in maritime environments, the symposium highlights innovative research that advances the design, operation, intelligence, and resilience of next-generation aerospace and ocean systems.

The symposium features two podium sessions and one poster session showcasing recent advances in space systems and exploration, aerospace structures and aerodynamics, autonomous aerial and maritime vehicles, ocean and coastal engineering, robotics, artificial intelligence, advanced sensing, digital engineering, and computational modeling. Presentations span fundamental science, engineering innovation, and real-world applications from academia, government laboratories, and industry, emphasizing interdisciplinary approaches that bridge aerospace, ocean, manufacturing, and intelligent systems.

Supporting contributions are provided by the Mechanical, Aerospace, and Naval Engineering (C-3 MAN), Civil and Environmental Engineering and Architecture (C-5 CEA), and Industrial, Manufacturing, and Systems Engineering (C-8 IMD) Technical Groups, along with the Astronautics and Space Engineering (A-1 ASE) and Ocean Science and Engineering (A-3 OSE) Affiliated Professional Societies (APS). Together, these communities foster interdisciplinary collaboration and the exchange of ideas that advance aerospace, space, and ocean engineering.

Chair



Martin Jun

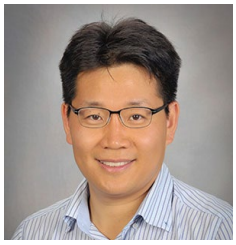
Purdue University

Co-chairs



Chang-Hwan Choi

Stevens Institue of Technology



Cha Bum Lee

Texas A&M University

Aerospace and Ocean

@ Oakmont A

Thursday, Aug 6 5:00 – 6:45pm

Aerospace and Ocean Cluster Session I

Chair: Martin BG Jun (Purdue University), Chang-Hwan Choi (Stevens Institute of Technology) and ChaBum Lee (Texas A&M University)

Time	Title and Speaker
5:00	**The Role of Submerged Aquatic Vegetation in Coastal Protection and Resilience** Hyun Dong Kim (Old Dominion University)
5:25	**Performance Evaluation of Transport Algorithms in the General Ocean Model (GOM) (Invited)** Jungwoo Lee (East Carolina University)
5:50	**Performance Prediction of an Electro-Optical Payload Focus Control System Based on Artificial Neural Networks** Jingwang Kim (Korea Aerospace Research Institute)
6:05	**Apophis 2029: What Happens When an Asteroid Passes Close to Earth?** Yaeji Kim (University of Maryland)
6:20	**Beyond the Cradle: Structural Foundations for the First Step of Human Civilization on the Moon** Simon Shim (Active Design Group)

Aerospace and Ocean

@ Oakmont A

Friday, Aug 7 3:15 – 5:00pm

Aerospace and Ocean Cluster Session II

Chair: Martin BG Jun (Purdue University), Chang-Hwan Choi (Stevens Institute of Technology) and ChaBum Lee (Texas A&M University)

Time	Title and Speaker
3:15	**Generating Machining Sound Using Operational Context** Invited Eunseob Kim (Wayne State University)
3:40	**Laser Powder Directed Energy Deposition of Al6061: Defect Evolution and Processing Window Development** Chang-Hwan Choi (Stevens Institute of Technology)
4:05	**Fabrication and Synthesis of the Nickel Cobalt Sulfide Nanowire Woven Kevlar Fiber and Polyester Composites** Hyungwook Park (Ulsan National Institute of Science and Technology)
4:10	**Knowledge-Graph Integrated Agentic Physical/Shadow AI for Autonomous Ships: A Hybrid Approach with LLM and Ontology** Geonwoo Kim (POSTECH)
4:35	**Diffusiophoresis-Driven Shear Enables Non-Invasive Biofilm Removal from Confined Geometries** Sangwoo Shin (The State University of New York, Buffalo)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Aerospace and Ocean Cluster Poster Session
Chair: Martin BG Jun (Purdue University), Chang-Hwan Choi (Stevens Institute of Technology) and ChaBum Lee (Texas A&M University)

P1	**Geometry-Controlled Deployment Energy in FW-TAK Kirigami** Yeongeun Ki (Purdue University)
P2	**Structural Reorganization of the Global Container Shipping Network under Geopolitical Risk: The Case of the Red Sea Crisis** Suyeon Park (Inha University)
P3	**CABLESSail: Solar Sail Momentum Management Using Shape Control** Soojeong Lee (University of Minnesota – Twin Cities)
P4	**Interpretable Prediction of Stem-to-Stem Contact-Regime Boundaries in Submerged Aquatic Vegetation using a Physics-guided Teacher-Student Surrogate Framework** Sebin Oh (Old Dominion University)
P5	**μLIBS : ELEMENTAL MAPPER, IN SITU PLANETARY EXPLORATION** Dong Jae Lee (Purdue University)
P6	**Effectiveness of Mold and Dampness Interventions for Occupant Health** San Jin (University of Texas, Arlington)

Agriculture, Food & Nutrition

Agriculture, Food, and Nutrition Symposium (AFN) will provide professional opportunities for leading and rising scientists and engineers to share, discuss, and learn the latest scientific, and technical advances in various fields of agriculture, ecology, food, and nutrition in the US, Korea, and the world. The symposium covers all areas related to the UKC 2026's topic, 'From Imagination to Innovation – Into Reality. Areas include:

1. Agricultural sciences including agricultural & bio-engineering, agricultural economics & agribusiness agronomy, animal science, crop science, entomology, environmental science, horticulture, plant science, smart farming & prevision agriculture, soil science, veterinary sciences, and other emerging areas.
2. Ecology including behavioral & physiological ecology, community ecology, ecosystem, human ecology, landscape, population ecology, and other emerging areas.
3. Food sciences including food chemistry, food engineering, food microbiology, food nanotechnology, food processing, food safety & regulation, functional food, sensory science, and other emerging areas.
4. Nutritional sciences including community nutrition, intestinal microbiota and diets, international nutrition, gene & diet interactions, metabolic diseases, nutrient metabolism & physiology, muscle & protein metabolism, precision nutrition, nutrition, and other emerging areas.

Chair



Sung Woo Kim

North Carolina State University

Co-chairs



Jooyeoun Jung

Oregon State University



Soonkyu Chung

University of Massachusetts Amherst

Agriculture, Food & Nutrition

@ Congressional A

Thursday, Aug 6 5:00 – 6:45pm

Nutrition Session

Chair: Soonkyu Chung (University of Massachusetts Amherst)

Time	Title and Speaker
5:00	**Welcome and introduction** Sung Woo Kim (AFN chair, North Carolina State University)
5:05	**Welcome** Soonkyu Chung (Nutrition Session Chair, University of Massachusetts Amherst)
5:10	**Obesity-induced epigenetic dysregulation of hypothalamic leptin signaling** Min-Hyun Kim (Arizona State University)
5:25	**Developing and evaluating a social media intervention to promote locally grown fruit and vegetable consumption among college students** Seung Eun Jung (Cluster invited speaker, University of Alabama)
5:45	**Toward precision zinc nutrition: from genetic regulation to aging-associated zinc dyshomeostasis** Sangyong Choi (University of Connecticut)
6:00	**Development and validation of an ai-generated food-as-medicine recipe platform** Heewon L. Gray (University of South Florida)
6:15	**The effect of US-grown Teff (Eragrostis Tef) consumption on obesity-associated metabolic dysfunction in mice** Ji-Young Lee (University of Connecticut)
6:30	**Repeated weight cycling disrupts hypothalamic neuroendocrine signaling through gut microbiota remodeling** Soonkyu Chung (University of Massachusetts Amherst)

Agriculture, Food & Nutrition

@ Congressional A

Friday, Aug 7 3:15 – 5:00pm

Agriculture session

Chair: Sung Woo Kim (North Carolina State University)

Time	Title and Speaker
3:15	**Welcome** Sung Woo Kim (AFN chair, North Carolina State University)
3:20	**Temperature-dependent energy allocation drives growth and storage trade-offs in juvenile black sea bass** Gwangseok Yoon (University of New England)
3:40	**A novel DNA-based vaccine for reduction of Salmonella in broilers** Young Min Kwon (Cluster invited speaker; University of Arkansas)

Agriculture, Food & Nutrition

@ Congressional A

Friday, Aug 7 3:15 – 5:00pm

Agriculture session

Chair: Sung Woo Kim (North Carolina State University)

Time	Title and Speaker
4:00	**Roles of non-starch polysaccharide degrading enzymes to mitigate non-starch polysaccharide interference with intestinal health in pigs** Hyunjun Choi (North Carolina State University)
4:20	**From genome editing to adaptive evolution: engineering yeast for better fermented foods** Yong-Su Jin (University of Illinois)
4:40	**Milk oligosaccharides for mucosal microbiota and mucosa immunity in the jejunum of young pigs post-weaning** Sung Woo Kim (North Carolina State University)

Agriculture, Food & Nutrition

@ Congressional A

Saturday, Aug 8 8:00 – 10:00am

Food Session

Chair: Jooyeoun Jung (Oregon State University)

Time	Title and Speaker
8:00	**Welcome** Jooyeoun Jung (Food Session Chair; Oregon State University)
8:05	**Kahweol, a diterpene found in coffee, reduces fat accumulation and extends lifespan in Caenorhabditis elegans** Yeonhwa Park (Cluster invited speaker; University of Massachusetts Amherst)
8:25	**Identification of host-associated genomic features in Salmonella enterica serovar Dublin using machine learning** Kwang Cheol Jeong (University of Florida)
8:45	**Dynamic remodeling of DNA methylation during fruit ripening in octoploid strawberry** Seonghee Lee (University of Florida)
9:05	**Effect of processing and cooking conditions on chicken aroma characteristics evaluated by instrumental and consumer evaluation** Jihye An (Auburn University)
9:25	**Development of AI and omics-based quantitative PCR (qPCR) assay for food safety and quality** Si-Hong Park (Oregon State University)
9:45	**Upcycling agri-food biowastes into functional fibers for sustainable molded pulp packaging** Jooyeoun Jung (Oregon State University)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Agriculture, Food & Nutrition Poster Session
Chair: Yong-Su Jin (University of Illinois)

P1	**Development and evaluation of a bench-scale flume washer for ozone micro-nano bubble washing of fresh produce** Haknyeong Hong (University of California Davis)
P2	**Blue light treatment of whole avocados to inactivate Listeria monocytogenes and Salmonella enterica on their exocarp surfaces** Minji Hur (University of Georgia)
P3	**Comparative evaluation of expert and AI greenhouse climate control for winter strawberry cultivation** Yuseok Jeong (National Institute of Agricultural Sciences)
P4	**Development of an end-effector system for apple harvesting using modular design and a custom PCB** Sang-Hyeon Kang (Rural Development Administration)
P5	**Haplotype-resolved genome assembly of strawberry cultivars Florida Encore and Florida Ember** Jaejoon Lee (University of Florida)
P6	**Exploring drought adaptation mechanisms in soybean genotypes: A pathway-based metabolomics approach** Namhee Lee (University of Georgia)
P7	**Anti-proliferative properties of Humulus lupulus (hops) flavonoids in human colorectal cancer cells** Seong-Ho Lee (University of Maryland)
P8	**Hemp seed attenuates colon tumorigenesis and immune responses in colitis-associated colorectal cancer mouse** Jieun Woo (Purdue University)
P9	**Effect of thermal processing on nutritional and quality parameters of grape juice** Moonsun Yang (Wilberforce University)
P10	**A protective effect of aged parsnip extract on diet-induced metabolic dysfunction-associated steatotic liver disease (MASLD) in vivo** Tongkewn Yoo (Purdue University)
P11	**Autonomous ground robotics for precision strawberry production in Florida** Daeun Choi (University of Florida)

Biology, Biotechnology & Health 1

Dedicated to advancing human health and life sciences, this cluster covers cutting-edge research in biotechnology, biomedical sciences, medical technologies, and translational medicine shaping the future of healthcare.

The Biology, Biotechnology & Health Technical Symposium will feature four podium sessions and a poster session. We invite scientists, engineers, and professionals from academia, industry, and government to share their work, foster collaboration, and address critical challenges in life sciences and healthcare, while engaging researchers from related fields—including information science, nanotechnology, advanced materials, and robotics—to advance interdisciplinary innovation in health and biotechnology.

This symposium is jointly organized by three Technical Groups (TGs) of KSEA and their affiliated professional societies (APS): Health Sciences; Biological and Biomedical Sciences; and Bioengineering and Biomedical Engineering.

The Health Sciences TG (B-1 MPS) brings together members working in medical science, veterinary medicine, pharmaceutical science, public health, nursing, and related fields, with shared interests in improving human and animal health, advancing clinical and translational research, and addressing emerging challenges in healthcare systems and biomedical practice.

The Biological and Biomedical Sciences TG (B-3 BME) is a community of members working in biology, molecular biology, cognitive science, botany, zoology, biomechanics, and related fields, with shared interests in understanding living systems across scales, advancing fundamental and translational bioscience, and addressing emerging challenges at the intersection of biology, health, and technology.

The Bioengineering and Biomedical Engineering TG (C-1 BME) includes members working in bioengineering, biomedical engineering, and related fields, with shared interests in applying engineering principles to biological systems, advancing medical technologies and devices, and addressing emerging challenges in healthcare, diagnostics, and human performance.

Chair



Bong-Ihn Koh (B3)

Yale University

Co-chairs



Soo Jin Yoo (B1)

The University of Texas Rio Grande Valley



Hungoo Lee (B1)

Johns Hopkins University

Invited Speakers



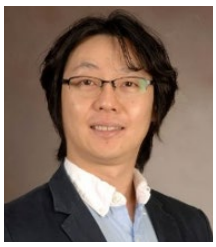
Jong Yun Park

Moffitt Cancer Center



Do-Gyoon Kim

Ohio State University



Sungha Hong

University of Rochester Medical Center



Mi Ho Jeong

Mass General Brigham



Hanjoong Jo

Emory University/ Georgia Institute of Technology



Dongsu Park

Baylor College of Medicine

B-1 Symposium: Medical, Pharmaceutical, and Physical Education Sciences (MPS)

From Discovery to Practice in Health Sciences

The Medical, Pharmaceutical, and Physical Education Sciences Symposium brings together scholars, clinicians, and practitioners from diverse disciplines—including medical science, veterinary medicine, pharmaceutical science, public health, nursing, and related fields—who share a common commitment to advancing health and well-being for both humans and animals. This interdisciplinary forum fosters collaboration and knowledge exchange aimed at strengthening clinical and translational research, promoting innovative therapeutic and preventive strategies, and addressing emerging challenges in healthcare systems and biomedical practice. By integrating expertise across sectors, the symposium highlights the critical importance of cross-disciplinary approaches in tackling complex health issues, improving patient outcomes, and shaping the future of global health.

B-3 Symposium: Biological and Biomedical Sciences (BME)

Reading the Niche: How Cells Sense and Respond Across Tissues

How do cells read their environment — and how do those responses scale into tissue function, organ physiology, and disease? This question sits at the heart of the most exciting work in modern biomedicine, cutting across vascular biology, neuroscience, and stem cell biology. In this session, featured talks illuminate how hemodynamic forces reprogram endothelial identity in atherosclerosis, how ultrasound mobilizes mechanosensory responses in immune cells, how skeletal stem cell heterogeneity is regulated within the perivascular niche during aging, how synaptic connectivity encodes neurotransmitter identity in whole-brain connectomes, how translational kinetics shape proteome integrity in the aging brain, and how human organoids recapitulate the developmental program of the amygdala. Together, they reveal that cell fate is not intrinsic but relational, shaped continuously by the mechanical, molecular, and architectural context of the niche.

Biology, Biotechnology & Health 1

@International Ballroom II

Thursday, Aug 6 5:00 – 7:00pm

B-1 Session I: Innovative Diagnostic and Molecular Approaches to Cancer and Disease Detection
Chair: Jihyun Song (University of Utah)

Time	Title and Speaker
5:00	**Differentially methylated genes in aggressive prostate cancer** Jong Yun Park (Moffitt Cancer Center & Research Institute) **Invited**
5:25	**Artificial Intelligence for Comparative Oncology: Modeling Rare Cancers Using Naturally Occurring Canine Cancers** Jong Hyuk Kim (University of Florida)
5:50	**Plasma-based single extracellular vesicle analysis for diagnosis of cholangiocarcinoma** Mi Ho Jeong (Mass General Brigham) **Invited**
6:15	**VASP, a F-actin polymerization factor, is a novel YAP-TEAD target gene in MDA-MB-231 cells** Tae-Hyung Kim (University of New Mexico Health Sciences Center)
6:40	**Activated Transient Receptor Potential Vanilloid Type 1 (TRPV1) endures global hypoperfusion following subarachnoid Hemorrhage (SAH)** Sung Ha Hong (University of Rochester Medical Center) **Invited**

Biology, Biotechnology & Health 1

@Olympic A, B

Thursday, Aug 6 5:00 – 7:00pm

B-3 Session I: Reading the Niche: How Cells Sense and Respond Across Tissues
Chair: Bong Ihn Koh (Yale School of Medicine)

Time	Title and Speaker
5:00	**Ultrasound-induced Macrophage Mechanotransduction via Actin Reorganization and Ca^{2+} Responses** Myeong Ryeol Choi (Pohang University of Science and Technology)
5:30	**Flow-Induced Reprogramming of Endothelial Cells (FIRE) in Atherosclerosis** Hanjoong Jo (Emory University/Georgia Institute of Technology)
6:00	**Skeletal Stem Cell Heterogeneity and Regulatory Mechanism in Aging** Dongsu Park (Baylor College of Medicine)
6:30	**Human Amygdala-like Telencephalic Organoids Capture Developmental Program of Human Amygdala** In-Hyun Park (Yale University)

Biology, Biotechnology & Health 1

@Colonial B

Friday, Aug 7 3:15 – 5:00pm

B-1 Session II: Innovative Diagnostic and Regenerative Therapies for Musculoskeletal Disease

Chair: Whasil Lee (University of Rochester, NY)

Time	Title and Speaker
3:15	**Can Cone Beam Computed Tomography Assess Oral Bone Density?** Do-Gyoon Kim (Ohio State University) **Invited**
3:40	**Vitamin E Nanosome Pretreatment Enhances Stem Cell Survival and Therapeutic Efficacy in a Post-Traumatic Osteoarthritis Mouse Model** Hongsik Jake Cho (University of Tennessee Health Science Center)
4:00	**Engineered 3D Microphysiological Systems for Identification of Therapeutic Myokines** Young Charles Jang (Emory University)
4:20	**Development of Antibody-Immobilized Electrodes to Detect Osteocalcin for Racehorse Bone Health Monitoring** Daniel Sim (University of Tennessee)

Biology, Biotechnology & Health 1

@Colonial B

Saturday, Aug 8 8:00 – 10:00am

MPS/BME Joint Session: Multiscale Perspectives on Neural Function, Aging, and Human Health

Chair: Bong Ihn Koh (Yale School of Medicine); Soojin Yoo (U Texas Rio Grande Valley)

Time	Title and Speaker
8:00	**Altered translation elongation contributes to key hallmarks of aging** Jae Ho Lee (Stony Brook University)
8:30	**Predicting Neurotransmitter Identity from Synaptic Connectivity in Drosophila Connectomes** Hyunju Kim (Georgia Institute of Technology)
9:00	**Nociceptic Nerve Remodeling in Osteoarthritic Mouse Knee Joints** Whasil Lee (University of Rochester)
9:20	**Effect of Aymara Enriched NFKB1 SNP on Acute Mountain Sickness in Austrians Exposed to Acute Hypoxia** Grace Min (University of Utah)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

B-1 Poster Session

Chair: Soojin Yoo (U Texas Rio Grande Valley); Hungoo Lee (Johns Hopkins University)

P1	**Algorithmic Fairness in Machine Learning Prediction for Long-Term Adjuvant Endocrine Therapy Adherence among Breast Cancer Survivors** Yeijin Kim (University of Texas at Austin)
P2	**Effects of Long-Term Episodic Heat Therapy on Skeletal Muscle Morphology and Capillarization in Aged Obese Mice** Bohyun Ro (Purdue University)
P3	**Clonal Convergence Between Mucosal and Systemic Human IgA Repertoires Following Norovirus Challenge** Dae Sung Kim (University of Texas at Austin)
P4	**Integrating PharmD-Informed Medication Literacy into Diabetes Self-Management Education and Support (DSMES) Programs to Address Polypharmacy in Type II Diabetes** Lucy Lee (UTHealth School of Public Health)
P5	**The Relationship Between Depression and Inflammatory Markers in Head and Neck Cancer Patients Undergoing Radiation Therapy** Hyein Kim (Emory University)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

B-1 Poster Session

Chair: Soojin Yoo (U Texas Rio Grande Valley); Hungoo Lee (Johns Hopkins University)

P6	**Exogenous mitochondrial transplantation improves tendon regeneration via modulating apoptosis signaling** Jimin Lee (Colorado State University)
P7	**Functional Connectome Alterations Underlying Posttraumatic Stress Disorder** Eun Namgung (Texas A&M University Health Science Center)
P8	**Household Living Arrangement, Obesity, and Psychosocial Risk Across the U.S.** Ilsoo Park (Azusa Pacific University)
P9	**Associations Between Greenspace Exposure and Cancer Outcomes in the U.S.** Jeonggyo Yoon (University of Arizona)
P10	**Early-Life Adversity Alters the Neuro–Immune Axis and Limits Anti–PD-1 Therapy** Yea In Park (George Washington University)
P11	**Comparative Evaluation of Cryogen Spray Cooling (R134a vs HFO-1234ze)** Yurie Jeong (UC Irvine / Johns Hopkins University)
P12	**Identifying the Epigenetic Mechanisms of Fragile X syndrome and Inducing the Contraction of CGG repeats and FMR1 reactivation** Hungoo Lee (Johns Hopkins University)
P13	**BMI Masks Significant Differences in Metabolic Risk Indicators** Soojin Yoo (University Texas Rio Grande Valley)
P14	**A study on early detection of mild cognitive impairment (MCI) in older Korean adults using daily speech and EEG data** Youngjin Park (Korea Electrotechnology Research Institute)
P15	**Capacitive Sensors for Non-invasive Monitoring of Vital Signs in Small Animals** Kwang Choi (Uniformed Services University)
P16	**Electrochemical Detection of Respiratory Viruses Using a Nanowell Biosensor Platform** HeaYeon Lee (MARA Nanotech New York Inc.)
P17	**Mass-produced Nanowell Biosensor for Clinical COVID-19 Diagnosis** HeaYeon Lee KA(MARA Nanotech New York Inc.)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

B-3 Poster Session
Chair: In-Hyun Park (Yale University)

P1	**Hippocampal α-Synuclein PFF mouse model recapitulates key pathological and cognitive features of Lewy Body Dementia** Jung Ha Byun (University of Georgia)
P2	**Multi-Omic Characterization of the Senescent Niche in Aging Skin** Yeaeun Han (Mayo Clinic)
P3	**Biomimetic Intrafibrillar Mineralization of Collagen** Hoyeon Jang (The Ohio State University)
P4	**Causal interrogation of bipolar disorder GWAS risk genes: cell- and circuit-targeted in vivo CRISPR editing at single and multiple loci** Yeonha Ju (University of Texas at Austin)
P5	**Bridging Functional Annotation and Molecular Interactions: Trustworthy Deep Learning for Enzyme and Protein-Compound Prediction** Mingon Kang (University of Nevada Las Vegas)
P6	**Endothelial tmTNFα as a Regulator of Immune-Related Networks and Schizophrenia-Relevant Phenotypes** Sanghyeon Kim (SMRI)
P7	**Gene–Diet Interactions in Alzheimer's Disease: APOE4 Rewires Astrocytic Ketone Metabolism to Drive Amyloid Pathology** Youbin Kim (Icahn School of Medicine at Mount Sinai)
P8	**Probing the paradoxical relationship between marine diazotrophs and oxygen through controlled hypoxia** Michael Kim (Johns Hopkins University, University of Southern California)
P9	**Functional Specialization of Craniofacial Bone Marrow Vasculature** Bong Ihn Koh (Yale School of Medicine)
P10	**Therapeutic Potential of Graphene Quantum Dots on Pterygium** Donghoon Koo (Seoul National University)
P11	**A Counterfactual Framework for Estimating Infectious Disease Prevalence under Repeated Testing with Symptomatic and Contact-Tracing Components** Jeongjin Lee (The Ohio State University)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

B-3 Poster Session
Chair: In-Hyun Park (Yale University)

P12	**Mitochondrial Dysfunction Induces Asparaginase Resistance in R-Spondin Fusion Colorectal Cancer** Su Hyun Lee (St. Jude Children's Research Hospital)
P13	**The role of KAZN in osteoclastogenesis** Sun Young Lee (Sookmyung Women's University)
P14	**Remote Ischemic Conditioning Rescues Delayed Transneuronal Degeneration and Promotes Long-Term Stroke Recovery** Keun Woo Park (Bergen Community College)
P15	**Epigenetic Memory Drives Fetal-like Revival Stem Cell Identity During Small Intestine Regeneration** Onyu Shin (Center for Genome Engineering, Institute for Basic Science (IBS), Korea)
P16	**Foot Placement as a Mediolateral Balance Control Strategy in an Avian Bipedal Animal Model During Sloped Perturbations** Junhyuck Woo (University of California, Irvine)
P17	**The Effects of Exercise Training on Anxiety and Insular-Centered Functional Connectivity in Healthy Older Adults** Kihoon Yuk (Program in Neuroscience and Cognitive Science, University of Maryland)
P18	**Biotechnology & Health Wearable Catalytic Graphene Sensor for Longitudinal Salivary Cortisol and Stress Monitoring** Jimin Lee (Georgia Institute of Technology)
P19	**Structural Studies of the Outer Surface Protein A (OspA) membrane lipoprotein from the Lyme disease agent Borrelia burgdorferi** Najin Kim (Arizona State University)
P20	**Biotechnology & HealthRole of Self-Assembled Water Chains in Enzymatic Reactions** Byung Kim (Boise State University)
P21	**Cytoprotective Effect of Kartogenin-Loaded Nanosomes on Arthritic Chondrocytes** Hongsik Cho (University of Tennessee Health Science Center)

Biology, Biotechnology & Health 2

As in any other major industry, problem solving in modern medicine increasingly requires a true convergence of many scientific and engineering fields. While some of the last frontiers of biomedicine, such as neuroscience and regenerative medicine, critically demands new ideas and tools from other disciplines, paradigm-shifting technological innovations in information science, nanotechnology, and robotics could open new opportunities in healthcare. At the same time, a new generation of engineers, "fluent" in many different languages of science, are creating entirely new fields to view the old questions with a fresh look. In the BME symposium, we strive to provide a stimulating forum for all researchers willing to go beyond the "comfort zone" to explore new opportunities in biomedical engineering.

Chair



James Moon
University of Michigan

Co-chairs



Chun Gwon Park
Sungkyunkwan University



Youngjae Chun
University of Pittsburgh



Jung Soo Suk
University of Maryland

Biology, Biotechnology & Health 2

@ Olympic A, B

Friday, Aug 7 3:15 – 5:00pm

BME Session I: Biomaterials, Immunotherapy, and Drug Delivery
Chairs: Jungho Ahn (Sungkyunkwan University), Sangyoon J. Han (Michigan Tech)

Time	Title and Speaker
3:15	**Translational Research for Female Reproductive System** Jungho Ahn (Sungkyunkwan University) **Invited**
3:35	**Evidence for Collective NK Cell Surveillance Revealed by Causal Network Analysis in Tumor-on-a-Chip Models** **Invited** Sangyoon J. Han (Michigan Technological University)
3:55	**Heart dECM Hydrogel Facilitates Structural Maturation and Functional Stability of Human Cardiac Organoids** Jaemyung Shin (Johns Hopkins University)
4:10	**Development of Inducible Stable Cell Lines for rAAV Production: From Packaging to Producer Cell Line** Seongkyu Yoon (University of Massachusetts Lowell)
4:25	**Systems Mechanobiology Approaches to Fibrosis Resolution and Cardiac Repair** Yoonyoung Choi (University of Massachusetts Lowell)
4:40	**Self-aggregating Long-acting Injectable Microcrystals (SLIM): A Versatile Platform** Sanghyun Park (Massachusetts Institute of Technology)

Biology, Biotechnology & Health 2

@ Olympic A, B

Saturday, Aug 8 8:00 – 10:00am

BME Session II: Bioelectronics and Medical Devices

Chairs: Byulee Park (Sungkyunkwan University), Soojung Claire Hur (Johns Hopkins University)

Time	Title and Speaker
8:20	**Multiscale Photoacoustic Imaging: From Nanostructures to Human Tissues I** Byullee Park (Sungkyunkwan University) **Invited**
8:40	**Toward Genetic Manipulation of Patient-Derived Circulating Tumor Cells Using Integrated Microfluidic Electroporation** **Invited** Soojung Claire Hur (Johns Hopkins University)
8:55	**A Synergistic Hybrid Bioceramic for Structural Reinforcement and Bioelectric Stimulation for Smart Implants** Albert Kim (University of South Florida)
9:10	**Multiplexed Microfluidics Decodes Antibiotic Combination and Sequence Effects** Yoon Jeong (University of Chicago)
9:25	**A Wireless Wearable Monitoring System with a Smart Mouthguard and Soft Chest Patches for Dehydration and Health Monitoring of Athletes** Karam Kim (Georgia Institute of Technology)
9:40	**Clinically Translatable Arthroscopic Instrument Stabilization Interface with Defined Regulatory Pathway** Sang-Eun Song (The University of Akron)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

BME Poster Session

Chairs: TBD

P1	**A Nanoemulsion-Based TLR7/8 Adjuvant Platform for Coordinated Immune Activation Against Diverse Viral Threats** JuA Song (Sungkyunkwan University)
P2	**Integrated spatial multi-omics identifies TRPS1 as a regulator of joint cell fate linking cartilage development to osteoarthritis** Ji-Hye Yea (Johns Hopkins University)
P3	**Assessing the Role of GAN-Based Synthetic Data in Cell Microscopy Classification under Limited Data Conditions** So-yun Park (Kumoh National Institute of Technology)
P4	**A Rat Glioma Spheroid-Neural Cell Tri-Culture Model to Investigate Cellular Crosstalk in Glioma Pathology** Testaverde Sangwoo Kim (University of California, Davis)
P5	**Rootin: A Mobile Symptom Tracking and Self-Care App for Women with Breast Cancer on Aromatase Inhibitors** Soyeon Lee (University of Connecticut)
P6	**Dual-Responsive Gelatin Microspheres for Ultrasound-Regulated Enzyme-Mediated Drug Release in Cancer Therapy** Yuri Kang (Pohang University of Science and Technology)
P7	**Flexible, Three-Dimensional Electronic Framework for Electromechanical Monitoring in Engineered Heart Tissues** Hayeon Yun (Northwestern University)
P8	**Soft Wearable BW-NIRS for Monitoring Sleep-Dependent Brain Water Dynamics** Seunghyeb Ban (Georgia Institute of Technology)
P9	**A 3D Brain Geometry Toolkit for Scalable Multisite Vertex-wise Brain Morphometry Analysis** Yanghee Im (University of Southern California)
P10	**Multiscale Biointerfaces for Neuromodulation: Access, Targeting, Modeling, and Sensing** Eunji Hong (Binghamton University)
P11	**A Minimally Invasive Magnetically Actuated Intravesical Occlusion Device for Urinary Incontinence** Youngjae Chun (University of Pittsburgh)
P12	**Microfluidic and Machine Learning–Guided Fabrication of Sub-5 μm PLGA Microparticles with Adhesive Integration for Vascular Drug Delivery** Youngjae Chun (University of Pittsburgh)
P13	**Soft Wearable NIRS for Monitoring Cardiac, Respiratory, and Slow-Oscillation Rhythms during Sleep** Junwoo Kwon (Cornell University)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

BME Poster Session
Chairs: TBD

P14	**Biophysical control of cell density promotes stem cell retention and tissue healing** Gwang-Bum Im (Boston Children's Hospital, Harvard Medical School)
P15	**Reactive Oxygen Species, Electrode Potential and pH Affect CoCrMo Alloy Corrosion and Semiconducting Behavior in Simulated Inflammatory Environments** Hwaran Lee (Clemson University)
P16	**Large Language Model and Human Performance on a Motor Sequence Learning Task** Hakjoo Kim (McLean Hospital, Harvard Medical School)
P17	**Comparative Analysis of Flexible Electrode Designs** Jong-Hoon Kim (Washington State University)
P18	**Capacitive Sensors for Non-invasive Monitoring of Vital Signs in Small Animals** Kwang Choi (Uniformed Services University)
P19	**Assessing the Role of GAN-Based Synthetic Data in Cell Microscopy Classification under Limited Data Conditions** Se-woon Choe (Kumoh National Institute of Technology)
P20	**The Effects of Copper Availability on Ethane Oxidation by Obligate Methanotrophs** Jaeho Choi (KAIST)
P21	**Coupling Mechanistic Lyophilization Models with a Multi-Agent AI Interrogation Engine for Autonomous Process Discovery** Saeyoung Kim (University Mass Lowell)
P22	**Bio-inspired zwitterion-treated silicone catheters reduce device-related complications in chronically catheterized patients** Min Kyu Lee (University of California, Los Angeles)
P23	**Real-Time Optical Control and Quantitative Imaging of Cellular Responses** Seohee Ma (Purdue University)
P24	**A study on early detection of mild cognitive impairment (MCI) in older Korean adults using daily speech and EEG data** YoungJin Park (Korea Electrotehcnology Research Institute)
P25	**All-in-One Wearable Bioelectronics for a Continuous Assessment and Early Diagnosis of Acute Kidney Injury** W. Hong Yeo (Georgia Tech)
P26	**Cytoprotective Effect of Kartogenin-Loaded Nanosomes on Arthritic Chondrocytes** Ryan Qiu (University of Tennessee Health Science Center)
P27	**Computational modeling of durotactic cell migration** Donghyun Yim (Purdue University)
P28	**Capacitive Sensors for Non-invasive Monitoring of Vital Signs in Small Animals** Ethan Reyes (The Geneva Foundation)

Energy, Materials & Resources

This cluster explores next-generation energy systems, advanced materials, and sustainable resource technologies that support global energy transition and industrial innovation.

The Energy, Materials & Resources Technical Symposium will feature three podium sessions and one poster session. We invite researchers and professionals conducting experimental, computational, and integrated work in chemical engineering, materials science, nanotechnology, advanced manufacturing, energy systems, and related fields to present innovations that address emerging challenges in energy, materials, and resource-related engineering, while engaging in discussions that foster interdisciplinary collaboration and new research connections.

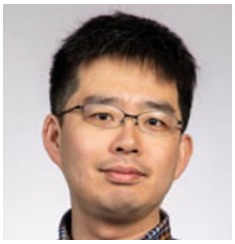
This symposium is jointly organized by two Technical Groups (TGs) of KSEA and their affiliated professional societies (APS): Chemical, Textile, Energy, and Nuclear Engineering; and Materials Science and Engineering, Nanotechnology.

The Chemical, Textile, Energy, and Nuclear Engineering TG (C-2 CHE) is a community of researchers and professionals advancing chemical engineering across fundamental and applied domains. The group encompasses areas including advanced nanomaterials and biomaterials, nanoscience and nanotechnology, and complex processes addressing challenges in energy, health, and environmental systems.

The Materials Science and Engineering TG (C-4 MSE) includes members working across materials innovation and advanced manufacturing, with shared interests in electronic materials, functional materials, nanomaterials, and related emerging areas that support advances in micro/nanoelectronics, energy conversion and storage, additive manufacturing, and other technologies critical to sustainable innovation.

Supporting contributions are provided by the Mechanical, Aerospace, and Naval Engineering (C-3 MAN) TG in mechanics, thermal systems, and precision manufacturing; the Civil and Environmental Engineering and Architecture (C-5 CEA) TG in sustainable infrastructure and environmental quality; and the Computer and Information Sciences (C-7 CIT) and Industrial, Manufacturing, and Systems Engineering (C-8 IMD) TGs in data-driven methods, optimization, and circular resource management.

Chair



Jaewon Lee (C2)

University of Missouri - Columbia

Co-chairs



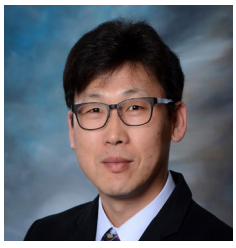
Inseok Chae (C2)

Texas Tech University



Sungwoo Nam (C4)

University of California, Irvine



Hyun-Tae Hwang (C2)

University of Kentucky

Energy, Materials & Resources

@Congressional B

Thursday, Aug 6 5:00 – 6:45pm

CHE Session: Hydrogen, Catalysis, and Sustainable Energy
Chair: Jaewon Lee (University of Missouri-Columbia), Inseok Chae (Texas Tech University), Sungwoo Nam (University of California, Irvine), Hyun-Tae Hwang (University of Kentucky)

Time	Title and Speaker
5:00	**Vapor Pressure Suppression of Hydrocarbons under Nanoconfinement Revealed by Differential Scanning Calorimetry** Hyeyoung Cho (Florida Polytechnic University)
5:12	**Korea's Path to Fusion Energy: Progress and Strategic Vision** Yeongkook Oh (Korea Institute of Fusion Energy)
5:24	**Optimization of Surfactant-Imbibition In-situ DNAPL Remediation with Horizontal Wells** Seung Ihl Kam (Louisiana State University)
5:36	**Sorp-Vection: A Non-Equilibrium Transport Platform for Complex Fluid Separations** Jinyoung Kim (Georgia Institute of Technology)
5:48	**Two-dimensional gas chromatography (GC×GC) Applications in Plastic Pyrolysis Research** Do Hyun Lee (Penn State University)
6:00	**A Semi-Markov Process Approach to Quantify Material Content Over Multiple Product Lifecycles with Application to a Hard Disk Drive** Yong Han Kim (Purdue University)
6:12	**Controlling Surface Cation Configurations in IrxRu1-xO2(110) and Their Effects on Adsorption** Jisu Shin (Purdue University)
6:24	**Balancing Dark Current and Photoresponse in Organic Photodetectors via Cleavable Side Chain Engineering** Seung Hyun Kim (University of North Carolina at Chapel Hill)
6:36	**Innovative Process Development for Natural Hydrogen as a primary energy source** Jihyun Hwang (Korea Institue of Energy Technology)
6:48	**Improved Hydrogen Yield and Safety in Solid-State Hydrolysis of Sodium Borohydride Using Water Adsorbents** Hyun-Tae Hwang (University of Kentucky)

Energy, Materials & Resources

@Congressional B

Friday, Aug 7 3:15 – 5:00pm

MSE Session: Advanced Manufacturing, Functional Materials, Nanomaterials
Chair: Jaewon Lee (University of Missouri-Columbia), Inseok Chae (Texas Tech University), Sungwoo Nam (University of California, Irvine), Hyun-Tae Hwang (University of Kentucky)

Time	Title and Speaker
3:15	**Novel Nanophotonic Devices based on Strong Light-Matter Interaction** Hong Gyu Park (Seoul National University)
3:27	**Fabrication of Textured pHEMA Hydrogels: The Impact of Micro/Nano Textures on Optical Property** Chang-Hwan Choi (Stevens Institute of Technology)
3:39	**Simulation Study of Mechanically Tunable Phononic Crystals: Effects of Scatterer Geometry and Material on Acoustic Band Gap Properties** Taeyul Choi (University of North Texas)
3:51	**Orientation-Dependent Residual Lattice Strain in Single-crystal Sapphire Cutting with Hard X-ray Nanoprobe** Sangkee Min (University of Wisconsin-Madison)
4:03	**Thermal Management Technologies for High-Thermal-Load Systems: Applications in Data Centers and Re-Entry Spacecraft** Tae Young Kim (Seoul National University of Science and Technology)
4:15	**Low-Cost Titanium Powder Design and in-situ Alloying Approach for Laser Powder Bed Fusion** Bin Lee (Kyung Hee University)
4:27	**Entanglements in Polymer Networks: A New Pathway for Soft Material Design** Junsoo Kim (Northwestern University)
4:39	**Purpose-Engineered Alloys for LPBF Additive Manufacturing: From Computational Alloy Design to Functional Component Demonstration** Yongho Sohn (University of Central Florida)

Energy, Materials & Resources

@Congressional B

Saturday, Aug 8 8:00 – 10:00am

CHE, MSE & CEA Session : Advanced Materials, Resources, Separations
Chair: Jaewon Lee (University of Missouri-Columbia), Inseok Chae (Texas Tech University), Sungwoo Nam (University of California, Irvine), Hyun-Tae Hwang (University of Kentucky)

Time	Title and Speaker
8:00	**Soft Piezoelectric-Powered Capacitive Sensor for High-Fidelity Vibration Detection** Jeng-Hun Lee (Georgia Institute of Technology)
8:12	**Plasticization-Driven Ionic Transport in AlBr3–Based Solid Electrolytes** Kyunghyun Kim (Hongik University)
8:24	**Materials and Devices for Event–Memory Bifurcation in Dynamic Vision** Won Il Park (Hanyang University)

Energy, Materials & Resources

@Congressional B

Saturday, Aug 8 8:00 – 10:00am

CHE, MSE & CEA Session : Advanced Materials, Resources, Separations
Chair: Jaewon Lee (University of Missouri-Columbia), Inseok Chae (Texas Tech University), Sungwoo Nam (University of California, Irvine), Hyun-Tae Hwang (University of Kentucky)

Time	Title and Speaker
8:36	**Highly Efficient Triboelectric Nanogenerator Based on Low Impedance and High Charge Density through Multi-Layer Design** JinKyeom Kim (University of Wisconsin-Madison)
8:48	**Effect of Hexagonal Boron Nitride Fillers on Ion Transport and Viscoelasticity of Vitrimer Electrolytes** Seongon Jang (University of Pennsylvania)
9:00	**Analysis of Cutting Force Characteristics in Ultra-Precision Milling of Single Crystal Sapphire** Jinho Park, (Korea Aerospace University)
9:12	**Effectiveness of Low-Cost Window Fans for reducing Indoor Cooking Emissions Compared with Kitchen Hoods** Semi Park (University of Texas at Arlington)
9:24	**From Classroom to Community: Preparing Next-Generation Engineering Through Municipal Water Quality Projects** Jun Kim (Florida Polytechnic University)
9:36	**Virus-Based Sustainable Recovery of Critical Minerals** Inseok Chae (Texas Tech University)
9:48	**Machine Learning Enhanced Modeling of Orientation-Dependent van der Waals Interactions in Nanostructured Cuboids with Surface Roughness Effects** Jaewon Lee (University of Missouri)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Energy, Materials & Resources Poster Session
Chair: Jaewon Lee (University of Missouri-Columbia), Inseok Chae (Texas Tech University), Sungwoo Nam (University of California, Irvine), Hyun-Tae Hwang (University of Kentucky)

P1	**Direction-Independent Stretchable Liquid-Metal Heater Enabled by a Space-Filling Printed Layout** Hongchan Kim (Seoul National University)
P2	**Spatial Visualization and Analysis of Architectural Heritages Classification and Sustainable Typology** Jae Yoon Byun (North Carolina State University)
P3	**Regulating Sulfur Redox Microenvironments through Phase Separation for High-Energy-Density Lithium-Sulfur Batteries** Dong-Yeob Han (The University of Texas at Austin)
P4	**Sustainable AI: Routing Queries to Small Language Models** Yun Kim (University of Minnesota)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Energy, Materials & Resources Poster Session

Chair: Jaewon Lee (University of Missouri-Columbia), Inseok Chae (Texas Tech University), Sungwoo Nam (University of California, Irvine), Hyun-Tae Hwang (University of Kentucky)

P5	**Quantifying the Ultimate Potential of Nucleate Pool Boiling Under Idealized Bubble Dynamics** Junseo Gu (University of Florida)
P6	**Development and Evaluation of an Alkaline Water Electrolysis Hybrid System for Resource Recovery** Sang Yong Nam (University of Florida)
P7	**Evaluation of Do-It-Yourself (DIY) Air Cleaner Performance: A State-of-the-Art Review** Semi Park (University of Texas at Arlington)
P8	**Self-crosslinking of PDMS on metal substrates for self-healing coatings** Kyujin Ko (University of Cincinnati)
P9	**Toward Automated Physics-Grounded Interpretation of HVAC Operational Data Using Large Language Models** Yujin Kim (North Carolina State University)
P10	**Opto-charge Microscopy (OCM) for Resolving Particle Dynamics in Electrochemical Network Materials** Jeongok Choe (Purdue University)
P11	**Electrification of Conventional Sustainable Aviation Fuel Production: Greenhouse Gas Emissions Benefits and Costs** TJ Park, (MIT)
P12	**Porosity Dependence of Furnace Thermal Cycling Lifetime and Failure Characteristics of Multi-layer Thermal Barrier Coatings** Hye-Yeong Park (University of Central Florida)
P13	**Development of a Thermal Energy Storage Combined with Water-side Economizer System** Kwanghee Kim, (Gyeongsang National University)
P14	**Plasmon Resonance Color Shifts in Nanogaps for Rapid Thickness Mapping in Two-Dimensional Materials** Lauren Park (Korean Minjok Leadership Academy)
P15	**Implementation of Radially Graded TPMS Lattice Structures for Stress Shielding Reduction and Optimized Material Utilization in Dental Implants** Abdus-Samad Shaik (University of Central Florida)
P16	**ZIF-8 as a Porous Additive for Phosphogypsum-Based Materials** Hyeyoung Cho (Florida Polytechnic University)

IT, Quantum & Semiconductors

This cluster brings together leaders in computing, information technologies, quantum science, and semiconductor systems to highlight breakthroughs that are shaping the future of artificial intelligence, digital infrastructure, intelligent devices, and next-generation computing.

The **IT, Quantum & Semiconductors Technical Symposium** will feature three podium sessions and one poster session. We invite researchers and professionals from academia, industry, and government laboratories to share advances spanning computer science, information technology, artificial intelligence, data science, quantum technologies, semiconductor devices and systems, computing hardware, communications, cybersecurity, software systems, and related emerging areas. The symposium aims to foster interdisciplinary discussions and new collaborations across computing, electronics, quantum engineering, and digital innovation. This symposium is jointly organized by two Technical Groups (TGs) of KSEA and their affiliated professional societies (APS): Electrical and Computer Engineering; and Computer and Information Sciences.

The **Electrical and Computer Engineering TG (C-6 ECE)** includes members working across electrical engineering, computer engineering, semiconductors, quantum technology, circuits, systems, communications, computing hardware, signal processing, intelligent devices, and related emerging technologies. The group promotes innovations that advance electronics, information systems, semiconductor platforms, and next-generation computing technologies.

The **Computer and Information Sciences TG (C-7 CIT)** connects researchers and professionals working in computer science, information technology, artificial intelligence, IoT, data science, software systems, cybersecurity, connected technologies, human-centered systems, and emerging digital innovations. The group supports advances in computation, intelligent systems, secure and connected infrastructure, and data-driven technologies that shape research, industry, and society.

Supporting contributions are provided by related KSEA Technical Groups, including **Materials Science and Engineering, Nanotechnology (C-4 MSE)** in electronic, quantum, and functional materials; **Industrial, Manufacturing, and Systems Engineering (C-8 IMD)** in AI-enabled manufacturing, optimization, and industrial systems; and **Physics (A-1 PHY)** in quantum science, photonics, and fundamental physical platforms that support emerging quantum and semiconductor technologies.

Chair



Mingon Kang

University of Nevada, Las Vegas

Co-chairs



Sam Chung

City University of Seattle



Jungkwun Kim

University of North Texas

IT, Quantum & Semiconductors

@Augusta A

Thursday, Aug 6 5:00 – 6:45pm

Session 1: Next-Generation Computing & Intelligence

Chair: Mingon Kang (University of Nevada, Las Vegas), Sam Chung (City University of Seattle), Jungkwun Kim (University of North Texas)

Time	Title and Speaker
5:00	**Member introduction**
5:10	**An Artificial-Intelligence Agent Framework for Intelligent Livingcare Services at Smart Home** Jaehoon Jeong (Sungkyunkwan University) **Invited**
5:30	**A Large Language Model-Based Analysis for Identifying Mold-Related Issues in Buildings** San Jin (The University of Texas at Arlington)
5:45	**Topological Patching for Time Series Forecasting: A Noise-Immune Transformer Framework** Hyeonkyu Kim (Arizona State University)
6:00	**Towards Efficient and Context-Aware KV Cache Management for Long-Context LLMs** Gyuwan Kim (University of California, Santa Barbara)
6:15	**All-in-One Wearable Bioelectronics for a Continuous Assessment and Early Diagnosis of Acute Kidney Injury** Yeo, W. Hong (Georgia Tech)
6:30	**Elevator Talks**

IT, Quantum & Semiconductors

@Augusta A

Friday, Aug 7 3:15 – 5:00pm

Session 2: Advanced Materials & Quantum Physics
Chair: Mingon Kang (University of Nevada, Las Vegas), Sam Chung (City University of Seattle), Jungkwun Kim (University of North Texas)

Time	Title and Speaker
3:15	**Member introduction**
3:25	**Novel framework for non-equilibrium quantum physics** Jong Yeon Lee (University of Illinois at Urbana-Champaign) **Invited**
3:45	**Radiation Effects on DDR4 DRAM Under Cyogenic Conditions: Temperature-Dependent Analysis with Proton and Gamma-Ray** Jungsik, Kim (Gyeongsang National University)
4:00	**Electric-Field-Driven Quantum Control of Exciton Motion in Semiconducting Carbon Nanotubes** Dong Yoon Shin (University of Maryland)
4:15	**Metal-Insulator-Metal (MIM) Diode with Different Work Function Metals** Jeongwon Park (University of Nevada Reno)
4:30	**Silicon/Glass Interposer Metrology and Inspection by Shadowgraphy** Chabum Lee (Texas A&M University)
4:45	**Emission from Isolated Organic Chromophores within a Metallocene Single Crystal** Bumsu Lee (Southern Illinois University-Carbondale)

IT, Quantum & Semiconductors

@Augusta A

Saturday, Aug 8 8:00 – 10:00am

Session 3: Hardware Architecture & Future MEMS
Chair: Mingon Kang (University of Nevada, Las Vegas), Sam Chung (City University of Seattle), Jungkwun Kim (University of North Texas)

Time	Title and Speaker
8:00	**Member introduction**
8:05	**Liquid Metal Based Flexible Metamaterials and Sensors** Jeong Bong Lee (Baylor University) **Invited**
8:25	**Meta-Interconnect: A Metaconductor-Based Interconnect for Energy-Efficient AI Infrastructure** Saeyeong Jeon (University of Florida) **Invited**
8:45	**HIGH-Q 3D MICROPILLAR FREQUENCY-SELECTIVE DEVICES FOR LOW-LOSS TERAHERTZ BANDPASS FILTERING** Jungkwun Kim (University of North Texas)
9:00	**Multiphysics Analysis of Architecture-Dependent Variability in Valence-Change Resistive Memory** Yongwoo Kwon (Hongik University)
9:15	**AlN MEMS Oscillators Operating in Harsh Environment** Jaesung Lee (University of Central Florida)
9:30	**Atmospheric Pressure Plasma Deposition for High-Performance PVDF-Based Piezoelectric Nanogenerator** Choonsang Park (Milligan University)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

IT, Quantum & Semiconductors Poster Session

Chair: Mingon Kang (University of Nevada, Las Vegas), Sam Chung (City University of Seattle), Jungkwun Kim (University of North Texas)

P1	**On the Phase of Autocorrelation for Initializing Fourier Phase Retrieval** DongHun Ryu (MIT)
P2	**Toward the Quantum Simulation and Computing Platform of Ultracold Quantum Gases of Polar Molecules** Sungjun Lee (Pohang University of Science and Technology)
P3	**Air-Hermetic Wafer-Level Packaging for High-Power RF MMICs** Jongmin Yook (KETI, Korea Electronics Technology Institute)
P4	**Research Trends in LLM-Based Code Generation** Uisang Lee (Seoul National University)
P5	**Mode conversion of hyperbolic phonon polaritons in van der Waals terraces** Byung-Il Noh (Auburn University)
P6	**How Data Centers Stream Videos** Edward Hong (Independent Researcher)
P7	**End-to-End Computer Vision Pipeline for Perforation Defect Detection and Classification in Industrial Imaging** Joanne Yun (University of Wisconsin-Madison)
P8	**Comparative Analysis of ARIMA, LSTM, Transformer, and Prophet Models for Stock Price Forecasting** Jiyoon Moon (Queen Mary University of London)
P9	**Fully Optical Synaptic Operations Enabled by Wavelength-Tunable Wafer-Scale $PtSe_2$ Layers** Sang Sub Han (Korea Basic Science Institute)
P10	**A Low Loss RF Conductor Using Cu/Co Multilayer Metaconductor for W Band Applications** Hanna Jang (University of Florida)
P11	**IGZO-Based Neuromorphic System for Spiking Neural Networks** Yumin Yun (Seoul National University)
P12	**Experiential Learning for non-STEM Major Students' Computational Thinking Through AI-Enabled Website Development with No Coding** Sehee Ha (City University of Seattle)
P13	**Dry Metal-Assisted Chemical Etching (MACE) for Black Silicon Fabrication** Taeyon Kwon (University of Florida)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

IT, Quantum & Semiconductors Poster Session
Chair: Mingon Kang (University of Nevada, Las Vegas), Sam Chung (City University of Seattle), Jungkwun Kim (University of North Texas)

P14	**Estimating the Empowerment of Language Model Agents** Jinyeop Song (MIT)
P15	**Effectiveness of Input Vector Control on CNFET Devices** Joseph Kim (Illinois Institute of Technology)

Infrastructure, Mobility & Robots

The physical world is being reshaped by rapid advances in infrastructure systems, mobility technologies, and intelligent machines. Infrastructure is becoming increasingly instrumented, data-rich, adaptive, and connected. Mobility systems are evolving into intelligent ecosystems that integrate autonomous agents, human decision-making, and real-time data. Robots are expanding from controlled industrial environments into construction sites, warehouses, healthcare settings, public spaces, and homes. Addressing these transformations requires collaboration across disciplinary boundaries. The Infrastructure, Mobility, and Robots symposium explores how the built environment, mobility systems, and intelligent machines can be designed, operated, and integrated to address complex societal and technological challenges. By bringing together researchers, practitioners, and emerging scholars, the IMR symposium provides a platform for sharing innovative research, identifying cross-disciplinary collaboration opportunities, and shaping the future of intelligent, resilient, and human-centered physical systems.

Chair



JuHyeong Ryu

West Virginia University

Co-chairs



Eul-Bum Lee

POSTECH



Seokgi Lee

Youngstown State University



Ryan Choi

Eastern Michigan University

Infrastructure, Mobility & Robots

@Augusta B

Thursday, Aug 6 5:00 – 6:45pm

Connected Mobility, Cybersecurity, and Adaptive Systems

Chair: Seokgi Lee (Youngstown State University), Ji-Hung (Ryan) Choi (Eastern Michigan University)

Time	Title and Speaker
5:00	**Session Introduction** (Session Chairs: Seokgi Lee, Ji-Hung(Ryan) Choi)
5:15	**An Attribute Group-Based Conjoint Analysis Model for Consumer Preference Measurement: Application to EV Design** Rhim, Hosun (Korea University Business School)
5:30	**Structural Reorganization of the Global Container Shipping Network under Geopolitical Risk: The Case of the Red Sea Crisis** Park, Suyeon (Inha University)
5:45	**FI-DARA: Adaptive Edge-Cloud Routing for Privacy-Preserving Health Monitoring** Choi, Michael (University of Illinois Chicago)

Infrastructure, Mobility & Robots

@Augusta B

Thursday, Aug 6 5:00 – 6:45pm

Connected Mobility, Cybersecurity, and Adaptive Systems
Chair: Seokgi Lee (Youngstown State University), Ji-Hung (Ryan) Choi (Eastern Michigan University)

Time	Title and Speaker
6:00	**Beyond Economic Returns: The Duality of AI Adoption on Data Breach Incidents** Jaesung Shin (Mississippi State University)
6:15	**A Semi-Markov Process Approach to Quantify Material Content Over Multiple Product Lifecycles with Application to a Hard Disk Drive** Yong Han Kim (Purdue University)
6:30	**Nudging Secure Behavior: Examining the Effects of Attentional Nudge Strategies on Phishing Email Detection Performance** Seeung Oh (South Carolina State University)
6:45	**Session Q&A and Conclusion**

Infrastructure, Mobility & Robots

@Augusta B

Friday, Aug 7 3:15 – 5:00pm

Resilient Infrastructure and Intelligent Physical Systems
Chair: JuHyeong Ryu (WVU), Eul-Bum Lee (POSTECH)

Time	Title and Speaker
3:15	**Session Introduction** (Session Chair: JuHyeong Ryu)
3:15	**Construction Automation and Robotics in South Korea: Current Status and Future Directions** Dr. Jae Young Kim, CTO and Head of the Construction R&D Division at Hyundai Motor Group (HMG) **Invited**
3:45	**Value for Money Analysis of Public–Private Partnership and Public Sector Comparator for Building Project** Joseph Kim(California State University Long Beach)
4:00	**Safe, Permeable and Quiet Highway Pavement Infrastructure for the States with Severe Freeze/Thaw Cycles** Hosin Lee (University of Iowa)
4:15	**Mixed Traffic Cooperative Platooning using Multi-Agent Reinforcement Learning** Byungkyu Brian Park (University of Virginia)
4:30	**Knowledge-Graph Integrated Agentic Physical/Shadow AI for Autonomous Ships: A Hybrid Approach with LLM and Ontology** Geonwoo Kim (POSTECH)
4:45	**Narrative Manufacturing: A Human-Centered Path from Automation to Mass Innovation** Han, Changheon (Purdue University)
5:00	**Session Q&A and Conclusion**

Infrastructure, Mobility & Robots

@Augusta B

Saturday, Aug 8 8:00 – 10:00am

Sensing, Automation, and Infrastructure Intelligence
Chair: Woo Hyoung Lee (University of Central Florida)

Time	Title and Speaker
8:00	**Session Introduction** (Session Chair: Woo Hyoung Lee)
8:00	**Novel Electrochemical MIP Sensors for Monitoring Emerging Water Contaminants: PFAS and Odor Detection** Woo Hyoung Lee (University of Central Florida)
8:15	**Performance Assessment of Permeable Pavement under Intense Rainfall in U-Ecotron: A CFD-Based Approac** Seunghun Baek (Seoul National University)
8:30	**Automated System for Bridge Corrosion Detection and Severity Classification** Joseph Kim (California State University Long Beach)
8:45	**AI-Driven Pavement Crack Detection and Severity Classification** Joseph Kim (California State University Long Beach)
9:00	**Compound Heatwave–Extreme Rainfall Effects on Urban Drainage and LID Performance: A SWMM Continuous Simulation Study in Seoul** Yun, Hyeryeong (Seoul National University)
9:15	**Mobile Routing System for Older Adults' Walking** John Sohn (University of Nevada Las Vegas)
9:30	**Exploring the Electro-Tribological Behavior of Laser Cladded High Entropy Alloys** Dongyun Lee (Iowa State University)
9:45	**Optimal Camera Placement for 3D Surface Coverage** Sumin Hu (University of Texas at Austin)
10:00	**Session Q&A and Conclusion**

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Emerging Research in Infrastructure, Mobility, and Robots

Chair: JuHyeong Ryu (WVU), Eul-Bum Lee (POSTECH), Seokgi Lee (Youngstown State University), Ji-Hung (Ryan) Choi (Eastern Michigan University)

P1	**Influence of cementitious additives mising method with clay soil in unconfined compressive strength** Hyunjong Cha (Texas A&M University)
P2	**Hierarchical Framework using Reinforcement Learning for AMR Dispatching in Flexible Job Shop Enviroment** Jaemin Park (Purdue University)
P3	**AI-CFD Coupled Simulation for Urban Ventilation and Heat Island Mitigation of Green Infrastructure atop the Yangjae IC Underground Road** Hyunjae Kim (Seoul National University)
P4	**Automated Urban Flood Risk Screening Across Diverse Korean Terrain Types Using SWMManywhere and SSP Climate Scenarios** Nayoung Kim (Seoul National University)
P5	**Safety-by-Design Vision-Language Models for Bridge Inspection Documentation Quality Control** Kyubyung Kang (Purdue University)
P6	**A Preliminary Study on the Feasibility of UAS-Based Lighting in Road Construction Work Zones** Kyubyung Kang (Purdue University)
P7	**Metaheuristic Optimization of Railroad Horizontal Alignment with Complete Curve Geometry and Obstacle Avoidance** Myungseob Kim (KOTTA)
P8	**A Post-Hurricane Building Roof Damage Assessment Using Multi-Source Aerial Observations** Anjin Chang (Michigan State University)
P9	**AI-Enabled Drone for Wildfire Spread Classification Using Synthetic Image Sequences** Kevin Lee (Cornell University)
P10	**Heuristic Approach for Collaborative UAV-UGV Area Coverage Path Planning with Battery Constraints** Jackie Lee (Texas A&M University)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Emerging Research in Infrastructure, Mobility, and Robots

Chair: JuHyeong Ryu (WVU), Eul-Bum Lee (POSTECH), Seokgi Lee (Youngstown State University), Ji-Hung (Ryan) Choi (Eastern Michigan University)

P12	**Physics-Informed Neural Network Modeling of Salt Transport and Thermal Conductivity Evolution in Unsaturated Soils** Jongwan Eun (University of Maryland)
P13	**Estimating the natural gas demand margin of electricity load growth** Jin Wook Ro (Oak Ridge National Laboratory)
P14	**End-to-End Computer Vision Pipeline for Perforation Defect Detection and Classification in Industrial Imaging** Joanne Yun (University of Wisconsin-Madison)
P15	**An Optimal Consolidation Policy for Vehicle Routing Plans in Last-Mile Delivery: A Deep Q-Learning Approach** Seokgi Lee (Youngstown State University)
P16	**Analysis of the Impact and Time Lag of Maritime Supply Chain Disruption on Air Freight Demand and Freight Rates** Seryang Kim (Inha University)
P17	**From Scene Perception to Actionable Space: Semantic Risk Field for Safe Robot Navigation** Seonho Woo (Purdue University)
P18	**Short-Term Resilience Strategies Amid Supply Disruptions: An Analytical Perspective** Ryan Choi (Eastern Michigan University)
P19	**Mixed Reality Training for Industrial Assembly: Integrating Optimized Task Sequences with Motion-Based Ergonomic Monitoring** JuHyeong Ryu (West Virginia University)

Basic Sciences

This cluster highlights foundational research in physics, chemistry, mathematics, and other core sciences that drive fundamental discoveries and enable technological breakthroughs across disciplines.

The Basic Sciences Technical Symposium will feature three podium sessions and a poster session. We invite researchers and professionals from diverse scientific backgrounds to participate, share their latest work, and engage in vibrant discussions that foster new ideas and interdisciplinary connections.

This symposium is jointly organized by three Technical Groups (TGs) of KSEA and their affiliated professional societies (APS): Physics; Chemistry; and Mathematics, Geology, Meteorology, and Statistics.

The Physics (A-1 PHY) TG represents a community advancing theoretical, experimental, and applied physics, with work spanning fundamental studies of matter, energy, and the universe, as well as interdisciplinary areas connected to emerging scientific and technological frontiers.

The Chemistry (A-2 CHM) TG brings together scientists whose work advances molecular understanding and chemical innovation across diverse domains, including materials, biological systems, energy, photonics, and other interdisciplinary areas.

The Mathematics, Geology, Meteorology, and Statistics (A-3 MAS) TG includes researchers contributing to quantitative and earth-system sciences through theoretical development and practical applications in modeling, prediction, data analysis, environmental systems, and quantitative methods that support scientific decision-making.

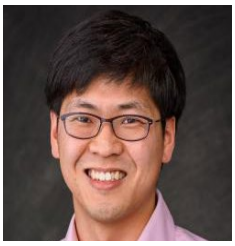
Chairs



Harold Kim

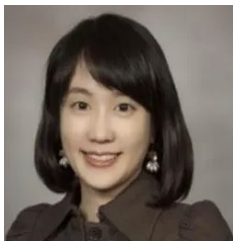
Georgia Institute of Technology

Co-chair



Bumjung Kim

New Jersey City University



Soeun Kim

Azusa Pacific University

Basic Sciences

@Colonial B

Thursday, Aug 6 5:00 – 6:45pm

CHM Session: Frontiers in Analytical Chemistry: Spatiotemporal Resolution, Molecular Insights, and Structural Control
Moderator: Bumjung Kim (Kean University)

Time	Title and Speaker
5:00	**Modeling secondary organic aerosol formation from atmospheric process of wildfire smoke: Chamber experiments to air quality simulations** Myoseon Jang (University of Florida)
5:17	**In Situ Raman Spectroscopy Reveals Bacterial Viability and Colony Growth Dynamics** Kaeul Lim (Purdue University)
5:35	**Fluorogenic Covalent Probes for RNA via 2'-OH-Selective Acylation** Jinwoo Shin (Stanford University)
5:53	**Complexation-Mediated Diffusion-Limited Crystal Growth: A General Framework for Anisotropic Crystal Growth** Youngjong Kang (Hanyang University)
6:10	**Accelerating Materials Characterization Using 4D-STEM and Data Analytics** Honggye Kim (University of Florida)
6:27	**Ultrafast Phase Transformation Studies using X-ray Free-Electron Lasers** Hyunjung Kim (Sogang University)

Basic Sciences

@Oakmont B

Friday, Aug 7 3:15 – 5:00pm

PHY Session: Investigating Nature Across Scales in the Physical Sciences
Moderator: Harold Kim (Georgia Institute of Technology)

Time	Title and Speaker
3:15	**Purely GHZ-like Entanglement is Forbidden in Holography** Monica Kang (Invited Speaker, Texas A&M University)
3:35	**Light-Front Helicity** Chueng Ji (North Carolina State University)
3:52	**Search for Associated Production of a Higgs Boson and Two Vector Bosons via Vector Boson Scattering** Philip Chang (University of Florida)

Basic Sciences

@Oakmont B

Friday, Aug 7 3:15 – 5:00pm

PHY Session: Investigating Nature Across Scales in the Physical Sciences
Moderator: Harold Kim (Georgia Institute of Technology)

Time	Title and Speaker
4:09	**Coherent Terahertz Radiation from Laser-Wakefield Acceleration** Ki-Yong Kim (University of Maryland)
4:26	**How molybdenum disulfide (MoS2) modulates actin assembly dynamics and fibroblast cell viability** Ellen Kang (University of Central Florida)
4:43	**Poloidal Dynamics of DNA Minicircles** Harold Kim (Georgia Institute of Technology)

Basic Sciences

@Oakmont B

Saturday, Aug 8 8:00 – 10:00am

MAS session: Advances in Mathematical Theory and Statistical Modeling
Moderator: Soeun Kim (University of Delaware)

Time	Title and Speaker
8:00	**Missing data imputation methods for models with interactions** Soeun Kim (University of Delaware)
8:20	**A Braun–Zeckner Sphere-Collapse Theorem for k = 3** Stephen Yoo
8:40	**Learning Contemporary Geometry Through Inquiry: Voronoi Diagrams and Delaunay Triangulations** Younggon Bae (University of Texas Rio Grande Valley)
9:00	**Goodness-of-fit Tests for Multinomial Models with Inverse sampling** Hokwon Cho (University of Nevada, Las Vegas)
9:20	**The All-k Neighborhood Collapse** Stephen Yoo
9:40	**Bayesian Analysis of Multivariate Joint Model with a Flexible Covariance Structure** Seongho Song (University of Cincinnati)

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

Chairs: Harold Kim (Georgia Institute of Technology), Bumjung Kim (New Jersey City University), Soeun Kim (Azusa Pacific University)

P1	**Practical T1 Analysis for Quadrupolar Solid-State NMR Experiments** YeonJun Choi (Texas A&M University)
P2	**Reconstruction of Atomic-Scale Electronic Structures via Active Learning-Driven Scanning Tunneling Spectroscopy Mapping** HyeongChan Suh (University of Texas at Dallas)
P3	**Low-energy tail of the spectral density for a particle interacting with a quantum phonon bath** Donghwan Kim (University of Texas at Austin)
P4	**Developing a catalysis-based fluorometric method for endogenous Copper in live cells** Soyoung Choi (University of Pittsburgh)
P5	**Tuning polymer nanoparticle morphologies via photochemical decarboxylation** Seungyoon Han (University of Florida)
P6	**Spatiotemporal organization of membrane protein controls bacterial extracellular electron transfer** Youngchan Park (Indiana University Bloomington)
P7	**Functional Connectome Alterations Underlying Posttraumatic Stress Disorder** Eun Namgung (Texas A&M University Health Science Center)
P8	**Integrated spatial multi-omics identifies TRPS1 as a regulator of joint cell fate linking cartilage development to osteoarthritis** Ji-Hye Yea (Johns Hopkins University)
P9	**Large Language Model and Human Performance on a Motor Sequence Learning Task** Hakjoo Kim (McLean Hospital, Harvard Medical School)
P10	**Modeling U.S. Drought and Wildfire Communications in Social Media** Woi Sok Oh (University of Waterloo)

Emerging Areas (Entertainment Tech & STEAM)

This cluster explores emerging areas in Social Sciences (Anthropology, Economics, Political Science, Sociology, Public Policy, etc.), Psychology, Digital Arts, STEM Education, and Other Sciences. The STEAM-Centered Social Science will feature three podium sessions and one poster session. We invite researchers and professionals conducting qualitative, quantitative, computational, and integrated work in artificial intelligence, educational technology, behavioral health, criminal justice, and related STEAM fields to present empirical findings and conceptual frameworks that address emerging challenges in human-AI interaction, educational ecosystems, and societal well-being, while engaging in discussions that foster interdisciplinary collaboration and new research connections.

The Framework & Artificial Intelligence Session examines how AI is transforming diverse domains through innovative frameworks and applications. Presentations introduce machine learning insights into volunteer mentor retention over time, analyses of university knowledge complexity versus regional innovation, an adaptive behavioral health platform, tools for evaluating AI-integrated STEM teaching and teacher–AI collaboration, and building social presence in virtual offices.

The Diverse Methodologies Session highlights the breadth of qualitative and quantitative approaches used to address critical questions across education, psychology, engineering, and healthcare. The qualitative studies explore the distinctive cultural assets of international female STEM students and analyze mentoring ecosystems in the engineering research center. The quantitative studies examine engineering team communication in a video game environment, investigate the relationship between children's emotion regulation and emotional responses using electroencephalography (EEG) and electrocardiography (ECG) measures, and evaluate the effects of feedback in medical certification standard-setting using survey data and statistical analyses.

The Artificial Intelligence and Practice Session highlights the practical implementation and direct impact of artificial intelligence across critical societal sectors, with a strong emphasis on criminal justice and education. Presentations in this session explore how AI is actively reshaping professional practices and operational security, including its dual role as an investigative tool and emerging threat in criminology, its effects on institutional security in U.S. prisons, and the use of deep learning for automated scoring of police shooting targets. Furthermore, the session addresses practical educational applications, examining the reliability of prompt engineering in human-AI grading agreements and the utilization of AI-powered student-emulating agents to enhance preservice teachers' responsive instruction.

Chairs



Hyoungah Park

Saint Peter's University

Co-chairs



Benjamin Ahn

The Ohio State University



Danielle Lee

American Board of Internal Medicine



Jung Han

K-EnterTech Hub

Emerging Areas

@Colonial A

Thursday, Aug 6 5:00 – 6:45pm

Session A: Framework & Artificial Intelligence
Chair: Benjamin Ahn (The Ohio State University)

Time	Title and Speaker
5:00	**Temporal Shifts of Key Factors for Volunteer Retention in Local Mentoring Programs Using a Machine Learning Approach** Juyoung Lee, Sunghyun Kim, Saumya Diwan (Emory University)
5:20	**University Complexity and the Decoupled Role of Universities in U.S. Regional Innovation Systems** Sooyeon Lim (Georgia Institute of Technology, Seoul National University)
5:40	**FitMindMove: Multi-Dimensional Hybrid Model Selection for Behavioral Health AI Systems** Saahoon Hong, Hea-Won Kim (Indiana University Indianapolis), Terry Choi, Dongwoo Shin (A TO Z Service Inc)
6:00	**Development of a Teacher-AI Collaboration Framework (TAiCF) in AISTEM Lessons** Younkyeong Nam, Jina Yoon, Dongyoung Lee, Woonseok Cho (Pusan National University)
6:20	**Building Social Presence in Virtual Offices: A Three-Phase Framework Integrating Metaverse, Agentic AI, and MMORPG Principles** Jinho Kim (University of Houston Downtown)

Emerging Areas

@Colonial A

Friday, Aug 7 3:15 – 5:00pm

Session B: Diverse Methodologies
Chair: Danille Lee (American Board of Internal Medicine)

Time	Title and Speaker
3:15	**Female International Students in STEM: Distinctive Cultural Assets** Jae Hoon Lim (University of North Carolina at Charlotte) **Invited**
3:40	**Analyzing Mentoring Ecosystems in Engineering Research Centers** Hwangbo Bae (University of Michigan) **Invited**
4:00	**Utilizing a Video Game to Examine Engineering Team Communication** Benjamin Ahn (The Ohio State University) **Invited**
4:20	**Child Executive Function Predicts Neurophysiology Indicators of Emotion Regulation: Insights from Frontal Alpha Asymmetry and Respiratory Sinus Arrhythmia** Yelim Hong (The University of Texas at Austin)
4:40	**How Does Feedback Influence Standard-Setting Ratings in Medical Certification Assessments?** Danielle Lee (American Board of Internal Medicine)

Emerging Areas

@Colonial A

Saturday, Aug 8 8:00 – 10:00am

Session C: Artificial Intelligence & Practice
Chair: Jung Han (K-EnterTech Hub)

Time	Title and Speaker
8:00	**AI and the Future of Criminology: Investigative Tool and Emerging Threat** Max Chang (Liner)
8:20	**Technological Changes in U.S. Prisons: Contraband, AI, and Institutional Security** Hyesun Kim (Worcester State University)
8:40	**Prompt Engineering and Human-AI Grading Agreement** Jesse Ha (Indiana University)
9:00	**AI-Based Automated Scoring for Police Shooting Targets** Hyoungah Park (Saint Peter's University)
9:20	**Preservice Teachers' Responsive Mathematics Teaching with AI-Powered Student Emulating Agents** Dabae Lee (Kennesaw State University)
9:40	**Q&A**

Poster Session

@ International Ballroom II

Friday, Aug 7 5:00 – 6:45pm

STEM-Centered Social Science Cluster Poster Session
Chair: Hyoungah Park (Saint Peter's University), Benjamin Ahn (The Ohio State University), Danielle Lee (American Board of Internal Medicine), and Jung Han (K-EnterTech Hub)

P1	**Combining Convex GSCA and Bayesian Networks: A Proof-of-Concept Application to Cognitive-Therapy Prioritization in CBT-I** GyeongCheol Cho (Ohio State University)
P2	**Lived Experiences of Loneliness and Connectedness Among Korean Immigrants Aged 50 and Older Living in the United States** Areum Han (University of South Florida)
P3	**Framing Conflict: A Domain-Adapted Language Model Approach to Cross-National Media Framing Analysis** Dawoon Jung (Purdue University)
P4	**Exercise, Prefrontal Oxygenation, and Cognitive Control in College Students** Yeonhak Jung (California State University, Northridge)
P5	**The Effects of AI Chatbot and Face-to-Face Counseling on Stress, Burnout, and Resilience in Athletes** Ga-young Kim (Old Dominion University)
P6	**Developing CareNoteAI: A Generative, Ontology-Informed Prototype for Behavioral Health Decision Support**Sungjun Kim (Boston University)
P7	**Humanities-Guided Human-AI Co-Evolution in Mental Health Services** June Sin (Texas Tech University)
P8	**Interdisciplinary Curriculum in Physical Education and Impact on Student Outcomes: A Systematic Review and Meta-analysis** Ji Hye Yang (Old Dominion University)
P9	**A Smart Home Interface Design Framework to Support Energy-Saving Behaviors** Jinmog Han (Iowa State University)

IES Symposium

Innovation and Entrepreneurship Symposium (IES)

The Korean-American Scientists and Engineers Association (KSEA) cordially invites you to the 8th Innovation and Entrepreneurship Symposium (IES). This premier symposium aims to bridge entrepreneurial communities from the US and Korea, fostering unparalleled networking opportunities.

The IES Workshop Program brings together leading founders, investors, researchers, and innovators for an intensive, insight-driven series of sessions designed to equip entrepreneurs with practical knowledge, global perspective, and meaningful partnership opportunities. With this year's emphasis on **R&D collaboration and strategic networking**, the program creates structured opportunities for startups, SMEs, and research institutions to explore cross-border joint development, technology commercialization, and long-term research partnerships. The IES Innovation Showcase Session provides a dynamic platform for selected startups and SMEs to showcase their technologies, products, and services to an audience of investors, researchers, and potential R&D partners. Designed to foster meaningful engagement, this session moves beyond traditional presentations by encouraging direct interaction, real-time feedback, and partnership exploration.

The IES offers the Startup Pitch Competition (SPC) and Idea Pitch Competition (IPC)—the symposium's pinnacle events. Through SPC, startups vie for a cash prize by pitching to potential investors and industry veterans. The Idea Pitch Competition (IPC) beckons early-stage startups and aspiring entrepreneurs to present their concepts, garnering invaluable feedback from investors.

This year, IES is launching a new Global R&D Networking Program to foster meaningful research collaborations and technology partnerships between Korean tech companies and Korean-American scientists and engineers.

The symposium is replete with diverse networking events, connecting attendees with investors, established entrepreneurs, funding agencies, and specialists in legal and financial domains. We warmly welcome all professionals with an entrepreneurial spirit to join us at the IES and delve into the burgeoning cross-border business vistas between the US and Korea.

Organizing Committee

Chair



Jeho Park

Claremont McKenna College

Co-Chairs



Deok-Ho Kim

Workshop Program
Johns Hopkins University



Jeniffer Cho

Pitch Competition
Solaris Venture Partners



Martin Jun

Innovation Showcase
Purdue University



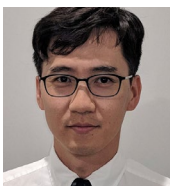
Kyeong Ho Yang

Fundraising/ Networking KITEE, KoAm Partners



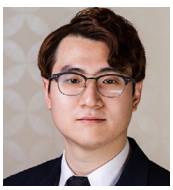
Kevin Kim

General Director, PR/Web/Social Media
Brave Turtles



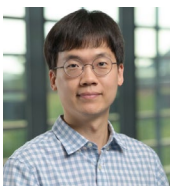
Joonyul Kim

Director, Workshop Program, Johns Hopkins University



James Han

Director, Pitch Competition
Harvard Medical School



Hyunseok Kim

Director, Showcase Demo, University of Illinois, Urbana-Champaign



Nathan Byun

Director, Networking Program

Program Overview

Thursday, August 6

Time	Content	Title and Speaker	Location
10:15-6:45 pm	IES Innovation Showcase	- 15 companies from Global R&D Partnership and Networking Program - 14 companies from Startup Pitch Competition Program	International Ballroom
3:15-4:15 pm	IES Opening Session	- Opening Remarks: 박제호 (IES2026 Chair) - Congratulatory Remarks: 윤용규 (KSEA President) - Sponsor Introduction - Fireside Chat with 하정우 대표, CEO, Bear Robotics, "***From Restaurant Floor to Robot Fleet : Building Bear Robotics***"	Royal Melbourne (Open to all UKC participants)
4:20-5:30 pm	IES Workshop I - Bio / Health	- 이홍표 (CTO, Co-founder), Medic Lifescience - "***From Functional Genomics to Precision Oncology: Building a Platform that Translates Biology into Medicines***" - 임채민 (CTO, Co-founder), Coiled Tx - "***How We Outlasted the Hype: A Small Biotech's Playbook***" - 박상혁 (Associated Director of Research), Institute of Cannabis Research (ICR) at Colorado State University-Pueblo -"***Cannabis from Prohibited Drug to Therapeutic Discovery***"	
5:35-6:45 pm	IES Workshop II - AI / IT	- 임헌민 (Former Senior Development Manager), Microsoft - " ***A First-Hand View (25 Years @ Microsoft) - AI in the Real World***" - 김태현 (Founder, CEO), Handiers Inc. -"***Building an AI-Native Company: The Handiers&NextPros Story***" -김세순 (Technical Staff), Sygaldry Technologies — "The Emerging Quantum Technology Stack: From Hardware to AI Applications"	

Friday, August 7

Time	Content	Title and Speaker	Location
10:15-12:00 pm	IES Global R&D Networking I	Closed Session for Registered Companies and Invited Participants	Royal Melbourne · Invitation Only
1:15-3:00 pm	IES Global R&D Networking II		

3:15-4:50 pm	IES Workshop III	- 손재권 (Founder & CEO), The Miilk — Korea's ₩5,000 Trillion Bet: Capital, Power, and the AI Infrastructure Race - Job Albo (VC, Early Stage Investor), Plug and Play — I***nside a Global Venture Capital Firm: Supporting Startups Entering the US Market*** - 박현호 (IP Lawyer), McCarter & English, LLP — ***Patent and Trade Secret Topics That Every Korean-American Professional Needs to Know*** - 배정융 (CEO & Executive Director), KIC Silicon Valley — ***From Seoul to Silicon Valley: A Practical Playbook for Korean Startups Entering the US Market*** - 이우정 ***(Associate), SOSV HAX Investment -- Building Hard Tech Is Hard***	Royal Melbourne · Open to all UKC participants
5:00-6:45 pm	Startup Pitch Competition	Finalists - BestTurn Inc. (Wonjin Choi) - COILS Co., Ltd. (Sungryul Huh) - EDmicBio inc. (Dong-Heon Ha) - FLYTO (Haejin Park) - OZOMETA (Changgyu Kim) - SpeedFloor (Sukmin Hong) - StellarCube (Sangmyung Hong) - Team Gencow (Kevin Choi) - UpcycleX Inc. (Wanghee (Wren) Lee) - Wis Medical (Josh Lee)	Royal Melbourne · Open to all UKC participants

Saturday, August 8

Time	Content	Title and Speaker	Location
1:00-3:00 pm	IES SPC Networking Lunch		TBD · Invitation Only

Call for Participation: Global R&D Partnership and Networking Program at IES 2026

The Global R&D Partnership and Networking Program is a brand-new initiative at UKC 2026, specifically designed for growth-stage Korean tech SMEs seeking global R&D collaboration with US academic and research partners.

The Program is aimed to foster meaningful research collaborations and technology partnerships between Korean technology companies and Korean-American scientists and engineers. The program will feature small-group networking sessions, with opportunities for follow-up one-on-one meetings, in various technology areas.

Through structured 1:1 meetings and small-group networking sessions, Korean corporate leaders and R&D executives will connect directly with vetted US experts to unlock cross-disciplinary, concrete partnership opportunities.

Date: August 6–8, 2026

Venue: Orlando, FL (UKC 2026 USA)

Participation Fee: $3,000 per company

Format: 1:1 and/or Small Group Sessions (Each company participates in 2 sessions across 4 technology tracks, designed in a 2x2 cross-disciplinary format)

Package Benefits
Field-Specific R&D Collaboration Matrix, Curated small-group sessions with vetted US academic and research experts across core technology fields: AI/ICT, Robotics, SaaS, Security, Pharma, Biotech, Digital Healthcare, Smart City, Aerospace, and Energy.

Innovation Showcase (1-Day Booth Exhibition)
Opportunity to demonstrate your technology, products, and services to all UKC attendees. Includes a 6 ft x 30-inch table, two chairs, and a basic tablecloth.

Exclusive Networking Access

IES Networking Dinner: An invitation-only evening with top investors, entrepreneurs, and technologists. IES-SPC
Networking Lunch: Connect directly with pitch judges and KSEA experts.
Small-Group Sessions: 2 field-specific networking rounds tailored for each company.

Complimentary Registration
Includes 1 complimentary full registration for UKC 2026.

Application Deadline: July 10, 2026

Online Application: bit.ly/UKC_GlobalRnD2026

Email Submission & Inquiries: entrepreneurship@ksea.org Website: ies.ksea.org

Email Submission & Inquiries: entrepreneurship@ksea.org

Official Website: ies.ksea.org

This session is sponsored by:

FIRE Symposium

FIRE Symposium

Thursday, August 6	5:00 - 6:45pm	ChampionsGate
Friday, August 7	3:15 - 6:45pm	ChampionsGate
Saturday, August 8	9:00 - 10:00am	ChampionsGate

The Fostering Innovation in Rising Experts (FIRE) Symposium at UKC brings together a dynamic community of young professionals, graduate and undergraduate students, postdoctoral researchers, and early-career faculty for a forum dedicated to career growth and leadership development. For UKC 2026, FIRE embraces the theme "***Connect Today. Build Beyond. Ignite Tomorrow***." a timely call to equip students and early-career professionals with the confidence and adaptability to thrive in an era of rapid change across STEM fields. Against the backdrop of evolving global challenges, this year's program offers a platform for growth, resilience, and visionary leadership. Through engaging discussions on career advancement, mentorship, and innovation, participants will leave equipped with practical tools to lead their careers with purpose and confidence.

Beyond keynote addresses from distinguished leaders in science and industry, FIRE participants will have the opportunity to showcase their career paths and professional work through four signature avenues of participation: **1) Mentoring Roundtables, 2) AI Build Challenge, 3) Career Flash Talk, and 4) Career Poster Presentation**. Together, these avenues cultivate a space for community building, peer support, and the exchange of ideas, helping shape the next generation of scientists and engineers. FIRE further offers participants meaningful opportunities to network within and beyond their respective disciplines, fostering cross-sector awareness of emerging innovations in science and engineering.

Organizing Committee

Chair



Taegon Jay Lee

Palantir AI & Data Science Manager at Department of War

Co-Chair



Riky Bae

Manufacturing Engineer at PECNA

Co-Chair



Judy Seohyun Kim

Co-Founder & CEO at K-Leap Global

Programs & Networking



Lucy Lee

Pharmacist, Ph.D. student at UTHealth Houston



Helen Mah

Software Engineer at Dell Technologies



Youra Shin

Ph.D. Candidate at New Jersey Institute of Technology

Admin and Communications



Lanette Choi

Graduate Student at Rush University



Daniel Kim

Undergraduate Student at University of Wisconsin-Madison

I. FIRE Symposium Opening

Thursday, August 6 5:00 - 6:45pm ChampionsGate

Session Chair: Taegon Jay Lee (Department of War)

Time	Program and Speaker
5:00 - 5:15 pm	**Welcoming Remarks** Taegon Jay Lee (Department of War)
5:15 - 5:40 pm	**Opening Keynote** Dr. William D. Phillips, Nobel Laureate in Physics (1997) NIST Fellow and Distinguished University Professor
5:40 - 5:55 pm	**Introductory Networking / Icebreaker** Riky Bae(PECNA) The event will begin with an Icebreaker Bingo networking activity designed to help attendees connect before the main program. Each participant will receive a bingo card at their seat featuring different prompts or qualities. Participants will mingle around the room, introduce themselves to others, and find people who match each prompt to sign the corresponding square. The first participant to complete a bingo wins the activity. The session is intentionally casual and interactive, encouraging attendees to meet new people, discover shared interests, experiences, and backgrounds, and build meaningful connections in a low-pressure environment. The activity is expected to last approximately 10–15 minutes, with participants actively moving around and engaging in conversation.

II. Career Flash Talk

Thursday, August 7 5:55 - 6:45pm ChampionsGate

Session Lead: Lucy Lee (UTHealth Houston)

The Career Flash Talk gives participants the opportunity to share leadership experiences, life lessons, and professional skills through an engaging 5-minute presentation. Speakers will highlight insights gained through their experiences in industry, academia, leadership, or their professional careers, with the goal of inspiring others and helping participants advance their own careers.

Each talk will be followed by a short Q&A, allowing speakers to engage directly with the audience and share additional insights. Presentations will be evaluated based on content, organization and professionalism, audience engagement and Q&A, and effective use of visual aids.

Time	Program and Speaker
5:55 pm	Lucy: Opening Remarks
6:00	Lanette: Never Stop Being a Student
6:05	Hoi Joong (Dominic): From Outsider to Connector: Building Beyond Boundaries
6:10	Kyu Won: Plot Twist: You Already Have the Advantage
6:15	Hyoungjin (Harry): Bridging Bench and Beside: Interdisciplinary Paths in Science and Medicine
6:20	Yanghee: Making the Most of Your PhD: Choosing the Right Lab, Seizing Opportunities, and Standing Out
6:25	Jinmog: From Engineering to Human-Centered Design
6:30	Sol: Owning Your Growth in Uncertainty
6:35	SoYoung: From the Sideline to the Laboratory: My Journey from Athletic Trainer to Researcher
6:40	Jongwoo: With, Not For: Inclusive Leadership Lessons from STEM Students with Disabilities

III. AI Build Challenge

Friday, August 8 3:15 - 4:15pm ChampionsGate

Session Chair: Helen Mah (Dell Technologies)

The AI Build Challenge is a no-code, low-code, and "vibe-code" hackathon open to participants of all technical backgrounds. Participants will work in teams of 2–3 to complete a 7-day sprint and develop an AI-powered prototype using modern tools.

Teams will submit a short demo video and present their prototype during the FIRE Conference on Friday, August 7, where they will receive live feedback and compete for awards. Projects will be evaluated on innovation, technical implementation, design, impact, viability, and presentation. The challenge offers an opportunity to collaborate, innovate, build with AI, and connect with the FIRE community.

Time	Program and Speaker
3:15-3:20	Helen: Opening remarks
3:20-3:35	Team OrlaP: Sunghwan(Sunny) and Jiwon
3:40-3:55	Team Knect: Alison and Nathan
4:00-4:15	Team Haechi Labs: Sunu, Clara, and Daniel

IV. Mentorship Roundtable Program

Friday, August 8 4:15 - 5:00pm ChampionsGate

Session Chair: Youra Shin (New Jersey Institute of Technology)

Each mentor will begin with a 30-second introduction and short pitch highlighting their topic and key insights. This will be followed by a 20-minute interactive discussion focused on sharing experiences, lessons learned, career advice, and practical insights.

Participants are encouraged to actively engage, ask questions, share perspectives, and connect with mentors and fellow attendees. The roundtables aim to foster knowledge sharing, professional development, networking, and meaningful connections within the UKC FIRE community.

Field	Title & Speakers
T1: Teamwork & Collaboration	Building Strong Teams Through Communication and Collaboration & Subin Lee, Ryan Shin
T2: Leadership Development	From Contributor to Builder: Taking Ownership and Leading What Comes Next & Yaeji Kim, Tony Lee
T3: Career Exploration	Embracing Unexpected Opportunities: Building a Meaningful Career & Terry Kim
T4: AI & Engineering	Building the Future through Advanced Engineering Technologies & Byeongchan Jeong, TJ Park
T5: Research Careers	Beyond the Ph.D.: Navigating Research Careers and Real-World Impact & Hyewon Kang, Seungwon Yoo
T6: Personal Growth & Communication	Understanding Yourself and Others for Personal and Professional Success & Jesse Ha, Jonathan Kim

V. Poster Presentation

Friday, August 8 5:00 - 6:40pm International Ballroom II

Session Lead: Riky Bae(PECNA)

The Career Poster Presentation offers participants an opportunity to showcase topics related to career development, professional growth, creative projects, or personal interests through visually engaging posters and interactive discussions. Presenters will provide a 5-minute overview and engage with attendees through questions and one-on-one conversations, fostering communication skills, knowledge sharing, and meaningful networking.

Slot	Presentation Title & Speakers
FIRE1	**Seunghyeb Ban** Georgia Institute of Technology | 3rd Year Ph.D AI-Enabled Wearable Systems for Sleep and Human Health Monitoring
FIRE2	**Yeju Choi** Korea University | 3rd Year BS Connecting Today to Build Beyond: My Roadmap as a Global Life Sciences Researcher
FIRE3	**Chiho Im** Stanford University | 3rd Year Ph.D Coming Full Circle: Integrating Artificial Intelligence With Science
FIRE4	**Uijeong Jo** Grady Health System | PGY2 Pharmacy Resident From Residency Showcase to Match Day: My Networking Journey
FIRE5	**Hanlim Kang** Massachusetts Institute of Technology | 4th Year Ph.D Finding My Voice Across Borders
FIRE6	**Dahye Kim** Houston Methodist Hospital | Pharmacy Resident Finding My Voice Across Borders
FIRE7	**Michael Kim** Johns Hopkins University | 2nd Year Masters Student Researcher Probing the paradoxical relationship between marine diazotrophs and oxygen through controlled hypoxia
FIRE8	**Min Kyu Lee** University of California, Los Angeles | R&D Consultant, 4th Year Ph.D From Residency Showcase to Match Day: My Networking Journey
FIRE9	**Jaylen Park** Kongsberg Maritime | Riser & Marine Engineer What Percentage of Life Is Luck?

VI. Closing & Award Ceremony

Saturday, August 9 9:00 - 10:00am ChampionsGate

Session Chairs: Judy Kim(K-Leap Global), Riky Bae(PECNA), and Taegon Jay Lee (Department of War)

Time	Program and Speaker
9:00 – 9:10	**Closing Remarks**
9:10 – 9:30	**FIRE Award Ceremony** The closing program will feature a recap of the FIRE symposium and an award ceremony, where the VISION Awards and the FIRE Award will be presented to recognize outstanding presentations in the Career Flash Talk, AI Build Challenge, and Poster Exhibition sessions.
9:30 – 9:50	**Final Group Discussion & Closing Activity**

Distinguished Sponsor Forums

Innopolis Forum

Global Deep tech Commercialization forum

Thursday, August 6 1:00 - 3:00pm Championsgate

INNOPOLIS
KOREA INNOVATION CLUSTER

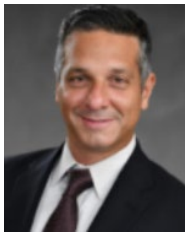
Chair



Hee Kwon Jung

President, Korea Innovation Foundation

Session1 Speakers



Ron Piccolo

CEO, Florida Semiconductor Engine



Sung-Hee Yun

CEO, Erudio Bio



Janice Logan

Partner, Morgan Lewis&Bockius LLP



Paul Sohl

CEO, Florida High Tech Corridor

Session2 Panelists



Ki Jung Kwon

CEO, Narma



Yeonglyeol Park

CEO, Elspes



Woojin Jun

CEO, WIM



Sung-Hee Yun

CEO, Erudio Bio

Time	Title and Speaker
12:30 - 1:00 pm	**Registration & Networking**
1:00 - 1:10 pm	**Welcoming Remarks** Heekwon Jung (President, Korea Innovation Foundation) **Congratulatory Remarks** Yongkyu Yoon (President, KSEA)
1:10 - 2:10 pm	**Session 1: Policy, Strategies, and Founder Insights** Focus: Policy framework and strategies for global expansion 1. Innovative Ecosystem & Synergy (Ron Piccolo, CEO, Florida Semiconductor Engine) 2. The Evolution of the AI Innovation Ecosystem (Sung-Hee Yun, CEO, Erudio Bio, secured $1M from the Gates Foudation in 2025) 3. IP Strategy Trends in the U.S. Market (Janice Logan, Partner, Morgan Lewis&Bockius LLP) 4. Soft Landing Strategies for Deep tech Startups (Paul Sohl, CEO, Florida High Tech Corridor)
2:10 - 2:20 pm	**Coffee Break**
2:20 - 3:00 pm	**Session 2: Breaking Into the U.S. – Challenges & Opportunities** Focus: Case studies and interactive talk concert (6-min pitch + 20-min discussion) 1. Narma (Ki Jung Kwon, CEO) - Certification & Commercialization Insights 2. Elspes (Yeonglyeol Park, CEO) - U.S. Manufacturing Setup & Investment Strategies 3. WIM (Woojin Jun, CEO) - Local Networking & Partnership Strategies 4. Erudio Bio (Sung-Hee Yun, CEO) - U.S. Incorporation & Global Scaling Experience
3:00- 3:10 pm	**Closing Ceremony**

NRF Forum

NRF(ANCHOR) - NSF(RIE) Regional Innovation Session

Thursday, August 6 1:00 - 3:00pm Olympic

KUSCO NRF
KOREA-U.S. SCIENCE COOPERATION CENTER
National Research Foundation of Korea

Host



Won Hwa Hong

National Research Foundation of Korea (NRF)

Chair



Ohbong Kwon

Associate Professor
New York City College of Technology

Presenters



Dong Seob Kang

Director General of NRF/KUSCO



Tyler Kim

Booz Allen



Hyun-Soo Ra

Kyungpook National University



John Allgair

CTO BRIDG
CTO, NSF Florida Semiconductor Engine



Glenn Oliver

Florida Site Lead
imec USA Nanoelectronics Design Center

Through this session, we seek to foster strategic partnerships between regional innovation initiatives in Korea and the United States, advancing collaborative frameworks that contribute to mutually beneficial growth in both countries.

- Specifically, the session will highlight semiconductor-focused projects supported by the National Research Foundation of Korea (NRF)'s "***ANCHOR***" program and the U.S. National Science Foundation (NSF)'s "***Regional Innovation Engine (RIE)***" program. By sharing insights and experiences from exemplary regional innovation initiatives, we aim to build a sustainable international network and explore new opportunities for cross-border collaboration, including researcher mobility, joint research, and industrial partnerships between Korea and the United States.

Time	Title and Speaker
1:00 - 1:05 pm	**Welcome Remarks** Won Hwa Hong (President, NRF)
1:05 - 1:20 pm	**Introduction : Outlines of the NRS's ANCHOR and NSF's RIE** Dong Seob Kang (Director General of Directorate for International Affairs, NRF)
1:20 - 1:50 pm	**Case Studies** **1. ANCHOR 1 - Hanseo University, taking a leap to the world together with the region** Tyler Kim (Researcher, Booz Allen) **2. ANCHOR 2 - KNU semiconductor industry-academia collaboration** Hyun-Soo Ra (Assistant Professor, Kyungpook National University)
1:50 - 2:20 pm	**Case Studies** **- (RIE 1) Regional Economic Development: Growing an Advanced System Integration and Packaging Manufacturing Base** John Allgair (CTO, BRIDG) **- (RIE 2) Global Semiconductor R&D: The Florida Connection** Glenn Oliver (Florida Site Lead, imec USA Nanoelectronics Design Center)
2:20 - 2:50 pm	**Panel Discussion, Q&A Session**
2:50 - 3:00 pm	**Wrap-up and Photo**

Hyundai Motor Chung Mong-Koo Foundation Forum

Solving Social Challenges: Sci-Tech Innovation Driven by Next-Generation Leaders

현대차 정몽구 재단 Chung Mong-Koo Foundation

Thursday, August 6 1:00 - 3:00pm Augusta

Chair



Gloria Kim

University of Florida

Presenters



Yuri Kang

Pohang University of Science and Technology



Kyunghyun Kim

Hongik University



Yurim Choi

Pohang University of Science and Technology

Speaker



William Phillips

Nobel Laureate in Physics
Fellow, NIST Distinguished University Professor, University of Maryland

The Hyundai Motor Chung Mong-Koo Foundation is at the forefront of nurturing science and technology talent to address the complex societal challenges. In alignment with this mission, this year's forum adopts the theme "***Solving Social Challenges: Sci-Tech Innovation Driven by Next-Generation Leaders***" to showcase how the innovative research outcomes of three foundation scholars—bridging imagination and innovation—can translate into tangible solutions to real-world societal problems.

This forum, featuring foundation scholars as primary presenters, transcends traditional academic knowledge-sharing. Centered on the core concept of "***solving future challenges,***" it serves as a pivotal platform to articulate on the global stage the philosophy and purpose behind the foundation's commitment to cultivating future talent through science and technology scholarships.

Time	Title and Speaker
1:00 - 1:05 pm	**Opening & Introduction** Gloria Kim (University of Florida)
1:05 - 1:10 pm	**Introduction of Hyundai Motor Chung Mong-Koo Foundation(Video)**
1:10 - 1:22 pm	**Dual-Responsive Gelatin Microspheres for Ultrasound-Triggered Drug Release** Yuri Kang (Pohang University of Science and Technology)
1:22 - 1:34 pm	**Design of Non-Flammable, Clay-Like Solid Electrolytes via Lewis Acid-Base Interactions** Kyunghyun Kim (Hongik University)
1:34 - 1:46 pm	**Bridging Mechanical Discontinuity: Bioinspired Stress-Dissipating Interface for Human-Integrated Materials and Devices** Yurim Choi (Pohang University of Science and Technology)
1:46 - 2:30 pm	**Conversation with Nobel Laureate Dr. William D. Phillips (Graduate Students & Postdocs Only; Advance RSVP Required)** Moderated by Gloria Kim (University of Florida)
2:30 - 2:35 pm	**Concluding Remarks / Photo Session** Moderated by Gloria Kim (University of Florida)

Korea – US Quantum & AI Application Forum

Thursday, August 6 1:00 - 3:00pm Colonial B

Chair



In-Saeng Suh

Oak Ridge National Laboratory

Presenters



Joongheon Kim

Korea University



Saesun Kim

Sygaldry Technologies



Seung-Wook Baek

National Research Foundation of Korea



Doyeol Ahn

Singularity Quantum Inc. & University of Seoul



Sean Oh

PsiQuantum

This forum provides a platform to discuss current research trends and challenges in quantum and AI applications, a rapidly evolving field at the intersection of quantum computing and artificial intelligence.

Time	Title and Speaker
1:00 - 1:02 pm	**Opening Remarks**
1:02 - 1:17 pm	**National Quantum Strategy and Program** Seung-Wook Baek (National Research Foundation of Korea)
1:17 - 1:32 pm	**Quantum AI and Software: Current Status and Future Trends** Joongheon Kim (Korea University)
1:32- 1:47 pm	**Quantum Computing and Computational Fluid Dynamics for Precision Medicine** Doyeol (David) Ahn (Singularity Quantum, University of Seoul)
1:47 - 2:02 pm	**AI-driven Distributed QAOA for Materials Science** In-saeng Suh (Oak Ridge National Laboratory)
2:02 - 2:17 pm	**Fault-Tolerant Quantum Computing for Commercial Impact** Sean Oh (PsiQuantum)
2:17 - 2:32 pm	**Quantum and AI: Asking the Right Question** Saesun Kim (Sygaldry Technologies)
2:32 - 2:57 pm	**Panel Discussion: Quantum Application Research and Korea-US Collaboration** In-saeng Suh (Oak Ridge National Laboratory)
2:57 - 3:00 pm	**Closing Remarks & Photo Session**

TIPA Distinguished Forum on Industry-Academic International Collaboration

TIPA Forum

Thursday, August 6 1:00 - 3:00pm Colonial A

Korea Technology and Information Promotion Agency for SMEs

Chair



Martin Jun

Purdue University

Co-Chair



Hoon Bae Lee

TIPA US Office

Speakers



Keely DeGroot

NeoCity



Sangkee Min

University of Wisconsin



Manyeol Han

Embassy of Korea

This Distinguished Forum, sponsored by the Korea Technology and Information Promotion Agency (TIPA), brings together internationally recognized scholars and researchers to highlight innovative research and foster collaboration between the United States and Korea.

Presenters



Sooyeon Jeong

Purdue University



Huai-Rhin Kim

Purdue University



Garam Kim

Purdue University



Sunghwan Lee

Purdue University

The forum features invited presentations from leading experts alongside presentations by researchers who are currently conducting TIPA-funded projects, providing participants with a unique opportunity to learn about both emerging research directions and ongoing collaborative initiatives. By showcasing cutting-edge research across disciplines, the forum aims to promote the exchange of ideas, strengthen international research partnerships, and inspire future collaborations that advance scientific discovery, technological innovation, and global competitiveness.

Time	Title and Speaker
1:00 - 1:05 pm	**Welcome Remarks** Martin Jun (Purdue University)
1:05 - 1:15 pm	**Welcome Remark and TIPA Introduction** Hoonbae Lee (TIPA)
1:15 - 1:35 pm	**Keynote Speech: Plug and Play Semiconductors: The NeoCity Model for Rapid Innovation** Keely DeGroot (NeoCity)
1:35 - 1:55 pm	**Keynote Speech: Defense Opportunity and Risk in US for Korean Companies** Sangkee Min (University of Wisconsin-Madison)
1:55 - 2:15 pm	**Keynote Speech: Intellectual Property (IP) Management in Korea-U.S. Joint Research** Manyeol Han (Embassy of the Republic of Korea in the USA)
2:15- 2:20 pm	**Q&A Session**
2:20 - 2:35 pm	**TIPA Project Presentation: Development of a Socially Assistive Robot (SAR) for Korean language and cultural learning as a second language** Sooyeon Jeong and Huai-Rhin Kim (Purdue University)
2:35 - 2:45 pm	**TIPA Project Presentation: Development of composite additive manufacturing process and AI-based intelligent twin systems** Garam Kim (Purdue University)
2:45 - 2:55 pm	**TIPA Project Presentation: Development of current collector primer for dry electrode process in rechargeable batteries** Sunghwan Lee (Purdue University)
2:55 - 4:00 pm	**Q&A Session**

Sponsor Forums

KEIT Forum

KEIT GATC Funding Opportunities for Global R&D Collaboration

Thursday, Aug 6 3:15 am - 5:00pm Colonial A

Chairs



Yonggon Cho

Director General of KEIT



Yong Kyu Yoon

President of KSEA

Presenter



KyeongChan Moon

Senior Researcher of KEIT

This session provides an overview of the Global Advanced Technology Center (GATC) Program, including its funding opportunities, collaboration framework, and participation process for U.S. researchers and organizations. It also offers an opportunity to discuss the research interests, collaboration needs, and potential participation of U.S. researchers, fostering meaningful dialogue toward future joint R&D collaboration.

- KEIT : Korea Planning & Evaluation Institute of Industrial Technology
- KSEA : Korean-American Scientists and Engineers Association

Co-Chairs



Joseph Kim

Vice President 2 of KSEA



Sangyoon Han

Professor, Michigan Technological University



Jaekeun Kim

Director of KEIT US Boston Office



Gihwan Nam

Director of KEIT US Silicon Valley Office

Time	Title and Speaker
3:15 - 3:20	**Welcoming Remarks** Yonggon Cho (Director General, KEIT)
3:20 - 3:25	**Welcoming Remarks** Yong Kyu Yoon (President, KSEA)
3:25 - 3:35	**Introduction to the GATC Program** Kyeongchan Moon (Senior Researcher of KEIT)
3:35 - 4:25	**Brief Presentations on Korean Companies' Technology Needs for GATC Proposals** • Development of 800VDC-1VDC Power Conversion System and WBG-Based High-Speed Switching Power Semiconductor Technology for AI Data Servers (DONGYANG E&P) • Development of AI-based, world-class building materials for carbon-neutral and sustainable construction (SILKROAD C&T) • Development of a 50 kW-Class Wireless Power Transfer System for Electric Vehicles and a Wireless Charging Infrastructure Management System (Korea Testing Certification Institute) • AI BMS Semiconductor Development for Battery Safety Diagnosis in SDV Based EVs (Airpoint co., Ltd.) • Development of AI-Based Integrated Operation Technologies for Autonomous Firefighting Robots in Fire and Disaster Response (Korea Fire Protection UBIS Co., Ltd)
4:25 - 5:00	**Technology Exchange and Partnership Meetings between Korean Companies and US Researcher**

Overview of Korean Companies and Their Technology Needs

Please find below an overview of the participating companies and their technology needs for your reference.

Company	Core Technologies	Technology Need	R&D goal
DONG YANG EnP	Analog and digital power control, high-capacity power conversion, power supply manufacturing	800VDC-to-1VDC power conversion and WBG-based high-speed switching technologies for AI data servers	• Develop an 800VDC-to-1VDC power conversion system • Apply high-speed WBG switching technology • Improve power efficiency, density, and reliability
SILKROAD C&T	Development of advanced precision chemical materials for construction safety and achieving a carbon-neutral society	Development of AI-based, world-class building materials for carbon-neutral and sustainable construction	• Develop a viscosity-reducing admixture • Develop a segregation-reducing admixture • Enable low-carbon and sustainable concrete
Korea Testing Certification institute	Test and Certification, R&D for standards, about EV Charger-Management system, Wireless Power, Power Supply	Development of a 50 kW-Class Wireless Power Transfer System for Electric Vehicles and a Wireless Charging Infrastructure Management System	• Develop a 50 kW wireless power receiver • Develop a 50 kW transmitter and power conversion system • Demonstrate a wireless charging management platform
Airpoint co., Ltd.	AI Based Battery Management System (BMS) Algorithm & System Semiconductor Development	AI BMS Semiconductor Development for Battery Safety Diagnosis in SDV Based EVs	• Develop AI-based BMS algorithms • Develop a BMS system semiconductor • Enable real-time battery safety diagnosis
Korea Fire Protection UBIS Co., Ltd	Fire & Disaster Safety Engineering, AI-based Disaster Safety Technologies, Digital Twin & Simulation, Fire Safety Big Data, and Disaster Response Technologies	Development of AI-Based Integrated Operation Technologies for Autonomous Firefighting Robots in Fire and Disaster Response	• Develop autonomous firefighting robot technologies • Integrate AI-based operation and control technologies • Establish an operational framework for Korea's firefighting environments and efficiency of disaster response.

NST Forum

Forum Name: Roundtable on Strengthening Collaboration between Korea GRIs and US public research organizations

Thursday, Aug 6 3:15 am - 5:00pm Congressional B

nst National Research Council of Science & Technology

Moderator



Jinhwan Lee

NST

Speakers



Young Jong Lee

NIST



Chang-Yong Nam

BNL



Seongsin Margaret Kim

NSF

Panels



Sun Kyu Park

KICT



Yeongkook Oh

KFE



Chang-Hoon Lee

KIMS

- BNL - Brookhaven National Laboratory
- KFE - Korea Institute of Fusion Energy
- KICT- Korea Institute of Civil Engineering and Building Technology
- KIMS - Korea Institute of Materials Science
- NIST -National Institute of Standards and Technology
- NSF - U.S. National Science Foundation
- NST - National Research Council of Science and Technology

This roundtable will bring together Korea Government-funded Research Institute(GRI) leaders and KSEA researchers to explore strategies for strengthening Korea-US collaboration among science and technology research institutions. This discussion focuses on developing practical research cooperation models that benefit both countries amid global technological competition, as well as sharing lessons learned from their collaboration experiences.

There are two talking points.

1. What are the key issues that Korea GRIs encounter when pursuing collaboration with U.S. research institutions, and what strategies can be adopted to address them?
2. How can Korea GRIs leverage the KSEA and/or Korean scientists and engineers in the United States to strengthen strategic research collaboration between Korea and the United States.

Time	Title and Speaker
3:15 - 3:20	**Introduction and Welcoming Remarks**
3:20 - 3:35	**Cooperation with NIST** Young Jong Lee (NIST)
3:35 - 3:50	**Cooperation with National Laboratories** Chang-Yong Nam (BNL)
3:50 - 4:05	**Cooperation with NSF** Seongsin Margaret Kim (NSF)
4:05 - 4:50	**Discussion**
4:50 - 5:00	**Concluding Remarks and Photo**

KIAT K-TAG Forum

K-TAG Steering Committee

Thursday, Aug 6 3:15 pm - 5:00pm Oakmont B

Host



Hwan Il Yoo

Chief Representative of KIAT US office

Chair



Jong Yun Park

Moffitt Cancer Center/University of South Florida



Jungkwun Kim

University of North Texas



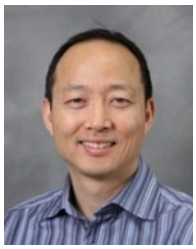
Sunkyu Park

North Carolina State University



Woo Hyoung Lee

University of Central Florida



Byung-Guk (Martin) Jun

Purdue University



Tae (Tom) Oh

Rochester Institute of Technology



Donghoon Yoon

University of Arkansas for Medical Sciences

Founded in 2014, K-TAG USA (Korea-Technology Advisory Group) is a professional organization dedicated to strengthening U.S.–Korea collaboration in technology and innovation. The K-TAG Steering Committee serves as the organization's governing body, providing strategic direction and overseeing major initiatives. During the UKC, the committee will review ongoing activities, discuss future priorities, and identify opportunities to expand collaboration among academia, industry, and government. The meeting will help shape K-TAG's long-term vision and enhance its impact on the Korean-American science and engineering community.

Time	Title and Speaker
3:15 - 3:20	**Welcome Remarks** Yong Kyu Yoon (President, KSEA)
3:20 - 3:40	**Overview of K-TAG USA: History, Mission, and Current Activities**
3:40 - 4:20	**Review of Recent Programs and Accomplishments**
4:20 - 4:45	**Discussion of Strategic Priorities and Future Initiatives**
4:45 - 4:50	**Closing Remarks**

Seoul National University (SNU) Forum

Innovate with SNU, Reinvent the Future

Friday, Aug 7 10:15 am - 12:00pm ChampionsGate

서 울 대 학 교
SEOUL NATIONAL UNIVERSITY

Chair



Ju Han Kim

Executive Vice President for Research Affairs
SNU

Presenters



Sung Jae Kim

Vice Dean of Pubilc Affairs, College of Engineering
SNU



Hong-Gyu Park

Vice Chair for Department of Physics and Astronomy
SNU



Junsuk Kang

Director for Specialized Graduate School of Intelligent Eco-Science
SNU

Seoul National University continues to lead in advanced research, technological innovation, and global collaboration, creating new value for the future. Under the theme "***Innovate with SNU, Reinvent the Future,***" this year's forum will open with welcoming remarks by the Executive Vice President for Research Affairs and feature presentations by distinguished faculty representing SNU's strengths in engineering, photonics, and AI-driven green infrastructure. The forum will highlight forward-looking perspectives on future-shaping engineering, next-generation photonics technologies, and sustainable innovation connecting research, startups, and society. The forum will offer participants an opportunity to explore SNU's vision for interdisciplinary innovation, engage in meaningful global dialogue, and identify new possibilities for impactful research collaboration and partnership.

Time	Title and Speaker
10:15 - 10:30	**Welcoming Remarks** Ju Han Kim (Seoul National University)
10:30 - 10:50	**SNU Engineering toward Future-Shaping Innovators** Sung Jae Kim (Seoul National University)
10:50 - 11:10	**Advancing Photonics for Future Technologies** Hong-Gyu Park (Seoul National University)
11:10 - 11:30	**From Intelligence to Impact: AI Green Infrastructure across Research, Startups, and Society** Junsuk Kang (Seoul National University)
11:30 - 11:50	**Open Discussion**
11:50 - 12:00	**Concluding Remarks and Photo**

Sookmyung Women's University Forum

Proud Sookmyung, Beyond 120; Future Research at Sookmyung Women's University

Friday, Aug 7 10:15 am - 12:00 pm Colonial B

숙명여자대학교
SOOKMYUNG WOMEN'S UNIVERSITY

Chair



Si Yeun Moon

President of Sookmyung Women's University (SMWU)

Co-Chair



Hye On Yoon

President of WISET

Celebrating its 120th anniversary in 2026, Sookmyung Women's University has long served as a premier institution for fostering female leaders. Building upon this legacy, Sookmyung now declares its "***Third Founding***"—a strategic leap forward. Anchored in its 120-year identity as Korea's first private women's university, Sookmyung aims to strengthen its position as a leading global institution. Through the Korean Wave (Hallyu) as a converging platform for technology and the humanities, the university plans to expand its educational and research horizons while establishing itself as a hub for international exchange.

Featuring President Si Yeun Moon, this forum serves as a collaborative platform to share Sookmyung's future vision and highlight cutting-edge research in pharmacy, life sciences, and women's health, co-hosted by the Research Institute of Pharmaceutical Sciences and the Research Institute of Women's Health.

Presenters



Ho Sun Lim

Dean of Research Affairs, SMWU



Chang-Young Jang

Director of Research Institute of Pharmaceutical Sciences, SMWU



Young Yang

Director of Research Institute of Women's Health, SMWU



Jun Dong Park

Professor of Department of Chemical and Biological Engineering, SMWU

Notably, the President of WISET will emphasize the importance of cultivating global female talent in STEM through strategic partnerships with Sookmyung. The forum will conclude with a brief introduction of key strategic research areas, followed by a Q&A session on recruiting outstanding researchers and fostering joint research initiatives.

Time	Title and Speaker
10:15 - 10:30	**Welcoming Remarks** Si Yeun Moon, President, Sookmyung Women's University (SMWU), Hye On Yoon, President, Korea Foundation for Women in Science, Engineering andTechnology (WISET)
10:30 - 10:45	**Proud Sookmyung, Beyond 120 – SMWU's 120 Year-Long Endeavor** Ho Sun Lim (Sookmyung Women's University)
10:45 - 11:00	**Drug Development for Healthy Aging in Research Institute of Pharmaceutical Sciences** Chang-Young Jang (Sookmyung Women's University)
11:00 - 11:15	**History and Milestones of the Research Institute of Women's Health, SMWU** Young Yang (Sookmyung Women's University)
11:15 - 11:30	**Sookmyung's 10 Years of Fostering Female Engineering Talent and Challenges for the Next 10 Years** Jun Dong Park (Sookmyung Women's University)
11:30 - 11:45	**Q&A**
11:45 - 12:00	**Concluding Remarks/Photo Session**

GNU Forum

Designing Researchers' Next Careers at GNU

Friday, Aug 7 10:15 am - 12:00pm Royal Melbourne

경상국립대학교
GYEONGSANG NATIONAL UNIVERSITY

Host	Chair	Presenters	
			
Eun-Suk Seo Professor, University of Maryland College Park	**Seok-Jun Buu** Glocal University Project Group, GNU	**Ki-Hwan Kim** GADIST, GNU	**Tae-Hoon Kim** Dept. of Design & Business, GNU

Under the single message "***Designing your next career at GNU***," this forum invites Korean-American early-career researchers in aerospace and defense, artificial intelligence, advanced materials, and all academic fields to explore their next career at Gyeongsang National University (GNU).

- The forum presents GNU's research and education environment, the Glocal University Project, and GADIST research achievements, concluding with concrete pathways to join GNU.
- Interest formed at the forum continues through GNU's promotion booth and networking during the three days of the conference (Aug. 5 to 7), and is followed up with recruitment and exchange procedures after the delegation returns to Korea.

Time	Title and Speaker
10:15 - 10:25	**Welcoming Remarks** Eun-Suk Seo (University of Maryland)
10:25 - 10:45	**Introduction to GNU and the Glocal University Project** Seok-Jun Buu (Deputy Director, Glocal University Project Group, GNU)
10:45 - 11:05	**Research Achievements of GADIST Research Centers** Ki-Hwan Kim (Deputy Director of GADIST, School of Materials Science and Engineering, GNU)
11:05 - 11:25	**GNU's Research and Education Strategy in Computing and AI** Seok-Jun Buu (Dept. of AI and Computer Engineering, GNU)
11:25 - 11:45	**Interdisciplinary Research Bridging AI, Design, and Engineering** Tae-Hoon Kim (Dept. of Design and Business, GNU)
11:45 - 12:00	**Closing Remarks** (Chair)

• GNU : Gyeongsang National University

• GADIST : Gyeongnam Aerospace & Defense Institute of Science and Technology

RDA Forum

Renewable Energy and Environmental Sustainability in Agriculture

Friday, Aug 7 10:15 am - 12:00pm Augusta B

농촌진흥청 Rural Development Administration

Chair



Sung Woo Kim

North Carolina State University
Raleigh, NC

Co-Chair



Kuk-Hwan Seol

Rural Development Administration

Presenter

- **Jin Kyung Kwon** Research Scientist, National Institute of Agricultural Sciences, RDA
- **Sung Woo Kim** WNR Distinguished Professor, North Carolina State University
- **Chung Geon Lee** Research Scientist, National Institute of Agricultural Sciences, RDA
- **Adegbola Adesogan** Associate Vice President and Director of Department of Animal Sciences, University of Florida

This forum brings together researchers from South Korea and the United States to address challenges from the instability of energy prices. Participants will share recent trends in agricultural renewable energy and collaborate on practical energy-saving technologies. Through this bi-national exchange, the session aims to develop sustainable, climate-smart solutions that secure the future of global farming.

Time	Title and Speaker
10:15 - 10:20	**Welcoming Remarks** Sung Woo Kim (North Carolina State University)
10:20 - 10:30	**Introduction of NAS, RDA** Je Hoon Sung (Director General, National Institute of Agricultural Sciences, Rural Development Administration)
10:30 - 10:45	**Current Status of Energy Efficiency Technology Development in Agriculture** Jin Kyung Kwon (Research Scientist, National Institute of Agricultural Sciences, RDA)
10:45 - 11:00	**N circulation for sustainable animal agriculture through crop and feed management strategies** Sung Woo Kim (North Carolina State University)
11:00 - 11:15	**Research Trends in the Utilization of New and Renewable Energy in Agriculture** Chung Geon Lee (National Institute of Agricultural Sciences, RDA)
11:15 - 11:30	**Leveraging Integrated AI, agriculture, and global partnerships for resilient food systems: A UF/IFAS GFSI collaboration framework** Adegbola Adesogan (University of Florida)
11:30 - 11:55	**Discussion**
11:55 - 12:00	**Closing** Kuk-Hwan Seol (Rural Development Administration)

KHIDI Forum

Korea-U.S Advanced Bio & Health, and Physician-Scientist Collaboration

Friday, Aug 7 10:15 am - 12:00pm Congressional B

KHIDI 한국보건산업진흥원 Korea Health Industry Development Institute

Chair



Min Suk Kang

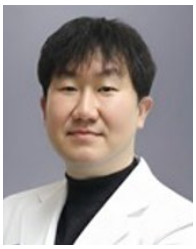
Columbia University Medical Center

Presenter



Hyunchul Kim

KHIDI USA



Jae Sang Oh

The Catholic University

This forum convened leading medical professionals, policy makers, and biotechnologists to discuss the next frontier of bilateral research cooperation between South Korea and the United States. The event highlighted institutional frameworks for nurturing physician-scientists, showcased breakthrough researcher presentations, and introduced the newly launched Advanced Bio & Health Strategic Hub in Boston, Massachusetts.



Hwo yeon Seo

KAIST Graduate School of Future Strategy



Albert Kim

University of South Florida



Donghoon Yoon

University of Arkansas for Medical Sciences



Jeung Yoong Bae

KIC Silicon Valley

Time		Title and Speaker
10:15 - 10:20		**Opening** Min Suk Kang (Columbia University Medical Center)
10:20 - 10:25		**Welcoming Remarks** Hyunchul Kim (KHIDI, USA)
Session 1. Korea-US Researcher Training	10:25 - 10:35	**Introduction of the Korea Physician Scientists Training Project** Hyunchul Kim (KHIDI USA)
	10:35 - 10:50	**Translational Research from Clinic to Bench as a Surgeon-Scientist** Jae Sang Oh (The Catholic University)
	10:50 - 11:05	**Connecting Dots** Hwo yeon Seo (KAIST Graduate School of Future Strategy)
Session 2. Advanced Bio & Health Strategic Hub	11:05 - 11:15	**Introduction of Advanced Bio & Health Strategic Hub** Hyunchul Kim (KHIDI USA)
	11:15 - 11:45	**Panel Discussion - Fostering Korea-U.S. Bio & Health Innovation: The Role of the Advanced Bio & Health Strategic Hub** Albert Kim (University of South Florida), Donghoon Yoon (University of Arkansas for Medical Sciences), Jeung Yoong Bae (KIC Silicon Valley)
11:45 - 11:55		**Q &A**
11:55 - 12:00		**Closing & Photo Session**

KIAT, KEIT, KETEP Forum

Introduction to Korea-US Industrial Technology Cooperation Program Session

Friday, Aug 7 10:15 am - 12:00pm Colonial A

Host



Hwan Il Yoo

Chief Representative of KIAT US office

Chair



Jungkwun Kim

University of North Texas

Presenters



Sunglook Sue

KETEP US



Woo Hyoung Lee

University of Central Florida



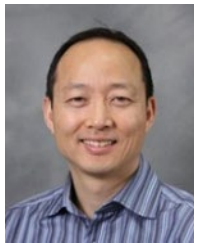
Woon-Hong Yeo

Georgia Institute of Technology



Deok-Ho Kim

Johns Hopkins University



Byung-Guk(Martin) Jun

Purdue University



Jae Keun Kim

Director of KEIT US Boston Office



Gihwan Nam

Director of KEIT US Silicon Valley Office



JinWhee Chung

Program Director (PD) of KEIT

KIAT, KEIT, KETEP will introduce the Industrial Cooperation Programs of the Ministry of Trade, Industry and Resources. The session will highlight key objectives, areas of support, and opportunities for international collaboration between Korea and USA. Participants will also have the chance to discuss program details directly with the presenters. It is designed to provide practical information for organizations and researchers interested in engaging in bilateral industrial cooperation.

Time		Title and Speaker
10:15 - 10:20		**Welcome Remarks** Yong Kyu Yoon (President, KSEA)
KIAT/KETEP	10:20 - 10:40	**Introduction of Korea-US Industrial Technology Cooperation Program (KIAT)** **Korea-North America Joint R&D on Energy (Korea Institute of Energy Technology Evaluation and Planning, KETEP)**
	10:40 - 11:20	**Case Studies** • **GITCC : Purdue, Johns Hopkins, Georgia Tech** • **K-TAG: AI-Based FlocFinder Technology Enhancement and International R&D Planning** Woo Hyoung Lee (University of Central Florida)
KEIT	11:20 - 11:30	**KEIT Global Open Innovation: Strategies and Funding Opportunities** Jaekeun Kim (KEIT)
	11:30 - 11:50	**Strengthening the Global Competitiveness of Korea's Defense Industry through R&D Support** JinWhee Chung (KEIT Defense Industry Program Director)
11:50 - 12:00		**Discussion, Q&A Session**

CKU & KNU Forum

Empowering Regional Innovation through AI, Sustainability, and Industry-Academia Collaboration

Friday, Aug 7 10:15 am - 12:00pm Congressional A

가톨릭관동대학교 CATHOLIC KWANDONG UNIVERSITY
KNU 강원대학교 KANGWON NATIONAL UNIVERSITY

Chair



Kyu Han Kim

Director, ANCHOR Initiative
Catholic Kwandong University (CKU)

Co-Chair



Dae Hee Lee

Director, ANCHOR Initiative
Kangwon National University (KNU)



Joo Hyong Noh

Professor,
Kanto Gakuin University
(KGU)



Bum Shick Shin

Professor
Catholic Kwandong University
(CKU)

Presenters



Jae Hyun Jo

Assistant Professor
Catholic Kwandong University
(CKU)



Kyu Tae Shim

Senior Researcher
Waterfront and Coastal Research Center(CKU)



EunSu Lee

Professor
New Jersey City University
(NJCU)

The ANCHOR Initiative is one of Korea's flagship regional innovation programs jointly promoted by the Ministry of Education and local governments to foster regional talent, strengthen university-industry collaboration, and drive sustainable regional development.

This forum represents the first collaborative achievement between Catholic Kwandong University (CKU) and Kangwon National University (KNU) under the ANCHOR Initiative. It provides a platform to share outstanding research outcomes and discuss future collaborative projects that will further advance regional innovation.
Centered on strategic research themes including Biohealth, Food Technology, Climate Change, Marine Energy, Future Energy, and Future Mobility, the forum highlights how universities can contribute to solving regional challenges while cultivating globally competitive talent.

Furthermore, CKU and KNU envision building an AI-powered advanced education ecosystem that integrates research, innovation, entrepreneurship, and digital learning to establish Gangwon as a leading hub for sustainable regional growth and global collaboration.

The forum will conclude with an open discussion on expanding international partnerships and developing next-generation collaborative projects through the ANCHOR Initiative.

Time	Title and Speaker
10:15 - 10:20	**Opening Remarks** Kyuhan Kim (Catholic Kwandong University) & Daehee Lee (Kangwon National University)
10:20 - 10:30	**A Vision for Achieving RE100 through Coastal Data Center Development and Marine Energy Utilization** Kyu Han Kim (Executive Director, ANCHOR Project, Catholic Kwandong University)
10:30 - 10:40	**The Role of the ANCHOR Project in Supporting Sustainable Partnerships Between Regional Universities and Their Communities** Dae-Hee Lee (Executive Director, ANCHOR Project, Kangwon National University
10:40 - 10:50	**Development of an Ultrafine Soybean Powder Processing Method for Functional Nutritional Foods** Kyutae Shim (Senior Researcher, Waterfront and Coastal Research Center)
10:50 - 11:00	**Gangneung City's Carbon Neutrality Plan and Vision for Climate Change Response** Bum-Shick Shin (Professor, Department of Smart Port Engineering, Trinity College, Catholic Kwandong University)
11:00 - 11:10	**Applicability of Both-Sided Flash Lamp Annealing (FLA) Method on Heat Treatment Cu Plating Thin Film and Low Dielectric Resin Films** Joo Hyong Noh (Professor, Kanto Gakuin University, Surface and Material Research Institute)
11:10 - 11:20	**AI Reading Behavior and Responses Simultaneously: A Study on an MMSE-Based Multimodal Mental Health Prediction Model** Jae Hyun Jo (Assistant Professor, Department of Digital Health Engineering, Trinity College, Catholic Kwandong University)
11:20 - 11:30	**A Vision for Port and Logistics Infrastructure on Korea's East Coast for the Arctic Shipping Route** EunSu Lee (Professor and Director of Supply Chain, Maritime Logistics, Analytics, Operations, and Service Management at New Jersey City University)
11:30 - 11:45	**Future Collaboration Discussion and Q&A**
11:55 - 12:00	**Closing Remarks / Group Photo**

Future Tech Forum

Global K-Tech Forum Where K-Content Meets the Future of Technology

Friday, Aug 7 1:00 - 2:30 pm Olympic

ACRYL

Chair



Jung Han

CEO of
K-EnterTech Hub

Presenter



Sam-Seok Ko

Professor
of Dongguk
University

K-Content is shaping global markets. The Global K-Tech Forum, an official session of UKC 2026, explores how K-content is expanding into Entertainment Tech, AI, Deep Tech, and Physical AI, with a focus on strategies for global market growth.

The forum opens with a keynote by Distinguished Professor Sam-Seok Ko, who introduces the concept of co-evolution as a framework for understanding the convergence of content and technology. Korean companies, beginning with Acryl, will present their global expansion strategies, while U.S.-based experts will provide practical perspectives on legal, academic, and media considerations for entering international markets. The forum concludes with a panel discussion designed to connect these insights with opportunities for real-world business collaboration.

Time	Title and Speaker
1:00 - 1:03	**Welcoming Remarks** Jung Han (CEO, K-EnterTech Hub)
1:03 - 1:07	**Welcome Remarks** Yong Kyu Yoon (President, KSEA)
1:07 - 1:10	**SBS Congratulatory Video Message**
1:10 - 1:30	**Co-evolution: AI and the Future of K-Content** Sam-Seok Ko (Distinguished Professor)
1:30 - 1:48	**Acryl — Bringing AI Platform Jonathan and Healthcare Platform Nadia to the Global Market**
1:48 - 2:00	**Ludens Partners — Transforming F&B with Physical AI**
2:00 - 2:08	**Emerging Trends in Entertainment Technology** Jung Han (CEO, K-EnterTech Hub)
2:08 - 2:18	**HelloWorks**
2:18 - 2:28	**Studio Meta-K**
2:28 - 2:58	**Panel Discussion : Taking Korean Startups to the Global Market**
2:58 - 3:00	**Q&A and Closing**

This forum is sponsored by :

YM&COMPANY SBS

Presenting Company lists :

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KSEA Forums

KWiSE-WISET Women in STEM Forum

Thursday, Aug 6 3:15 - 5:00pm Colonial B / Friday, Aug 7 1:00 - 3:00pm Augusta B

Chair



Sungsil Moon

President of KWiSE

Chair



Hye On Yoon

President of WISET

Co-Chair



Sun Mee Kang

President of KOFWST

Co-Chair



Eun Sook Hwang

Vice president of KWSE

Forum Overview

The KWiSE-WISET Women in STEM Forum brings together leading organizations and professionals to exchange ideas on career development, leadership, and the empowerment of women in STEM. This year's forum drives forward-looking discussions on the convergence of future science and technology, highlighting how interdisciplinary collaboration and strategic innovation can expand professional pathways and improve global societal outcomes.

To explore these dynamics, the forum features two distinct, cutting-edge technical sessions led by prominent women scientists and researchers:

- **The KWiSE-KOFWST Forum** will center on the theme, "**Empowering Women in the Age of AI: Breaking Barriers Across Generations**." This session explores global strategies for a sustainable R&D ecosystem, focusing on how generative technologies and cross-generational mentorship can strengthen leadership, mitigate technical biases, and build career resilience for women scientists.
- **The KWiSE-KWSE Forum** will focus on the theme, "**The Future of Healthcare Across the Human Experience.**" This session features insights from researchers across diverse fields examining precision medicine, big data, and technology to address human health as a continuous, dynamic, and lifelong journey.

Key Highlights & Awards

- **Celebrating Excellence**: This year, the forum will proudly honor exceptional achievements with the **KWiSE Outstanding Women Scientist and Leadership Award**.
- **Nurturing Next-Gen Talent**: The forum will recognize emerging talent with the **Young Scientist Award** for outstanding participation in the KWiSE-WISET Global Mentoring program.
- We invite all interested participants to join us for insightful discussions, networking opportunities, and the celebration of achievements in the STEM community.

KWiSE-WISET Women in STEM 1 - KWiSE- KOFWST Forum

Empowering Women in the Age of AI: Breaking Barriers Across Generations

Thursday, Aug 6 3:15 - 5:00pm Colonial B Moderator : Hyunsook Park (California State University LA)

Time	Title and Speaker
3:15 - 3:20 pm	**Opening Remarks** Sung-Sil Moon (KWiSE President)
3:20 - 3:30 pm	**Welcoming Remarks** Hye On Yoon (WISET President)
3:30 - 3:40 pm	**Welcoming Remarks** Sun Mee Kang (KOFWST President)
3:40 - 3:45 pm	**Welcoming Remarks** Si Yeun Moon (Sookmyung Women's University President)
3:45 - 4:00 pm	**KWiSE-WISET Global Mentoring Award Ceremony**
	KWiSE-KOFWST Session
4:00 - 4:10 pm	**Session topic and speaker introduction** Hyunsook Park (KWiSE)
4:10 - 4:55 pm	**Paner Discussion** Dr. Hyunjung Kim (Sogang University) Dr. Ohbong Kwon (New York City College of Technology, President elected KSEA) Dr. Jae-Kyung Lee (University of Georgia) Dr. Dabae Lee (Kennesaw University) Dr. Youbin Kim (Icahn School of Medicine at Mount Sinai) Dr. Su Hyun Lee (St. Jude Children's Hospital) Ms. Namhee Lee (University of Georgia)
4:55 - 5:00 pm	**Closing Remarks/ Photo Session**

KWiSE-WISET Women in STEM 2 - KWiSE-KWSE Forum

The Future of Healthcare Across the Human Experience

Friday, Aug 7 1:00 - 3:00pm Augusta B Moderator : Youbin Kim (Icahn School of Medicine at Mount Sinai)

Time	Title and Speaker
1:00 - 1:05 pm	**Opening Remarks** Sung-Sil Moon (KWiSE President)
1:05 - 1:15 pm	**Welcoming Remarks** Eun Sook Hwang (KWSE Vice President)
1:15 - 1:30 pm	**KWiSE Outstanding Women Scientist Award Ceremony**
	KWiSE-KWSE Forum
1:30 - 1:50 pm	**From Cradle to Grave: Data Science for Women's Health Across the Life Course** Mikyong Shin (KWiSE Southeastern Chapter)
1:50 - 2:10 pm	**Modulation of stress-induced steroidogenesis** Eun Sook Hwang (Ewha Womans University)
2:10 - 2:30 pm	**Environmental Risk Factors in Pregnancy: Implications for Maternal and Fetal Health** Bo Young Park (California State University Fullerton)
2:30 - 2:50 pm	**Precision Sleep Health for Chronic Disease Prevention** Ji-Eun Park (Korea Institute of Oriental Medicine)
2:50 - 3:00 pm	**Closing Remarks/ Photo Session**

KSEA Joint Science Policy and Diplomacy Forum

Thursday, August 6 3:15 - 5:00pm Olympic

Co-Chairs



Jaehoon Yu

Professor
University of Texas
Arlington



Un-Ki Yang

Professor
Seoul National
University

Presenters and Panelists



Inkyu Park

Vice Minister,
MSIT



William Phillips

Fellow, NIST
Professor, Dept. of
Physics, University of
Maryland, Maryland



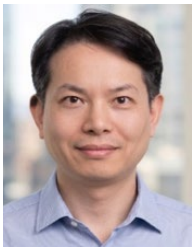
Kyoungl 8im Lee

Director,
Americas and
Asia Cooperation
Division, MSIT



Sowjanya Gollapinni

Senior staff scientist
Los Alamos National
Laboratory
Co-Spokesperson DUNE



Myung Hun Park

Professor, Seoul
National University
of Science and
Technology



Jayhyun Jo

Staff Scientist,
Brookhaven National
Laboratory

Science Policy and Science Diplomacy are intimately intertwined. This year, the joint forum of Science Policy and Science Diplomacy invites the directors of the Advanced Science Computing Research (ASCR) directorate in the U.S. Department of Energy which provides strong support on fundamental sciences, and of the Korean Ministry of Science and IT, together with prominent scientists from each country to serve on the panel.

The two directors will discuss the fundamental approach and the plan of close cooperation between the two countries on Artificial Intelligence (AI) and its roles on the basic science, in particular related to the DOE's Genesis Mission. Science policy must be established to ensure the U.S. and Korea to be a close partner to lead the science diplomacy for the good of the entire humanity in this rapidly changing world of AI.

- Hosting Presidents: Dr. Yong Kyu Yoon (KSEA), Dr. Oh Nam Kwon (KOFST)

Panel Members:

- National Institute of Science and Technology : Dr. William Phillips (Fellow)
- Ministry of Science & ICT, ROK: Dr. KyeongLim Lee (Director, America & Asia Cooperation)
- USA Scientist Expert: Dr. Sowjanya Gollipinni (DUNE Co-spokesperson)
- ROK Scientist Expert: Professor Myung Hun Park (Seoul National Univ. of Science and Technology)
- USA Scientist Expert: Dr. Jayhyun Jo (Brookhaven National Laboratory)

Time	Title and Speaker
3:00 – 3:15 pm	**Meet and Greet** All participants with the Co-chairs
3:15 – 3:25 pm	**Welcoming Remarks** Yong Kyu Yoon (KSEA President) & Oh Nam Kwon (KOFST President)
3:25 – 3:30 pm	**Congratulatory Remark** Inkyu Park (Vice Minister, MSIT, ROK)
3:30 – 3:40 pm	**Participant Photo** All participants
3:40 – 3:50 pm	**Importance and roles of humanity in AI World & of fundamental sciences** William Phillips (1997 Nobel Laureate, NIST, USA)
3:50 – 4:00 pm	**US DOE Genesis Mission and its Roles in Fundamental Sciences** Dr. Sowjanya Gollapinni (Co-Spokesperson, DUNE collaboration, Staff Scientist, Los Alamos National Lab, USA)
4:00 – 4:10 pm	**Pathways to U.S.-Korea Cooperation on Genesis Mission and Fundamental physics** Kyeonglim Lee (Director, Asia-Americas International Cooperation, MSIT, ROK)
4:10 – 4:30 pm	**Scientist Expert Short Statements** Myung-Hun Park (ROK) & Dr. Jayhyun Jo (USA)
4:30 – 4:55 pm	**Panel Discussion and Audience Q&A** Phillips, Lee, Park, Jo and Gollapini – Moderator: Jaehoon Yu
4:55 – 5:00 pm	**Closing** Un-Ki Yang (SNU)

KSEA University Leadership Forum

Navigating the AI Frontier: Transforming University Education, Research, and Administration

Friday, August 7 12:00 - 3:00pm Congressional B

Chair



Yongho Sohn

Pegasus Professor
University of Central Florida (UCF)

Co-Chair



Soyoon Kum

Assistant Professor
Angelo State University (ASU)

Presenters



Stephen M. Kuebler

Professor and
Founding Director of
UCF Center for Ethics



Dong Hwan Kim

President of
Seoul National
University of Science
and Technology

Panelists



Hyang-Sook Lee

President of Ewha
Womans University



Si Yeun Moon

President of
Sookmyung
Women's University



Keechoo Choi

President of
Ajou University



Kunwoo Lee

President of
Daegu Gyeongbuk
Institute of Science
and Technology
(DGIST)



Jin Hwe Kweon

President of
Gyeongsang National
University



Kyeongho Lim

President of Kongju
National University



Seong Taek Yun

Executive Vice
President of
Research
Korea University



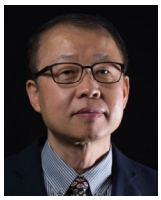
Dong-Hyun Baek

Executive Vice
President of
ERICA, Hanyang
University



Dong Seog Han

Vice President
for Research
of Kyungpook
National University



Hyoung Jin Cho

Professor and Chair
Mechanical and
Aerospace Engineering
University of Central
Florida

Time	Title and Speaker
12:00 - 1:00 pm	**Group Lunch**
1:00 - 1:05 pm	**Welcoming Remarks from Chairs** Yongho Sohn (University of Central Florida) and Soyoon Kum (Angelo State University)
1:05 - 1:25 pm	**AI Leadership and the New Three Rs: Responsibility, Relevance, and Reason** Stephen M. Kuebler (University of Central Florida)
1:25 - 1:35 pm	**From AI Adoption to AI Transformation: Building an AI-Ready University – The Experience of Seoul National University of Science and Technology** Dong Hwan Kim (Seoul National University of Science and Technology - SeoulTech)
1:35 - 2:50 pm	**Panel Discussion**
2:50 - 3:00 pm	**Closing Remarks and Photo Session**

KSEA and KOFST are pleased to host the 9th University Leadership Forum during the 39th US-Korea Conference on Science, Technology and Entrepreneurship (UKC 2026) in Orlando Florida. This forum offers a unique opportunity for university leaders from the United States and Korea to engage in meaningful dialogue on emerging issues in higher education.

Artificial intelligence is rapidly reshaping higher education, presenting universities with both unprecedented opportunities and complex challenges across teaching, research, and administration. This forum brings together university leaders to critically examine how AI is transforming the academic enterprise and to envision responsible pathways forward. AI enables personalized learning, automated assessment, and enhanced accessibility, while raising urgent questions about academic integrity, equity, and pedagogical adaptation. AI accelerates discovery across disciplines, yet concerns around data privacy, authorship attribution, and the integrity of AI-generated outputs demand clear ethical frameworks. AI-powered tools are improving student advising and retention outcomes, though algorithmic bias, data governance, and workforce implications require careful and equitable implementation strategies. Cutting across all domains of university operation are foundational questions of ethics, governance, and institutional strategy that no university can afford to ignore. Through facilitated discussions, university leaders will gain a sharper understanding of AI's transformative impact and concrete ideas for shaping their institution's response to this defining technological moment.

During the panel discussion, university leaders will engage in candid reflection on implementation realities, institutional power, and shared responsibility, addressing six critical considerations:

1. Governing the Ungovernable: How do institutions move from AI principles to enforceable, adaptive governance structures that keep pace with rapidly evolving capabilities?
2. Academic Integrity: Is the answer better detection/policing, or a fundamental reimagining of authentic assessment in an AI-saturated environment?
3. Amplified or Eroded Equity: Who truly benefits from AI-personalized learning, and are historically underserved students being supported or further sorted by algorithmic systems?
4. Research Authorship: How should universities define and enforce disclosure norms across disciplines where AI is now embedded in every stage of scholarship?
5. Global Convergence or Divergence: Should there be an international governing body specifically to regulate the AI in higher education?
6. The Workforce Question: What ethical obligations do universities hold toward staff and faculty whose roles are being redefined or eliminated by automation?

Through facilitated dialogue, participants will leave with actionable strategies and a deeper sense of collective responsibility for shaping higher education's response to this defining technological moment.

KSEA R&D Leadership Forum

Roundtable discussion on Leveraging Frameworks for US-Korea Institutional Research Collaboration

Friday, August 7 12:00 - 3:00 pm Congressional A

Chair



Ohbong Kwon

Associate Professor New York City College of Technology

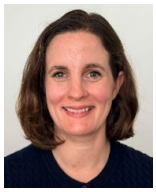
Co-Chair



Tae (Tom) Oh

Professor/Strategic Initiatives and Innovation Director Rochester Institute of Technology

Presenter



Stacey Standridge

Acting Deputy Office Head of National Science Foundation

R&D Leaders from Korea



Kwon, Oh Nam

President of KOFST



Dong Seob Kang

Director General of NRF/KUSCO



Hyunchul (Huey) Kim

President of KHIDI USA



Hwan Il Yoo

Chief Representative of KIAT US office



Taemin Bae

President of KIRD



Hye On Yoon

President of WISET



Yeongkook Oh

President of KFE



Max Chang

US Business Development Manager, LINER



Chang-Jeon Hwang

Vice President of KARI



Ji Woong Yoon

President of Science and Technology Policy Institute



Chang Hoon Lee

Vice President of KIMS

Time	Title and Speaker
1:00 - 1:10	**Welcoming Remarks** Ohbong Kwon (New York City College of Technology)
1:10 - 1:30	**Keynote Talk- Collaboration by Design: Leveraging NSF Programs for Enduring U.S.–Korea Research Partnerships** Stacey Standridge (NSF)
1:30 - 2:50	**Round Discussion and brainstorming with the participating institutes** • Oh Nam Kwon, President, Korean Federation of Science and Technology Societies (KOFST) • Dong Seob Han, Director General, Directorate for International Affairs,, National Research Foundation (NRF) • Hyunchul(Huey) Kim, President of KHIDI USA, Korea Health Industry Development Institute (KHIDI) • Hwan IL Yoo, Chief Representative, Korea Institute for Advancement of Technology (KIAT) US office • Taemin Bae, President, Korea Institute of Human Resources Development in Science and Technology (KIRD) • Hye On Yoon, President, Korea Foundation for Women In Science, Eng. and Technology (WISET) • Yeongkook Oh, President, Korea Institute of Fusion Energy (KFE) • Max Chang, US Business Development Manager, Liner • Chang-Jeon Hwang, Vice President, Korea Aerospace Research Institute (KARI) • Ji Woong Yoon, President, Science and Technology Policy Institute (STEPI) • Chang Hoon Lee, Vice President, Korea Institute of Materials Science (KIMS)
2:50 - 3:00	**Concluding Remarks and Photo session**

- KARI - Korea Aerospace Research Institute
- KFE - Korea Institute of Fusion Energy
- KIAT - Korea Institute for Advancement of Technology
- KIMS - Korea Institute of Materials Science
- KIRD - Korea Institute of Human Resources Development in Science and Technology
- KOFST -The Korean Federation of Science and Technology Societies
- KUSCO - Korea-US Science Cooperation Center
- NRF - National Research Foundation of Korea
- NSF - National Science Foundation
- STEPI - Science and Technology Policy Institute
- WISET - Korea Foundation for Women in Science, Engineering and Technology

The Office of International Science and Engineering (OISE) at the National Science Foundation (NSF) plays a pivotal role in advancing international science diplomacy and global research partnerships. Today, international research collaboration has become an increasingly vital priority for addressing complex global challenges through cross-border synergy.

At this year's KSEA R&D Leadership Forum, we will focus on moving from dialogue to action by exploring how participating organizations and research leaders can leverage existing frameworks and NSF funding opportunities to foster sustainable, mutually beneficial partnerships.

As the keynote speaker, Dr. Stacey Standridge, Acting Deputy Office Head at NSF's OISE, will share insights on NSF's international programs and mechanisms that support U.S.-Korea collaborative research, advance scientific excellence, and strengthen science diplomacy. Following the keynote, the invited participants will engage in a roundtable discussion to exchange best practices and identify practical pathways to deepen future collaboration.

KOFST Next Generation Alumni Forum

Friday, August 7 1:00 - 3:00pm ChampionsGate

Chair



Clara Kim

Medical Impact Lead,
Boehringer Ingelheim

KSEA is proud to host the KOFST Next Generation Alumni Forum at UKC 2026 in Orlando. For over two decades, the Young Generation Forum (YGF) and Young Professional Forum (YPF) have connected young scientists and engineers of Korean heritage from around the world since 2002, building a global community that continues to shape innovation and international collaboration. This year's forum, "***Roots & Reach***," invites alumni to reflect on how their YGF/YPF experience has shaped their paths, and to pass that forward. Through energizing discussion, cross-sector dialogue, and a closing reflective activity, participants will leave with renewed connections, actionable ideas for the KSEA community, and a letter to the next generation of YGF/YPF alumni — bridging the past and future of this enduring program.

Time	Title and Speaker
1:00 - 1:10 pm	**Welcoming Remarks**
1:10 - 1:20 pm	**"*Where Are We Now*?" Lightning Round**
1:20 - 1:40 pm	**Alumni Spotlight: Then vs. Now**
1:40 - 1:50 pm	**Global Citizenship in Practice — Panel + Audience Q&A**
1:50 - 2:10 pm	**Small Group Challenge: "*What Should YGF/YPF Build Next?*"**
2:10 - 2:40 pm	**Letter to a Future YGF/YPF Participant**
2:40 - 3:00 pm	**Closing Remarks + Photo Session**

Scholarship Winners

2026 KSEA - KUSCO Graduate Scholarship Winners



Alice Lee
University of Pittsburgh School of Medicine



Da Hae Choi
Albert Einstein College of Medicine



Dayoung (Gloria) Lee
Columbia University



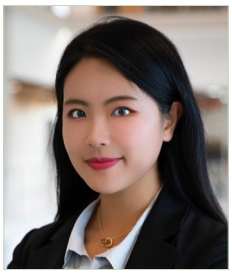
DongHun Ryu
Massachusetts Institute of Technology



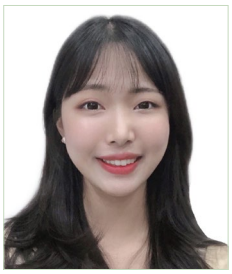
Gyuwan Kim
University of California Santa Barbara



Jeong Hui Kim
Purdue University



Jiin Ryu
University of Florida



Kaeul Lim
Purdue University



Kihoon Yuk
University of Maryland, College Park



Kihyeon Ahn
Virginia Tech



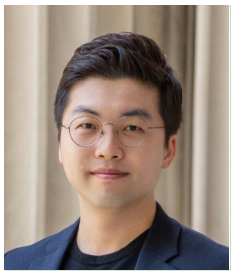
Kyujin Ko
University of Cincinnati



Michael Kim
Johns Hopkins University



Namhee Lee
University of Georgia



Sanghyun Park
Massachusetts Institute of Technology



Soojung Lee
Columbia University



TJ (Tae Joong) Park
Massachusetts Institute of Technology



Uk Jin Lee
Cornell University Weill Cornell Medicine



Ye Eun Koo
Boston University Chobanian & Avedisian School of Medicine



Yeijin Kim
University of Texas at Austin



Yujin Lee
University of Texas at Austin

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KNU 강원대학교 KANGWON NATIONAL UNIVERSITY

경상국립대학교 GYEONGSANG NATIONAL UNIVERSITY

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Liner

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KIMS 한국재료연구원 Korea Institute of Materials Science

KARI 한국항공우주연구원 Korea Aerospace Research Institute

STEPI 과학기술정책연구원 SCIENCE AND TECHNOLOGY POLICY INSTITUTE

KIOST 한국해양과학기술원 KOREA INSTITUTE OF OCEAN SCIENCE & TECHNOLOGY

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KOFST Korean Federation of Science & Technology Societies

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The Korea-U.S. Science Cooperation Center (KUSCO) is a non-profit organization established in Vienna, Virginia, founded in 1997, to accomplish two major missions: to enhance cooperative efforts in S&T between Korea and the U.S. and to support Korean - American scientists & engineers in the United States.



VISION & MISSION

The vision of KUSCO is *"Advancement of the S&T collaborations between Korea and the U.S."*
To realize its vision, KUSCO pursues the mission of becoming a premium center for S&T cooperation and Exchanges by pursuing three goals as follows:

- To strengthen S&T cooperation portfolio between Korea and the U.S.
- To broaden global exchange programs
- To support and leverage Korean-American scientists and engineers

MAJOR ACTIVITIES

- Enhance scientific and technological development of both Korea and the U.S.
- Support mutual cooperation and initiate joint programs with U.S. and Korean scientific and engineering societies, academic universities, and other institutions
- Assess significant trends in scientific research and technological developments affecting Korea and the U.S.
- Assist young Korean-American and other scientists in developing and maintaining networks addressing matters of scientific and technical interest to the two countries



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Seegene Medical Foundation

Seegene Medical Foundation (SMF) established OPEN Healthcare, Inc. (OHC) in July 2023 to expand its leading diagnostic capabilities from Korea to the global stage. SMF and OHC operate diagnostic laboratories, clinics, and health check-up centers in countries including Kazakhstan, the United States, and Vietnam.



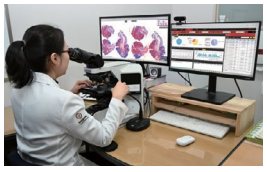
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Conducts tests based on Korea's largest molecular diagnostic testing capability



Develops a next-generation diagnostic testing system based on AI technology



Provides an electronic medical record (EMR) solution, SeeChart & Dr.EMR

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2. **초연결 융합교육**
   Hyper-connected Convergence Education
3. **초격차 응용연구**
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Republic of Korea
농촌진흥청
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VISION
"Smart Science, Vibrant Agriculture, Better Future"
MISSION
Integrating Technology & Sustainability for Agricultural Growth
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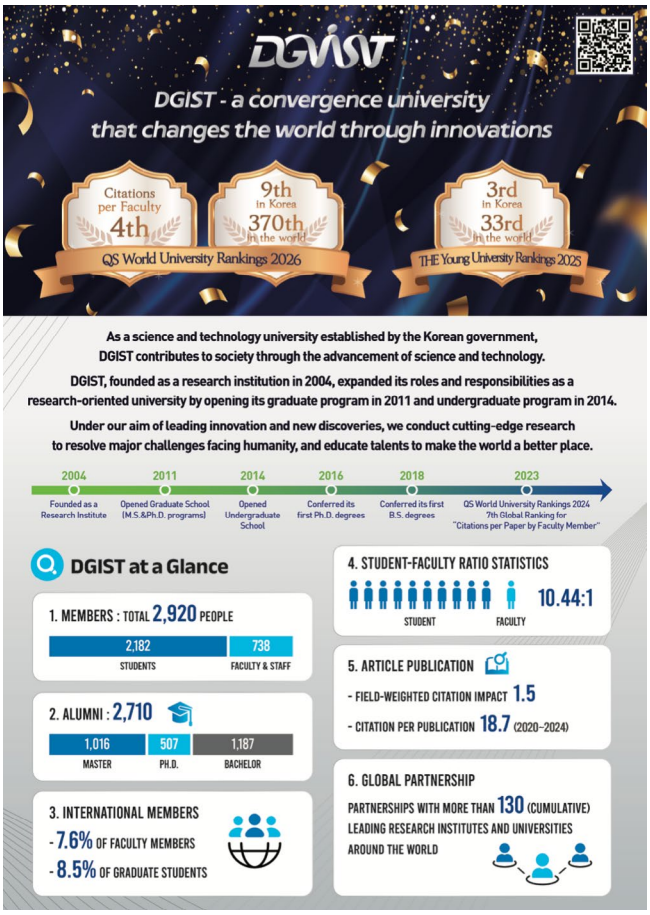

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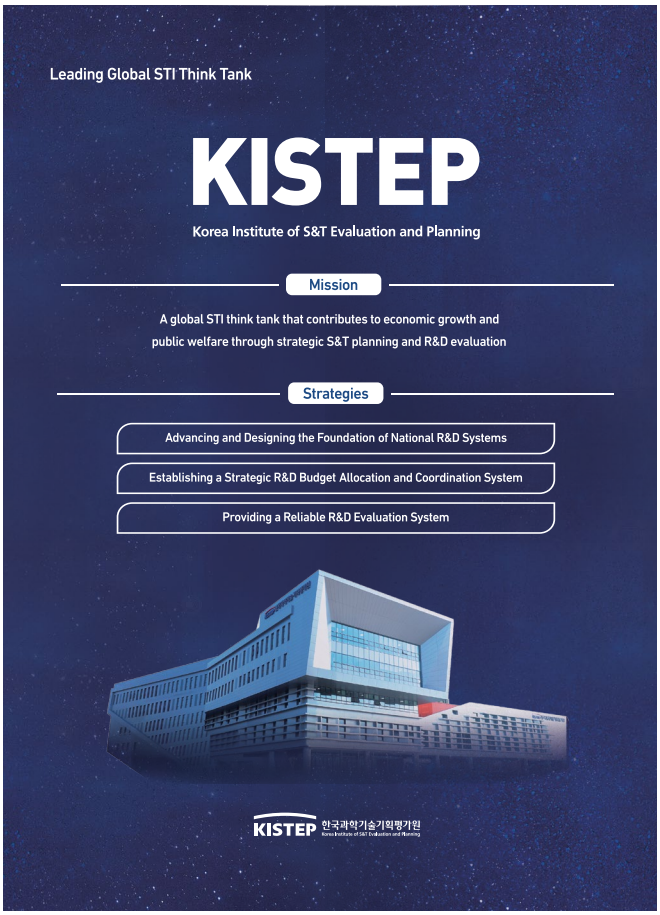

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to resolve major challenges facing humanity, and educate talents to make the world a better place.
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2011 Opened Graduate School (M.S.&Ph.D. programs)
2014 Opened Undergraduate School
2016 Conferred its first Ph.D. degrees
2018 Conferred its first B.S. degrees
2023 QS World University Rankings 2024 7th Global Ranking for "Citations per Paper by Faculty Member"
DGIST at a Glance
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2,182 STUDENTS
738 FACULTY & STAFF
2. ALUMNI : 2,710
1,016 MASTER
507 PH.D.
1,187 BACHELOR
3. INTERNATIONAL MEMBERS
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- 8.5% OF GRADUATE STUDENTS
4. STUDENT-FACULTY RATIO STATISTICS
10.44:1
STUDENT
FACULTY
5. ARTICLE PUBLICATION
- FIELD-WEIGHTED CITATION IMPACT 1.5
- CITATION PER PUBLICATION 18.7 (2020-2024)
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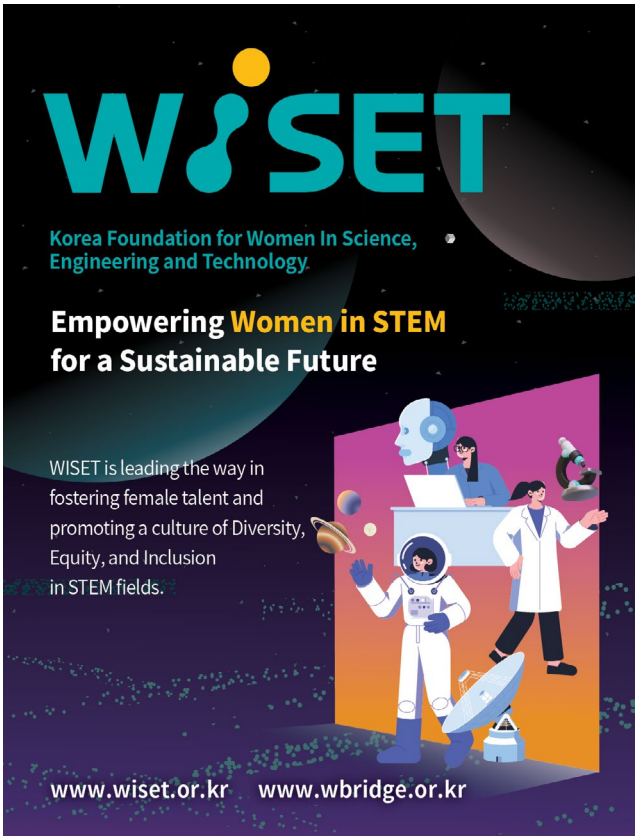

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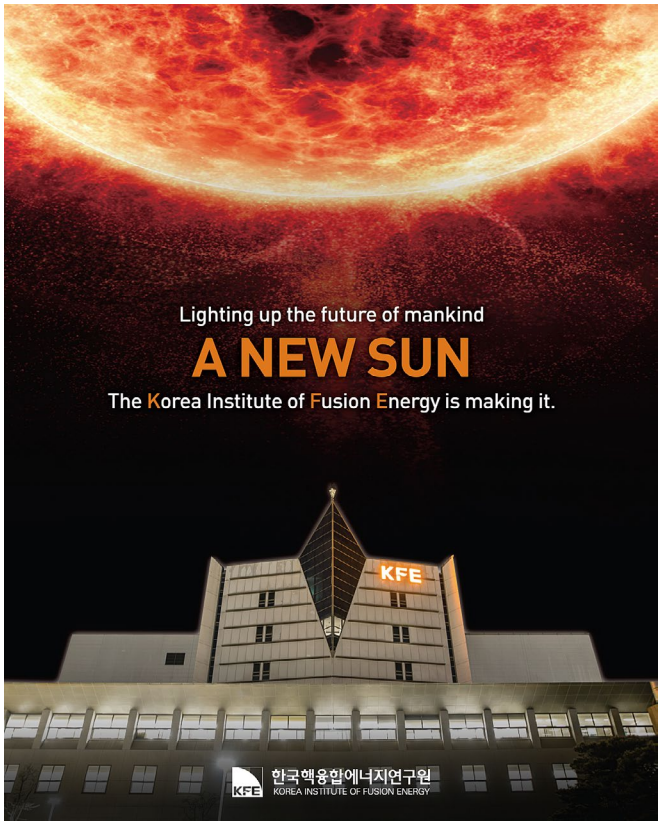

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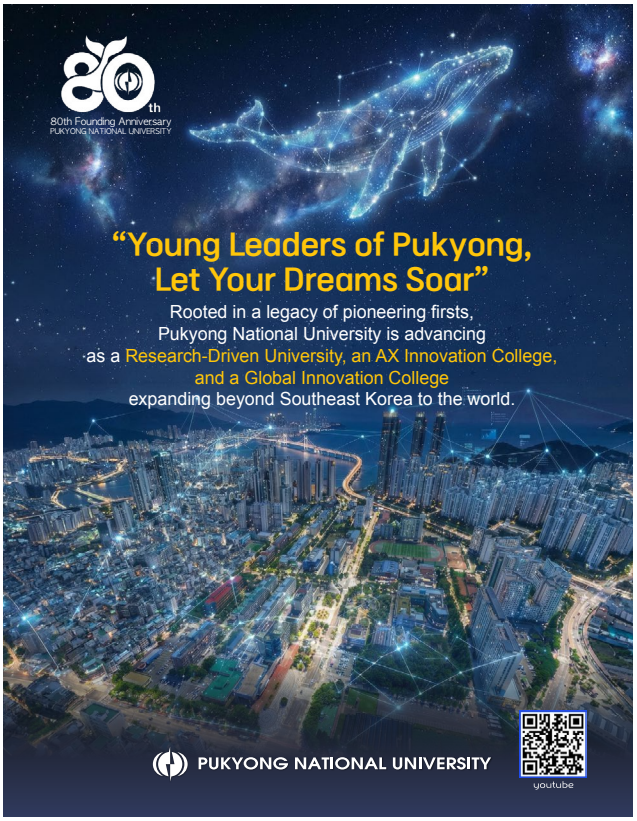

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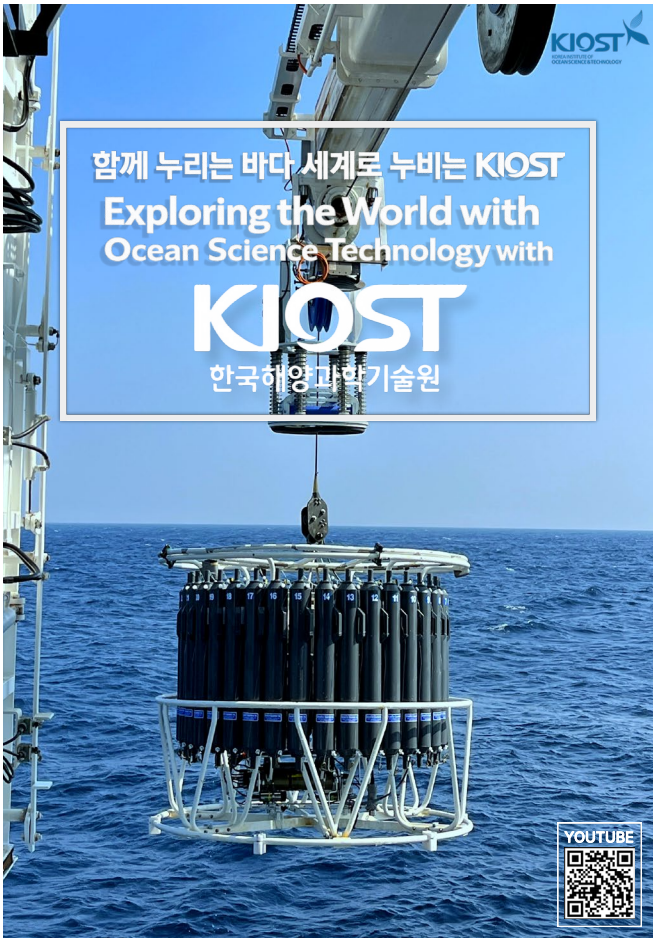

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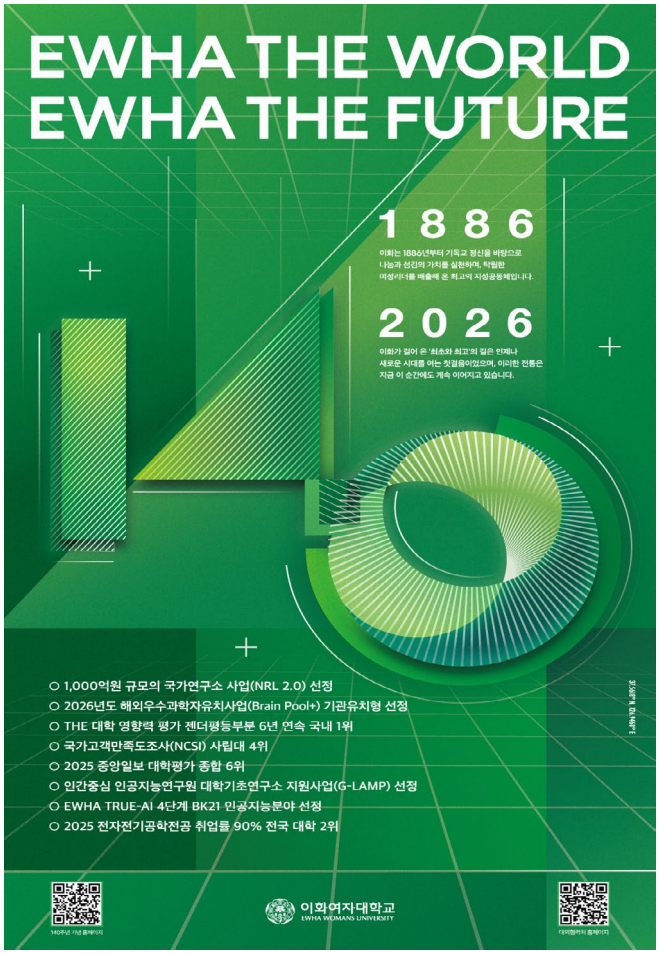

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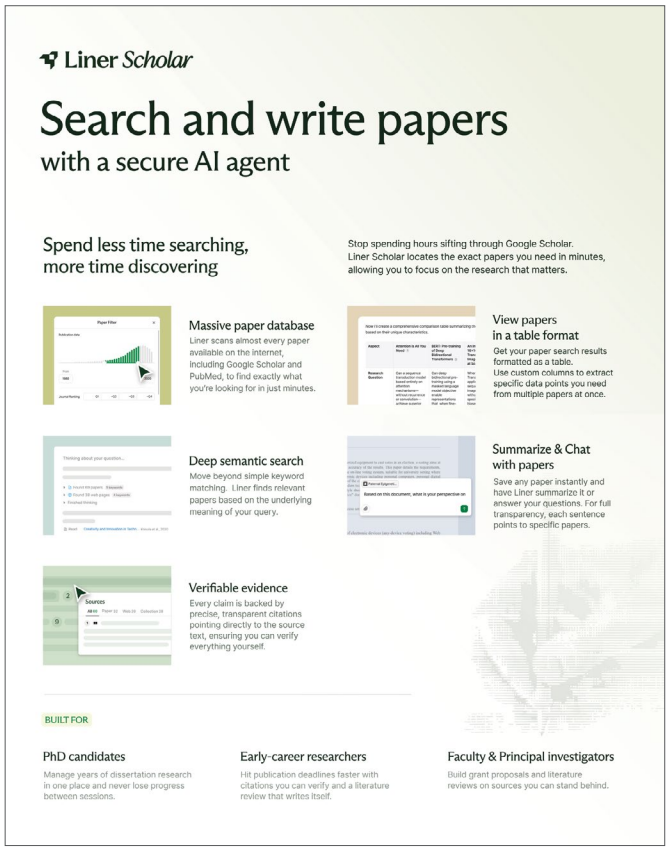

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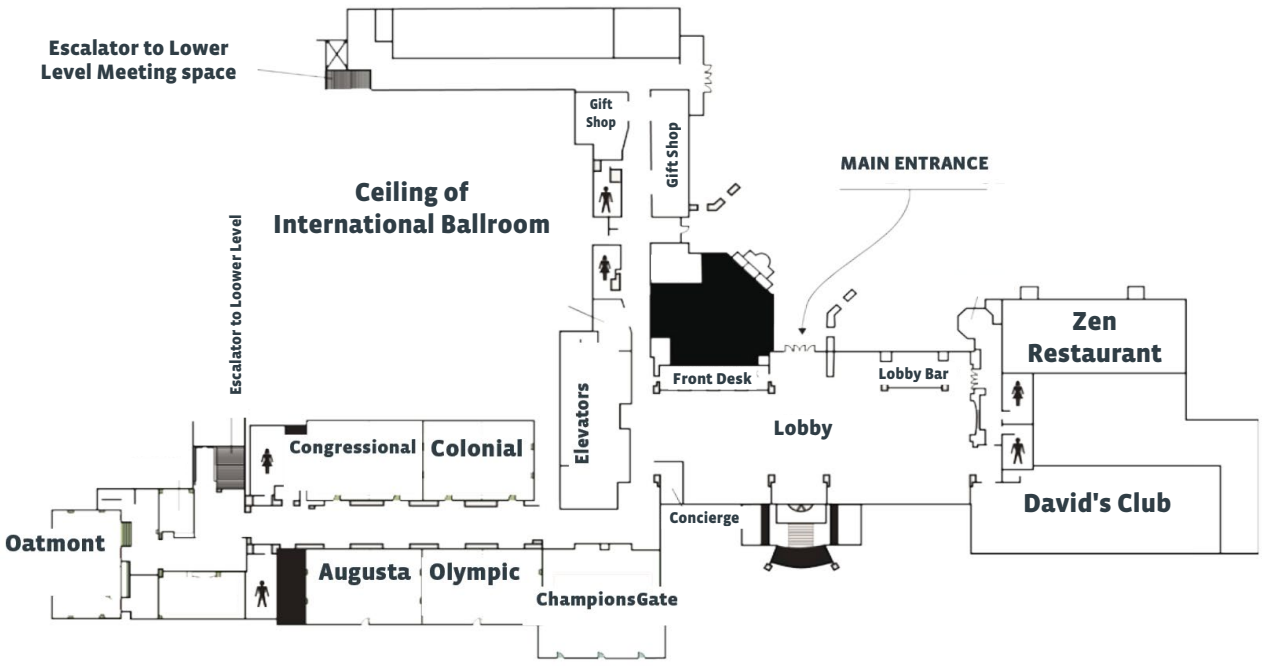

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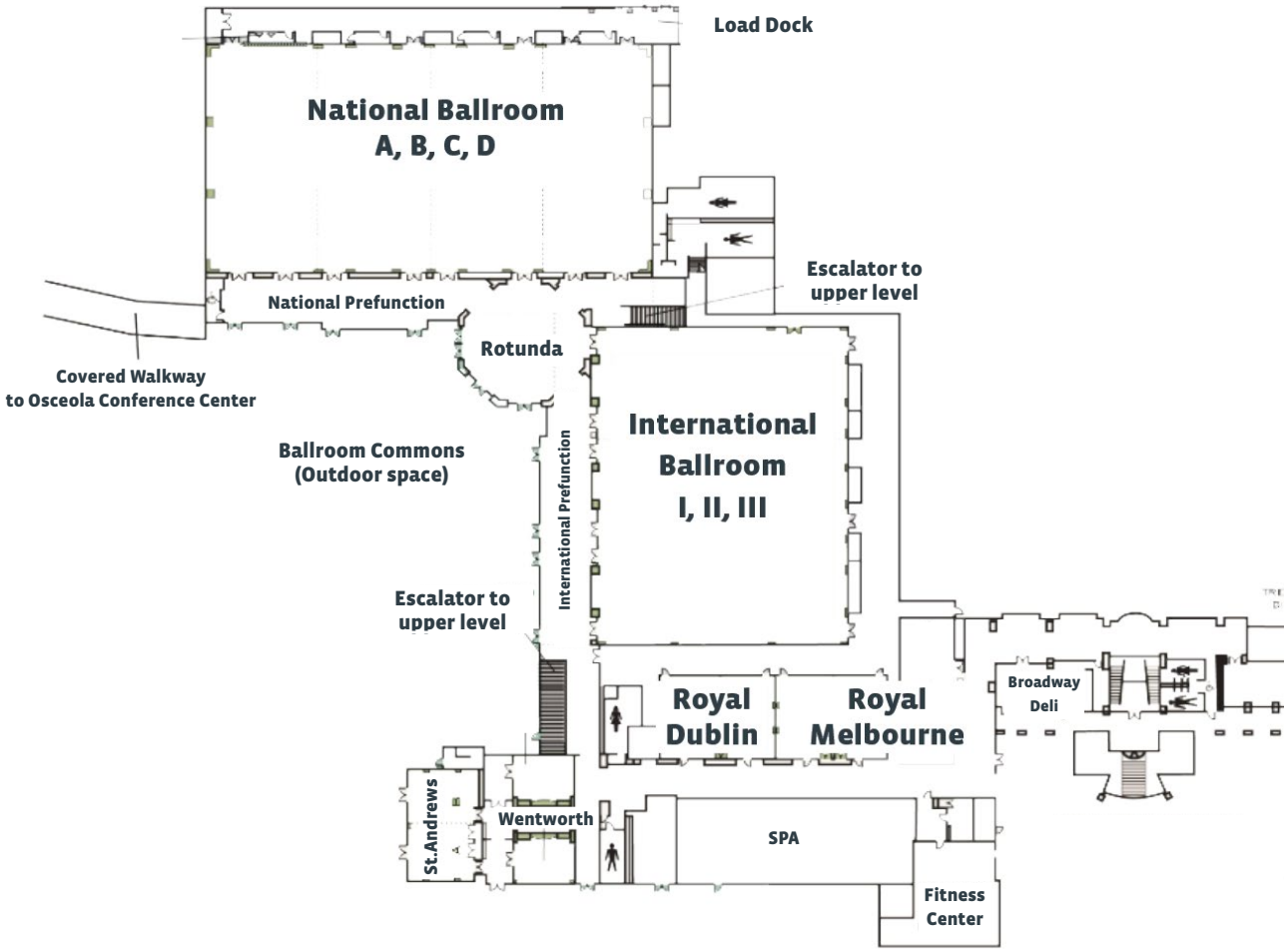

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Conference Venue Map

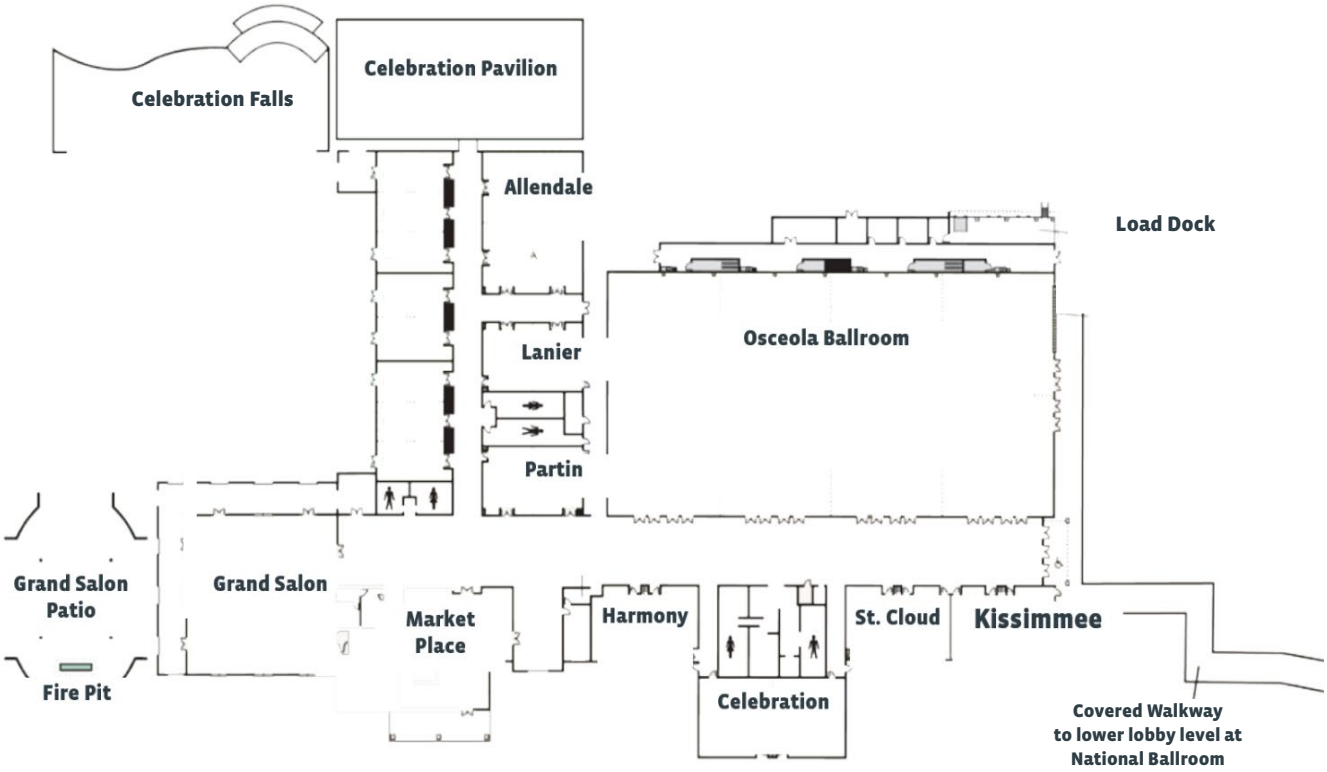
Lobby Level



Lower Lobby Level



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Korean-American Scientists and Engineers Association
1952 Gallows Road, Suite 300, Vienna, VA 22182
Tel. 703-748-122 Fax. 703-748-1331
sejong@ksea.org www.ksea.org