The 20th U.S.- Korea Forum on Nanotechnology

Energy-efficient Systems for Artificial Intelligence and Quantum & Neuromorphic Applications

September 14th & 15th, 2026

McKimmon Conference and Training Center, NCSU

https://www.cmu.edu/nanotechnology-forum/Forum_20/GeneralInfo.htm

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General Information

The 20th U.S.-Korea Forum on Nanotechnology:

Energy-efficient Systems for Artificial Intelligence and Quantum & Neuromorphic Applications

The Forum will take place on Monday and Tuesday, September 14 & 15, 2026, in Raleigh, North Carolina.

| Program & Presentation

On the first day, the keynote speakers and session participants will give oral presentations (27 minutes and 15 minutes), and on the second day, the young scientists will participate in a poster session, which will include a 5-minute presentation. All presenters should participate in the group discussion workshop on the second day.

| Meeting Location

Mckimmon Center, Raleigh, North Carolina

| Dates & Time

September 14 & 15, 2026 @ 8:30 a.m.
Lunch (September 14th) will be provided for all attendees..
Dinner (September 14th) and lunch (September 15th) will be provided for invited participants.

| Conference Hotel

Towneplace Suites by Marriott Raleigh-University Area, Raleigh, North Carolina

The 20th U.S.-Korea Forum on Nanotechnology:

Energy-efficient Systems for Artificial Intelligence and Quantum & Neuromorphic Applications

| Supporting Organization

National Science Foundation (USA)
Ministry of Science and ICT (Korea)
National Nanotechnology Policy Center (Korea)
Korea-US Science Cooperation Center (USA)

| Organizers

Korea Nanotechnology Research Society (Korea)
Carnegie Mellon University (USA)
Northeastern University (USA)
University of Pittsburgh (USA)
North Carolina State University (USA)

| Organizing Committee:

USA	Korea
Myung S. Jhon (Chair)	Joosun Kim (Chair)
Ahmed Busnaina	Jo-won Lee
Elias Towe	Bae Ho Park
In Hee Lee	Je-Hyung Kim
David A. Ricketts	Ho Won Jang

General Information

Chair

Professor Myung S. Jhon

· Carnegie Mellon University

| Biography

Professor Jhon is a Professor Emeritus of Chemical Engineering at Carnegie Mellon University in Pittsburgh, PA. Professor Jhon received his B.S. in Physics from Seoul National University, Korea, and his Ph.D. in Physics from the University of Chicago. He has served as visiting professor in several institutions, including the U.S. Department of Energy (National Energy Technology Laboratory and Sandia National Laboratories); the Department of Chemical Engineering, University of California, Berkeley; IBM Almaden Research Center, San Jose; and the Naval Research Laboratory, Washington, D.C. He served as a consultant to the United Nations Industrial Development Organization, and also served as a Corporate Science and Technology Advisor for Mitsubishi Chemical Corporation (Japan) for several years. He served as the President & CEO of Doosan DND Co., Ltd (Korea) and also served as a World Class University Professor at Sungkyunkwan University in Korea and as a Distinguished Advisor for Exa Corporation.

Professor Jhon is internationally known for his work in the fields of information storage systems, computational science, nano/quantum technology, engineering policy, semiconductors, graphene, organic light-emitting devices (OLED), atomic force microscope, and chemical mechanical polishing (CMP). He is a Fellow of the Korean Academy of Science and Technology. He served as an advisory committee member for a Korean national program for Tera-level nanodevices and is serving as the chair of the advisory board and a lead organizer for the U.S. -Korea Nanotechnology Forums. He has contributed publications in the areas of information storage systems, nanotechnology, computational methods (lattice-Boltzmann method, finite-element method, smoothed particle hydrodynamics, quantum simulation, Monte Carlo, molecular dynamics & multiscale simulation, and parallel computing), fuel cells, equilibrium and non-equilibrium statistical mechanics, nucleation, fluid and solid mechanics, interfacial dynamics, polymer engineering, rheology, multiphase flow, tribology, chemical kinetics, OLED & CMP, and robotic equipment. He is also dedicated to the educational process, as is evident from his numerous teaching awards and his role as an ABET evaluator (Akron, Worcester Polytechnic Institute, Rochester, Tufts, Stanford, Connecticut, Tennessee Tech, Stevens Institute of Technology, Maryland, and Florida), and was the Carnegie Institute of Technology Faculty Chair & Undergraduate Chair in his department. He has won a number of teaching and research recognition awards, including the Ladd, Teare, Ryan, Dowd, and Li Awards.

Chair

Dr. Joosun Kim

· Director-General
· Gangneung Branch
· Korea Institute of Science & Technology (KIST)

E-mail | joosun@kist.re.kr

| Biography

Dr. Joosun Kim is Director-General, Gangneung Branch of Korea Institute of Science and Technology (KIST) Korea. He is currently responsible to establish natural product research and provide related new projects. Currently, He has also served as President of Korea Nanotechnology Research Society (2026-present) and a Director at Korea Foundation for Advancement of Science & Creativity (2023-present). Prior to rejoining KIST Gangneung in 2024, he has served as Director-General at National Research Council of Science and Technology Korea, Director at Convergence Research Policy Center and Technology-Policy Research Institute of KIST. Dr. Kim has also served for government as a Program Manager of National Research Foundation (Korea) and a Korea Delegate of IEA working party. Dr. Kim has over 30 years of research experiences in the areas of fuel cells, Li-ion batteries, ceramic processing and R&D policy, while he has been working as a Principal Research Scientist at KIST since 2000. He received his Ph.D. in materials science from KAIST. His graduate work was followed by postdoctoral research associate position at UPENN.

The 20th U.S.-Korea Forum on Nanotechnology:

Energy-efficient Systems for Artificial Intelligence and Quantum & Neuromorphic Applications

The purpose of the Forum on Nanotechnology is to provide a platform for researchers from the U.S. and Korea to discuss emerging technologies that advance the state of the art in nanotechnology and related fields. This year's Forum focuses on (i) energy-efficient systems for artificial intelligence, (ii) quantum/nano technologies, and (ili) neuromorphic systems and applications.

These Fora are held on the recommendation of the Korea-U.S. Joint Committee on Scientific and Technological Cooperation. The first Forum took place two decades ago, and since then, the Fora have alternated between Korea and the U.S. Because nanotechnology intersects a broad range of fields, each with a wide array of technical challenges, each Forum has centered on a different emerging technology. The year's Forum, the 20h in the series, will feature three keynote speakers, 23 senior presenters, and 10 early-career presenters from the U.S. and Korea.

We expect this year's Forum to lead to meaningful milestones and to strengthen research collaborations between our two countries in fields where artificial intelligence and quantun technology are expected to generate significant economic and social impact. We hope the discussions at the Forum will help both nations pivot toward transformative approaches to novel quantum and neuromorphic systems and computing technologies, and toward new and innovative approaches for research collaboration.

We look forward to seeing you in Raleigh!

Sincerely,

The Organizing Committee

Program

| Day 1, September 14, 2026 (Monday), Mckimmon Center, Room#6

Session	Time	Program
08:30~09:00		**Registration**
Opening Session Co-chairs Jo-won Lee Myung S. Jhon	09:00~09:03	**Opening Remarks** • Elias Towe, Carnegie Mellon University
	09:03~09:21	**Welcoming Remarks** • Jim Pfaendtner, Provost, North Carolina State University • Joosun Kim, President, Korea Nanotechnology Research Society • Seongsin Margaret Kim, Program Director, National Science Foundation
	09:21~10:42 (27min/talk, including Q&A)	**Keynote Speeches** • Seongsin Margaret Kim, National Science Foundation *- US Strategy for Quantum Science and Engineering*
		• Jaewan Kim, Korea Research Institute of Standards and Science *- Toward Scalable Quantum Computing: The Quantum Interconnect Project of KRISS, KIST, ETRI, and KISTI*
		• Robert Westervelt, Harvard University *- Center for Nanoscale Systems*
10:42~11:00		Coffee Break & Group Photo
Session I-1: Quantum/Nano Technologies Co-chairs Elias Towe Je-Hyung Kim	11:00~12:09 (16min/talk, including Q&A)	• Elias Towe, Carnegie Mellon University *- Overview of Session I & II (5 minutes)*
		• Norbert Linke, University of Maryland *- Phonon-qubit hybrid quantum simulation with trapped ions*
		• Je-Hyung Kim, Ulsan National Institute of Science and Technology *- Quantum playground with semiconductor quantum emitters*
		• Kathleen Hamilton, Oak Ridge National Laboratory -
		• Sang-Wook Han, Korea Institute of Science and Technology *- Quantum Key Distribution toward Scalable Quantum Communication Networks and Photonic Integrated Systems*
12:09~13:10		Lunch
Session I-2: Quantum/Nano Technologies Co-chairs Elias Towe Je-Hyung Kim	13:10~14:30 (16min/talk, including Q&A	• Vinayak Dravid, Northwestern University - From Atoms to Architecture: Emerging Electron Microscopy for Quantum and Neuromorphic Materials
		• Gregory Fiete, Northeastern University - Inducing quantum states in materials with light
		• Yonuk Chong, Sungkyunkwan University *- Research and Development of superconducting quantum devices in SKKU Quantum Fab*
		• Shinjae Yoo, Brookhaven National Laboratory *- Cryogenic AI Software-Hardware Computing for Energy Applications*
		• Kyoung-Duck Park, Pohang University of Science and Technology *- When near-field plasmonic tip meets quantum technologies*

Program

| Day 1, September 14, 2026 (Monday), Mckimmon Center, Room#6

<table>
<tr><td rowspan="4">Session II-1:
Energy-efficient for AI &Neuromorphic Systems

Co-chairs
Ahmed Busnaina
Ho Won Jang</td><td rowspan="4">14:30~15:34
(16min/talk, including Q&A)</td><td>• Ahmed Busnaina, Northeastern University
- On Demand Micro and Nanoelectronics using a Fab in a Box Micro Factory</td></tr>
<tr><td>• Ho Won Jang, Seoul National University
- Linearly programmable memristors for neuromorphic computing hardware</td></tr>
<tr><td>• Sung-Kyu Lim, University of Southern California
- Logic Folding and Fine-Grained Logic-on-Logic 3D ICs: A Key Enabler of Tau Law</td></tr>
<tr><td>• Yiran Chen, Duke University
- Energy-Efficient Hardware for AI: Subthreshold Silicon Neurons and Gain-Cell Analog In-Memory Computing</td></tr>
<tr><td colspan="2">15:34~15:50</td><td>Coffee Break</td></tr>
<tr><td rowspan="8">Session II-2:
Energy-efficient for AI &Neuromorphic Systems

Co-chairs
Ahmed Busnaina
Ho Won Jang</td><td rowspan="8">15:50~17:58
(16min/talk, including Q&A</td><td>• Kaustav Banerjee, UC Santa Barbara
- From Atoms to Architectures: Two-Dimensional Materials for Energy-Efficient AI and Emerging Computing</td></tr>
<tr><td>• Sanghun Jeon, Korea Advanced Institute of Science and Technology
- Polarity-Configurable Photodiodes for In-Pixel Computing in Neuromorphic AI Vision</td></tr>
<tr><td>• Dhireesha Kudithipudi, UT San Antonio
- The Next Horizon of AI Hardware: Silicon That Learns Continually</td></tr>
<tr><td>• Jiyong Woo, Kyungpook National University
- Probabilistic Bits for Unconventional Computing Systems</td></tr>
<tr><td>• Alper Bozkurt, North Carolina State University
- Designing for Energy Efficiency: Advances in Wearable Sensing from NSF ASSIST Center</td></tr>
<tr><td>• Young Min Song, Korea Advanced Institute of Science and Technology
- Bioinspired Vision Systems for Intelligent Robotics</td></tr>
<tr><td>• Paschalis Gkoupidenis, North Carolina State University
- Organic neuromorphic electronics</td></tr>
<tr><td>• Kaushik Roy, Purdue University
- From Devices to Algorithms: Neuromorphic Computing for Energy-Efficient Autonomy</td></tr>
<tr><td colspan="2">18:45~20:00</td><td>Dinner Banquet
• Welcome: Veena Misra, Dean, NCSU</td></tr>
</table>

| Day 2, September 15, 2026 (Tuesday), Mckimmon Center, Room#6

Poster Session Co-chairs Myung S. Jhon	09:00~09:50 (5min/talk, including Q&A	• Matthew T. Flavin, Georgia Institute of Technology *- Scalable networks of wearable bioelectronics for treating sensory impairments*
		• Tingjun Chen, Duke University *- Radio Frequency Neural Networks*
		• Honggi Jeon, Duke University *- Robust meta-stable qutrit and mid-circuit cooling of barium ions*
		• Inhee Lee, University of Pittsburgh *- Millimeter-Scale Neuromorphic Vision System*
		• Wonjae Lee, Harvard University *- Strongly-interacting, two-dimensional ensembles of spin defects in hexagonal boron nitride*
		• Robert Nawrocki, Purdue University *- Organic, Spiking, and Flexible Embodied AI*
		• Demitry (Dima) Farfurnik, North Carolina State University *- Toward scalable photonic entanglement using quantum dots coupled to inverse-designed nanophotonic cavities*
		• Michael Kuban, Carnegie Mellon University *- Ab Initio Investigation of Erbium Point Defects in 4H-SiC for Quantum Emitters*
		• Brittany Smith, North Carolina State University *- Pushing the Limits of Active Microelectronics via Additive Manufacturing*
		• Bokyung Kim, North Carolina State University *- Dataflow-Aware Memory-Centric Computing: From Synaptic Devices to Practical AI Systems*
09:50~11:00		Poster Exhibition & Coffee Break
Discussion / Working Groups	11:00~12:00	**Group Discussion Workshop** • Group I: Quantum/Nano Technologies (Co-chairs: Elias Towe/Je-Hyung Kim) • Group II: Energy-efficient for AI & Neuromorphic Systems (Co-chairs: Ahmed Busnaina/Ho Won Jang)
12:00~13:00		Lunch
Discussion / Working Groups	13:00~14:00	**Group Discussion Workshop** • Group I: Quantum/Nano Technologies (Co-chairs: Elias Towe/Je-Hyung Kim) • Group II: Energy-efficient for AI & Neuromorphic Systems (Co-chairs: Ahmed Busnaina/Ho Won Jang)
Closing Session	14:00~15:00	**• Poster Award** **• Wrap-up Discussion** **• Generate Recommendation to the Governments** **• Signature of Overall Summary and Recommendation** **• Closing Remarks**
15:30~17:00		Tours of Duke Quantum Centers

Opening Session

Co-chairs
Jo-won Lee / Myung S. Jhon

Co-Chair

Jo-Won Lee

· Chairman, 3D Printing Research Organization

Web | www.3dpro.or.kr
E-mail | joosun@kist.re.kr

| Biography

• Education

1971-1278: B.S. in Metallurgical Eng. from Hanyang Univ.
1980-1983: M.S. in Metals Science from Penn State Univ.
1982-1286: Ph.D. in Metals Science from Penn State Univ.

• Professional Positions

1978-1280: Researcher at ADD
1985-1220: Research Associate at Carnegie Mellon Univ.
1990-1922: Visiting Scientist at IBM T. J. Watson Research Center
1992-2000: General Manager and Project Manager at SAIT
2000-2010: Director at The National Program for Tera-level Nanodevices
2010-2012: Professor at Hanyang University
2019-2023: President at National Nanofab. Center
2023-Present: Chairman at 3D Printing Research Organization

• Research Field and Interests

His field of research is primarily neuromorphic devices with a variety of experiences such as magnetic media/head, high To superconducting devices, diamond devices and nanoelectronics/memory.

• Professional Activities

In 2001, he was a general secretary of the governmental planning committee for the 10 years Korea Nanotechnology Initiative. This plan has been revised in 2005 under the guidance of Dr. Lee as a principle investigator. He was serving as a first vice president of Korean nanotechnology research society in charge of international affairs and a chairman of advisory committee for nanotechnology information. He was also working as a Korean-side chairman of advisory committee for Korea-US nanotechnology forum and was an NT focal point of Korea-UK focal point programs. He has been also serving as Chair, NANO KOREA 2006, 2007, 2008 and 2009 Symposium Steering Committee. He completed national nanotechnology roadmap (Feb. 2008) and national nanotechnology standardization development roadmap (Oct. 2007) as a principle investigator. He was served as a general chair of IEEE-Nanotechnology Conference 2010. He was a chair of study group on neuromorphic devices in Korea. He also served as a chairman of Korea Infrastructure Organization for Nanotechnology from 2020-2023.

Opening Remarks

· **Elias Towe,** *Carnegie Mellon University*

Welcoming Remarks

· **Jim Pfaendtner,** *Provost, NCSU*
· **Joosun Kim,** *Korea Nanotechnology Research Society*
· **Seongsin Margaret Kim,** *Program Director, National Science Foundation*

Keynote Speeches

- **Seongsin Margaret Kim** 16
  National Science Foundation
- **Jaewan Kim** 18
  Korea Research Institute of Standards and Science
- **Robert Westervelt** 20
  Harvard University

Seongsin Margaret Kim

· Program Director
· National Science Foundation

| Biography

Dr. Seongsin Margaret Kim currently serves as a Program Director for the Electronics, Photonics, and Magnetic Quantum Devices (EPMQD) program within the Electrical, Communications, and Computing Systems (ECCS) Division of the Directorate for Engineering (ENG) at the National Science Foundation (NSF). She is also a Professor of Electrical and Computer Engineering at the University of Alabama.

Dr. Kim earned her Ph.D. in Electrical and Computer Engineering and M.S. in Physics from Northwestern University, following a B.S. in Physics from Yonsei University in South Korea. Prior to joining the University of Alabama, she held research and academic positions at Stanford University as a Research Associate and Consulting Assistant/Associate Professor. She also worked in industry at Agilent Technologies and Samsung.

Her research spans photonics, metamaterials, and terahertz (THz) technologies, with applications in next-generation biomedical diagnostics, quantum sensing, quantum networks, 6G/7G communications, AI-assisted bio-imaging, space and underwater exploration, and neurophotonics.

At NSF, Dr. Kim manages a broad portfolio of high-impact programs, including Quantum Leap Challenge Institute (QLCI), the Future of Semiconductors, the NSF-NIH joint initiative on quantum sensors for biomedical applications, the NSF-AFRL collaboration on Floquet-engineered quantum systems, Addressing Systems Challenges through Engineering Teams (ASCENT), Major Research Instrumentation Program (MRI) in addition to the core programs and among others. She is an active member of the Quantum Information Science and Engineering (QISE) working group. She is also deeply committed to advancing human-centered technologies across her programs.

Dr. Kim has authored over 180 publications, holds three patents, and is the recipient of the NSF CAREER Award. She is a Fellow of OPTICA, recognized for her pioneering contributions to photonics and THz science.

US Strategy for Quantum Science and Engineering

Seongsin Margaret Kim, PhD

[1]National Science Foundation, USA
[2]University of Alabama, USA

E-mail address: sekim@nsf.gov; seongsin@eng.ua.edu

Abstract

Quantum science and engineering has become a strategic national priority for the United States, driven by its potential to transform computing, sensing, communications, materials discovery, and national security. This talk will examine the evolving U.S. quantum strategy and the coordinated roles of federal agencies, national laboratories, universities, industry, and international partnerships. It will discuss how the nation is balancing long-term fundamental research with near-term technology development, workforce preparation, infrastructure, standards, and pathways to commercialization. Particular attention will be given to the pillars of quantum information science—computing, networking, and sensing—and to the enabling technologies that connect them, including photonics, materials, cryogenic systems, control electronics, and advanced manufacturing. The talk will also consider persistent challenges, including scalability, benchmarking, supply-chain resilience, talent development, and translation from laboratory demonstrations to deployable systems. It will conclude with perspectives on research priorities and strategic opportunities for sustaining U.S. leadership in quantum science and engineering.

Jaewan Kim

· National Distinguished Research Fellow
· Korea Reseach Instituite of Standards and Science/ Republic of Korea

| Biography

Dr. Jaewan Kim is a National Distinguished Research Fellow at the Korea Research Institute of Standards and Science (KRISS) and Director of the Strategic Research Center for Hyper-Connected Scalable Super-Quantum Computing. He also serves as a member of Korea's National Quantum Strategy Committee. He leads a national collaborative research program involving KRISS, KIST, ETRI, and KISTI, aimed at developing scalable quantum computing architectures based on multi-core quantum processors and quantum interconnects.

He received his B.S. in physics from Seoul National University and his Ph.D. in physics from the University of Houston. He subsequently served as Computational Science Team Leader at the Samsung Advanced Institute of Technology (SAIT) and as a Research Associate Professor at KAIST. He then joined the School of Computational Sciences at the Korea Institute for Advanced Study (KIAS), where he served as a professor, Vice President, and Acting President. Following his retirement, he continued his academic service at KIAS as a Distinguished Professor. He also served as Director of the Institute of Quantum Information Technology at Yonsei University.

Dr. Kim was the founding President of the Quantum Information Society of Korea (OisK) and formerly served as Chair of the AQIS Steering Committee. He currently serves as Academic Co-Chair of the Future Quantum Convergence Forum. His research interests include quantum information science, quantum computing, and scalable and interconnected quantum computing architectures.

Toward Scalable Quantum Computing: The Quantum Interconnect Project of KRISS, KIST, ETRI, and KISTI

Jaewan Kim

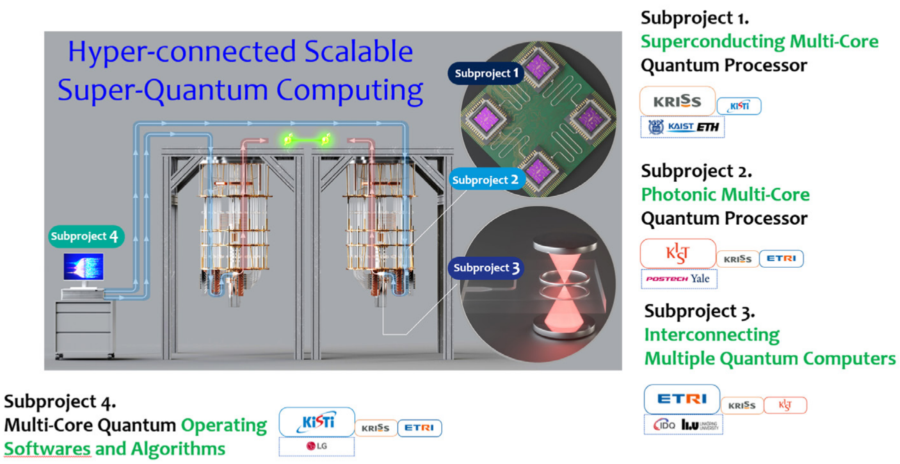
Korea Research Institue of Standards and Science,
Republic of Korea

E-mail address: johnjaewan@kriss.re.kr

| Abstract

By exploiting a computational state space that grows exponentially with the number of qubits, quantum computers are expected to address complex problems that are intractable for conventional digital computers. However, today's quantum computers, which contain only hundreds to a few thousand physical qubits, remain far from the scale required for practically important applications, particularly when the substantial overhead of quantum error correction is taken into account.

To overcome the limitations of a single quantum processor, this national research project aims to develop scalable quantum computing architectures based on quantum interconnects. The project consists of four closely coordinated research programs. KRISS is developing technologies for interconnecting multiple superconducting-qubit modules. KIST is pursuing modular photonic quantum processors and methods for interconnecting multiple photonic-qubit modules. ETRI is developing quantum interconnect technologies for networking the resulting quantum computing systems. KISTI is developing the system software, middleware, and quantum algorithms required to operate and utilize these interconnected, modular quantum computing platforms.



Robert M. Westervelt

· Professor of Applied Physics and of Physics
· Harvard University

| Biography

Robert Westervelt received his PhD in Physics from the University of California, Berkeley in 1977. Following a postdoctoral appointment, he moved to Harvard University, where he is currently the Mallinckrodt Professor of Applied Physics and Physics. He serves as the Director of the Center for Nanoscale Systems (CNS) at Harvard, which provides shared facilities for nanofabrication and imaging of quantum materials and devices. In addition, he is the Director of the NSF Science and Technology Center for Integrated Quantum Materials based at Harvard, with partnerships at Howard University, Massachusetts Institute of Technology, and the Museum of Science, Boston.

Center for Nanoscale Systems*

Robert M. Westervelt

Harvard University, USA

E-mail address: westervelt@seas.harvard.edu

Abstract

The Center for Nanoscale Systems (CNS) at Harvard University provides outstanding facilities and expertise for the fabrication, imaging, and analysis of nanoscale structures and systems. CNS provides a collaborative, multi-disciplinary environment for researchers from academia and industry to create nanoscale structures, devices, and systems from new materials. The topics addressed include quantum materials and devices, photonics, meta-optics, and integrated lithium niobate photonic circuits. The goals of CNS are to push the frontiers of nanotechnology and to help build a high-tech workforce in the US.

*Supported in part by NSF National Nanotechnology Coordinated Infrastructure (NNCI) grant ECCS-2025158.

Session I

Quantum/Nano Technologies

Co-chairs

Elias Towe / Je-Hyung Kim

Professor Elias Towe

· Carnegie Mellon University, USA

| Biography

Elias Towe is the Albert and Ethel Grobstein Professor and University Professor in the Department of Electrical and Computer Engineering at Carnegie Mellon. Towe's group pursues research in photonics and quantum information science and technology. Prof. Towe is currently Director of the National Science Foundation Industry-University Center on Quantum Computing and Information Technologies (QCiT) at Carnegie Mellon. Research at the Center is in the broad areas of quantum computing and quantum networks. In computing, the team is focusing on the quantum computing stack: from the bottom qubit layer, through the control layer to the compiler layer, to the top software and algorithm layers, including software for use-case applications in select areas. In networks, the team works on secure quantum networks for distributed computing and communication, including networked quantum sensors.

Towe received the S.B., S.M., and Ph.D. degrees from the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology in Cambridge, MA, where he was a Vinton Hayes Fellow. He is a Fellow of the IEEE, Optica (formerly OSA), American Physical Society, and the American Association for Advancement of Science. He is a recipient of several academic and professional awards that include the John Bardeen Award. Prof. Towe is a Member of the US National Academy of Engineering.

Norbert M. Linke

· Associate Professor of Physics
· University of Maryland

| Biography

Norbert M. Linke is an Associate Professor of Physics, a Fellow of the Joint Quantum Institute, and the Director of QLab, the National Quantum Laboratory at the University of Maryland (UMD). His research focuses on quantum applications of trapped ions and the realization of quantum algorithms. Born in Munich, Germany, he graduated from the University of Ulm and received his doctorate at the University of Oxford, UK, working on microfabricated ion traps and microwave-addressing of ions. He spent four years as a postdoc and research scientist in the group of Chris Monroe at UMD, where he led a project that turned a physics experiment into a programmable quantum computer. He became an Assistant Professor at UMD in 2019. From 2022, he spent three years at the Duke Quantum Center at Duke University in Durham, NC, working on quantum networking. In 2025, he returned to UMD to become the Director of QLab, a user facility providing access to quantum computers for researchers, educators, and start-ups.

Phonon-qubit hybrid quantum simulation with trapped ions

Norbert M. Linke

National Quantum Laboratory, University of Maryland

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Abstract

Trapped-ion systems are a leading platform for quantum computing, but achieving scalability to large system sizes remains a challenge. In order to significantly increase the available Hilbert space, we incorporate the quantized vibrational (motional) modes originating from the ion confinement directly into the computational toolkit. This talk presents experiments demonstrating this capability in a chain of individually addressed Ytterbium ions. We present an analog-digital hybrid simulation of the Yukawa model, a simplified model of interacting nucleons and pions. High-energy physics models of this kind are notoriously challenging for both classical and quantum computers due to the complex interactions involved and the infinite-dimensional bosonic Hilbert space, which is costly to map to qubits. The motional modes of trapped ions provide a natural, direct representation for these bosons. We present results from the first analog-digital hybrid quantum simulation of the Yukawa model that combines digital gates on qubits with motional modes along multiple directions, demonstrating the substantial resource savings offered by this approach for simulating complex field theories.

We also present recent quantum applications on commercial quantum computers from our quantum computing user facility, QLab, at the University of Maryland.

Assoc. Prof. Je-Hyung Kim

· Ulsan National Institute of Science and Technology, Republic of Korea

| Biography

Je-Hyung Kim received his Ph.D. in Physics from the Korea Advanced Institute of Science and Technology (KAIST), South Korea, in 2014. He then worked as a postdoctoral researcher at the University of Maryland from 2014 to 2017. Since 2017, he has been with the Department of Physics at the Ulsan National Institute of Science and Technology (UNIST), South Korea, where he is now an Associate Professor. From 2023 to 2024, he was also a visiting fellow at JILA, University of Colorado Boulder.

His research group focuses on a wide range in quantum science, spanning from fundamental studies of quantum light-matter interactions in solid-state quantum emitters to the development of advanced quantum photonic and spin resources, with applications in emerging quantum information technologies.

Quantum playground with semiconductor quantum emitters

Je-Hyung Kim*

Ulsan National Institute of Science and Technology, Republic of Korea

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| Abstract

Solid-state quantum emitters, such as semiconductor quantum dots and crystal color centers confine electrons in a nanoscale size, resulting in quantized energy levels as electrons confined in atoms. These artificial atoms provide versatile quantum resources, including photonic and spin qubits, without the need for complex trapping systems. However, their solid-state environment also introduces challenges, including interactions with phonons and charge fluctuations, limited light-extraction efficiency, and spectral inhomogeneity.

Over the past decade, remarkable advances in quantum material growth, nanophotonic integration, coherent control techniques, and high-efficiency single-photon detection have transformed these emitters into leading platforms for quantum light sources, quantum memories, and applications ranging from quantum communications to quantum sensing. In particular, the integration of quantum emitters with photonic cavities and waveguides has enabled efficient light-matter interfaces and scalable quantum interactions among multiple photons and emitters.

Given these advances in performance and scalability, solid-state quantum emitters are now transitioning from individual quantum devices to fully integrated quantum systems implemented on photonic integrated circuits and optical fiber platforms. This evolution paves the way for practical quantum technologies in which quantum generation, manipulation, transmission, and detection are seamlessly integrated within real-world photonic architectures. In this talk, I will present recent progress in scalable integrated quantum photonics, highlight emerging opportunities enabled by solid-state quantum emitters, and discuss the key challenges toward realizing practical quantum photonic technologies.

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Director. Sang-Wook Han

· KIST, Republic of Korea

| Biography

Dr. Sang-Wook Han is the Director of the Quantum Application Technology Hub and a Principal Research Scientist at the Korea Institute of Science and Technology (KIST). He also serves as a professor at the University of Science and Technology (UST) and the KU-KIST Graduate School. He received his B.S., M.S., and Ph.D. in Electrical Engineering from KAIST.

Before joining KIST in 2012, he worked at Samsung Advanced Institute of Technology (SAIT) and Pixelplus, where he conducted research on CMOS image sensors and advanced imaging devices. His current research focuses on quantum communication, quantum computing systems, integrated quantum photonics, and diamond quantum technologies. His group has developed practical quantum key distribution (QKD) systems, integrated lithium niobate quantum photonic circuits, and photonic quantum computing technologies.

Dr. Han has authored more than 70 SCI journal papers and holds over 50 domestic and international patents in quantum information technologies. He has received numerous honors, including the Prime Minister's Commendation for the Promotion of Science and Technology (2021), the KIST Scientist of the Month Award (2022), the Journalist's Scientist of the Year Award (2023), and the NST Chairman's Outstanding Researcher Award (2026). He has also served in several national leadership roles, including President of the Korean Quantum Information Society and as a member of Korea's National Quantum Strategy Committee, contributing to the advancement of the nation's quantum science and technology ecosystem.

Quantum Key Distribution toward Scalable Quantum Communication Networks and Photonic Integrated Systems

Sang-Wook Han[1,2,3]

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| Abstract

Quantum Key Distribution (QKD) is the most mature quantum technology and is expected to play a key role in securing future communication infrastructures against quantum-computing attacks. Despite remarkable progress over the past two decades, practical deployment of QKD still requires significant advances in network scalability, long-distance transmission, and system miniaturization.

Over the past decade, our research group at the Korea Institute of Science and Technology (KIST) has focused on addressing these challenges through system-level innovation and photonic integration. We have developed practical QKD network architectures based on wavelength - and polarization-division multiplexing, enabling efficient one-to-many quantum key distribution over field-deployed optical fiber networks while maintaining stable quantum bit error rates in real communication environments.

To further improve scalability and reduce system size, our recent research has concentrated on photonic integrated QKD systems using thin-film lithium niobate (TFLN). By integrating passive and active optical components on a monolithic photonic chip, we demonstrated on-chip BB84 QKD over a 32-km field-deployed fiber network. The identical transmitter and receiver chip architecture provides a practical route toward compact, robust, and mass-producible quantum communication systems suitable for future quantum networks.

Building upon these achievements, our current research is focused on next-generation Twin-Field QKD (TF-QKD), which has the potential to overcome the fundamental distance limitation of conventional QKD without quantum repeaters. In particular, we are investigating high-precision phase estimation, pure phase error analysis, and experimental implementation of TF-QKD for ultra-long-distance secure communication. We are also extending integrated lithium-niobate photonic technologies toward chip-scale TF-QKD platforms.

This presentation will review the evolution of our QKD research from practical quantum communication networks to integrated photonic quantum systems and discuss future directions toward scalable quantum internet technologies.

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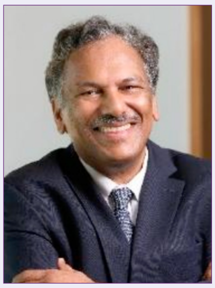

Vinayak P. Dravid

· Professor of MSE
· Northwestern University

| Biography

Vinayak P. Dravid is a professor of MSE at Northwestern University and founding director of the NUANCE Center, a shared scientific infrastructure for nanoscale characterization. His research spans advanced electron microscopy, quantum and neuromorphic materials, nanoscale structure–property relationships, and data-enabled materials discovery.

His group develops multimodal, in situ, cryogenic, and AI-assisted microscopy approaches that connect defects, interfaces, strain, and chemical heterogeneity with transport, coherence, and device performance. He also leads efforts in scientific data infrastructure and data provenance, aimed at making complex characterization data reproducible, interoperable, and trustworthy for AI-enabled discovery and translation.

From Atoms to Architecture: Emerging Electron Microscopy for Quantum and Neuromorphic Materials

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| Abstract

Quantum and neuromorphic technologies promise transformative gains in energy-efficient computing and related applications. However, their performance is often governed by localized noise events or extremes of distributions rather than "averaged" information. Here, unlike *"conventional"* microstructure that is governed by average and often amplitude-based information, *quantum* microstructure represents perturbation to the *phase* of the wavefunction relevant in quantum systems. Such a *quantum* microstructure represents sparse, structurally severe defects, interfaces, strain fields, chemical heterogeneity, and dynamic disorder that control coherence, charge/spin/heat transport, switching, and thus, reliability.

In this context, advanced electron microscopy has therefore moved beyond supplying an illustrative "Figure 3" micrograph. Multimodal imaging, spectroscopy, nD-STEM, and some *in situ* and cryogenic methods can now extract quantitative, distribution-resolved variables—including defect density, curvature, strain variance, correlation length, and interface topology—that are directly relevant to decoherence and transport. I will introduce *a prescriptor formalism,* $\Pi_j = \rho_j G_j$. Unlike conventional descriptors that report what is present, prescriptors connect microscopy observables to device performance through falsifiable structure–property relations, enabling attribution, inverse design, and AI-guided adaptive measurement.

The talk will conclude with opportunities for U.S.–Korea collaboration in shared instrumentation, data infrastructure, and translation from atoms to functional architectures.

Gregory A. Fiete

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| Biography

Gregory A. Fiete is a Professor of Physics at Northeastern University in Boston, Massachusetts. He received his PhD in physics from Harvard University, and did postdoctoral work at the Kavli Institute for Theoretical Physics at UC Santa Barbara. He was a Lee A. DuBridge Prize Fellow in Theoretical Physics at Caltech. He is a recipient of the NSF CAREER Award, the DARPA Young Faculty Award, a DARPA Director's Fellowship, the Presidential Early Career Award for Scientists and Engineers (PECASE), a Simons Fellowship in Theoretical Physics, and a Bessel Research Award from the Alexander von Humboldt Foundation. He is both an elected Fellow and an Outstanding Referee of the American Physical Society.

Inducing quantum states in materials with light

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| Abstract

Recent advances in laser technology allow for higher levels of quantum state control in materials. In this talk, I will describe recent theoretical studies from my group exploring different mechanisms of quantum state control. I will discuss situations of coexisting competing orders, Floquet engineering of psuedo-magnetic fields, and a scheme for opto-electrical control of chiral lattice structure for reversable, non-contact enantiomer control in a material. The signatures of these states and transitions in various observables will be discussed, along with new frontiers for artificial intelligence in the theory of these systems.

Prof. Yonuk Chong

· SKKU (Sungkyunkwan Univ.), Korea

| Biography

2020-current: Professor, SKKU (Sungkyunkwan University)
2005-2020: Research Scientist, KRISS (Korea Research Institute of Standards and Science
2002-2005: Postdoctoral Researcher, NIST Boulder, USA
1999-2002: Postdoctoral Researcher, Seoul National University
1996-1997: Visiting Scientist, Forschungszentrum Juelich, Germany
1999, 1994, 1992: PhD, MsC, BS in Physics, Seoul National University

Research and Development of superconducting quantum devices in SKKU Quantum Fab

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| Abstract

In this presentation I will introduce SKKU OFab, a superconducting quantum foundry for quantum device research. As one of our main research, we introduce our activities in the development of superconducting qubit device technology targeting a quantum processor, as a part of a large nationwide project to build a scalable quantum computer system. The superconducting qubit emerges as a very promising platform for realizing a useful quantum computing system. The qubit device is based on Josephson junctions and superconducting resonators, which is already relatively mature technology reaching a level of commercial device fabrication. Especially we have established a state-of-art superconducting device foundry OFab to provide the researchers with qubit devices with relatively small qubit counts.
The device technology still needs a far more improvement for practical quantum computing.
In general, I will present the current status and future direction of SKKU OFab and superconducting quantum processor research.

Shinjae Yoo

· Computational Research Division Lead
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| Biography

Dr. Shinjae Yoo is the Department Chair of the Artificial Intelligence Department within the Computing and Data Sciences Directorate at Brookhaven National Laboratory (BNL). His research focuses on the convergence of artificial intelligence, high-performance computing, quantum computing, and neuromorphic hardware architectures. Dr. Yoo leads multidisciplinary initiatives in scientific machine learning, multimodal foundation models, physics-informed AI, and cryogenic software-hardware co-design. His work aims to drive technical breakthroughs across next-generation computing paradigms to accelerate scientific discovery and energy applications.

Cryogenic AI Software-Hardware Computing for Energy Applications

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Abstract

Recent advancements in cryogenic analog computing—across both quantum and neuromorphic domains—are opening new frontiers for high-performance and energy-efficient computation. This presentation explores state-of-the-art capabilities, key technical bottlenecks, and the near-term outlook for enabling these novel computing paradigms. We highlight recent achievements in quantum and neuromorphic systems at Brookhaven National Laboratory, emphasizing the pivotal role artificial intelligence plays in hardware-software co-design, error mitigation, and system optimization to drive breakthroughs in energy applications.

Prof. Kyoung-Duck Park

· Pohang University of Science and Technology (POSTECH), Republic of Korea

| Biography

Kyoung-Duck Park is an Associate Professor in the Departments of Physics and Semiconductor Engineering at Pohang University of Science and Technology (POSTECH), Korea. He received his Ph.D. in Physics from the University of Colorado Boulder in 2017. His research focuses on tip-enhanced nano-spectroscopy and the nanoscale control of light-matter interactions in low-dimensional quantum materials.
His group develops advanced near-field optical techniques to investigate and manipulate excitons, trions, polaritons, and single quantum emitters with nanometer-scale spatial resolution. His research has been recognized with several honors, including the Hyundang Physics Award, the Young Physicist Award of the Korean Physical Society, and a Ministerial Commendation from the Korean Ministry of Science and ICT.

When near-field plasmonic tip meets quantum technologies

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| Abstract

The ability to probe, manipulate, and engineer quantum states at the nanometer scale is essential for the development of next-generation quantum technologies. A sharp metallic tip provides a unique platform for this purpose by concentrating optical fields into a nanoscale volume and dramatically enhancing local light-matter interactions. Importantly, the plasmonic tip can function not only as a near-field imaging probe, but also as a dynamically tunable nanoantenna and optical cavity that actively modifies the quantum system beneath it.

In this talk, I will discuss how tip-enhanced nano-spectroscopy can be used to investigate and control excitons, localized emitters, defects, and other quantum states in low-dimensional materials. Tip-induced field enhancement and cavity coupling can generate exotic hybrid light-matter states, modify radiative and nonradiative decay pathways, and enable the nanoscale tuning of strong-coupling conditions. For quantum emitters, the confined plasmonic field can substantially enhance emission intensity and provide active control over single-photon generation, polarization, and photon statistics. The extreme spatial confinement and sensitivity of the tip-enhanced interaction also offer new opportunities for quantum sensing. Local electric and magnetic fields, charge fluctuations, strain, vibrational modes, and dielectric variations can be detected through their influence on nanoscale quantum states.

Extending these concepts to soft matter and biological interfaces may ultimately enable quantum-enhanced optical sensing of biomolecules, membranes, and cellular environments with nanometer-scale resolution. Finally, I will present emerging directions in ultrafast, nonlinear, cryogenic, and device-integrated tip-enhanced spectroscopy. These developments illustrate how the near-field plasmonic tip can evolve from a passive characterization tool into a versatile nanoscale platform for creating, controlling, and reading out quantum states.

Session II

Energy-efficient for AI & Neuromorphic Systems

Co-chairs
Ahmed Busnaina / Ho Won Jang

Ahmed Busnaina

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| Biography

Ahmed A. Busnaina, Ph.D. is the William Lincoln Smith Chair Professor, Distinguished University Professor and founding Director of the National Science Foundation's Nanoscale Science and Engineering Center for High-rate Nanomanufacturing since 2004, the Advanced Nanomanufacturing Cluster for Smart Sensors and Materials since 2015 and the NSF Center for Microcontamination Control at Northeastern University, Boston, MA since 2002. He is also the founder and CTO of Nano OPS, Inc. since 2017. Prior to joining Northeastern University in 2000, he was a professor and a director of the Particulate Control Lab at Clarkson University from 1983-2000. Dr. Busnaina is internationally recognized for his work on nano and micro scale defects mitigation and removal in semiconductor fabrication. He specializes in directed assembly-based nano and microscale printing of inorganic and organic conductors, semiconductors, and dielectricsfor making micro and nanoscale interconnects, transistors, sensors, LEDs, and other devices. He developed many techniques for directed assembly-based additive manufacturing of nanoscale electronics, sensors, advanced and heterogeneous electronic packaging, and other optical and bio applications. His research support exceeds $61 million. He authored more than 600 papers in journals, proceedings, and conferences. He also has 25 granted and 45 pending patents. He organized and chaired over 175 conferences, workshops, sessions, and panels for many professional societies. He was awarded the 2020 American Society of Mechanical Engineers (ASME) William T. Ennor Manufacturing Technology Award and Medal for his contributions to the printing of nanoelectronics. He is a fellow of the National Academy of Inventors, fellow American Society of Mechanical Engineers, the Adhesion Society, and a Fulbright Senior Scholar at the University of Cairo (1993-1994). He was awarded the 2006 Nanotech Briefs National Nano50 Award, the Innovator category, the 2006 Outstanding Faculty, the 2006 SØren Buus Outstanding Research Award, the 2005 Aspiration Award, and the 2016 Outstanding Translational Research Award at Northeastern University. He is an editor of the journal of Microelectronic Engineering and an associate editor of the Journal of Nanoparticle Research. He also serves on many advisory boards, including Samsung Electronics, the Journal of Particulate Science and Technology, the Journal of Electronic Materials Letters, the Journal of nanomaterials, and the Journal of nanomanufacturing.

On Demand Micro and Nanoelectronics using a Fab in a Box Micro Factory

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| Abstract

Directed assembly is a new additive, bottom-up semiconductor manufacturing process in which nanoscale and microscale structures are built by precisely assembling nanoparticles, molecules, or liquids for making passive and active electronic components, trace, and interconnects at the nano and microscale [1]. The technique eliminates etching, vacuum deposition, and other chemically intensive processing by utilizing the directed assembly at ambient temperature and pressure at a rate of one circuit layer per minute on a 4-inch wafer. This technology has demonstrated the manufacturing of devices utilizing inorganic (or organic if desired) nanomaterials such as conductors including metals, silicon, III-V and II-VI semiconductors, and low and high k dielectrics such as SiO2, Al2O3, and HfO2 to make electronics. Single-crystal conductors and semiconductors [2] can be printed and sintered at ambient temperature or by using thermal sintering (for particles larger than 20 nm). The nanoparticles are suspended using colloid chemistry, and the post-assembly crystallization utilizes different sintering conditions if needed. The manufacturing of transistors with an on/off ratio greater than 106 has been demonstrated. The process begins with substrate patterning using lithography followed by selective surface functionalization to enable site-specific particle or liquid deposition. The assembly of nanoparticles onto the functionalized substrate is enabled by applying external fields such as electrophoretic, dielectrophesis, convective, fluidic, or capillary forces that drives particles to the patterned sites to make complex, multi layer, multi-material devices. After each layer, processes such as sintering and annealing fuse the nanoparticles into continuous, functional films. All of the required manufacturing processes are integrated in a fully automated platform Fab-in-a-Box (FIBOX) that enables lithography, directed assembly and sintering.

The presentation will show the repeatable manufacturing and yield of micro and nanoelectronics including logic made using a fully additive process down to the submicron scale without using etching, vacuum, or chemical reactions. This additive high-throughput manufacturing solution can enable low-cost trace, interconnect, passive, and active components manufacturing while reducing the carbon foot print by 10-20 times.

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Prof. Ho Won Jang

· Seoul National University, Republic of Korea

| Biography

Ho Won Jang, a Full Professor in the Department of Materials Science and Engineering at Seoul National University, leads a research group focused on pioneering new materials and devices. After earning his Ph.D. from POSTECH in 2004, he expanded his expertise as a Research Associate at the University of Wisconsin-Madison and as a Senior Research Scientist at KIST. Since joining SNU in 2012, his work has made significant contributions to diverse technological fields. His research portfolio includes developing materials for solar fuel generation, high-performance chemical sensors, nonvolatile memory, and neuromorphic computing systems, often leveraging phenomena such as plasmonics, ferroelectrics, and metal-insulator transitions. He is associate editors for journals including Exploration (IF: 30.4) and EcoEnergy. With over 700 peer-reviewed publications, professor Jang is a recognized international leader in materials science.

Linearly programmable memristors for neuromorphic computing hardware

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| Abstract

In conventional von Neumann architecture computing, a major bottleneck exists between the processor and memory, leading to high power consumption. To overcome this limitation, neuromorphic computing, which mimics the human brain, has emerged as a promising solution. Just as synapses in the brain perform both memory and computation simultaneously, researchers are developing neuromorphic hardware that uses memristors as artificial synapses and neurons. These devices can store multiple resistance states at low power, which are then used for computation. Our research team is focusing on new materials to overcome the limitations of amorphous metal oxides, which are commonly used in existing memristors.

Amorphous metal oxides operate via a conductive filament mechanism, which results in asymmetric and non-linear synaptic weight modulation. This leads to low accuracy in parallel computing and poor energy efficiency. To address this, our team has utilized halide perovskite materials, which have high ion mobility. While conventional organic-inorganic hybrid perovskites suffered from moisture instability and low reliability, the researchers developed a vertically aligned 2D halide perovskite [1]. The devices operate stably in the air for several months. By providing a uniform ion migration pathway, this new material enables highly linear and symmetric synaptic weight modulation. This breakthrough significantly enhances the accuracy and energy efficiency of AI computations.

Reference

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Prof. Sung Kyu Lim

· Electrical and Computer Engineering
· University of Southern California

| Biography

Dr. Sung Kyu Lim is Dean's Professor of Electrical and Computer Engineering at the University of Southern California, joining in Fall 2025 after over two decades at Georgia Tech. He received his B.S., M.S., and Ph.D. in Computer Science from UCLA. His research focuses on the architecture, design, and electronic design automation (EDA) of 2.5D and 3D integrated circuits, with over 450 publications. Dr. Lim is an IEEE Fellow and recipient of major awards including multiple Best Paper Awards (DAC 2023, TCAD 2022), and several Georgia Tech teaching honors. From 2022 to 2024, he served as a Program Manager at DARPA's Microsystems Technology Office.

Logic Folding and Fine-Grained Logic-on-Logic 3D ICs: A Key Enabler of Tau Law

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| Abstract

Fine-grained 3D ICs distribute individual logic gates across multiple tiers using a logic-on-logic stacking architecture, enabling a level of integration beyond conventional memory-on-logic designs. This approach has demonstrated superior power, performance, and area (PPA) compared with coarse-grained 3D integration, and recent processors employing Logic Folding exemplify its growing adoption. Fine-pitch bonding technologies, such as face-to-face hybrid bonding, have made fine-grained 3D ICs practical. Realizing their full potential, however, requires advanced physical design methodologies that co-optimize millions of gates across tiers while efficiently managing millions of hybrid-bond interconnects. In this talk, we present novel algorithms and methodologies for physical design and multi-physics analysis of fine-grained 3D ICs, achieving significant PPA improvements over both coarse-grained 3D ICs and state-of-the-art 2D designs. We also discuss AI EDA techniques for reducing cross-tier connectivity while preserving PPA and improving yield, manufacturability, and testability.

Prof. Yiran Chen

· Electrical and Computer Engineering
· Duke University

| Biography

Yiran Chen is the John Cocke Distinguished Professor of Electrical and Computer Engineering at Duke University. He serves as Principal Investigator and Director of the NSF AI Institute for Edge Computing Leveraging Next Generation Networks (Athena), Director of the Institute for AI Engineering (IAIE), and Co-Director of the Duke Center for Computational Evolutionary Intelligence (DCEI). His research spans emerging memory and storage technologies, machine learning systems, neuromorphic computing, and edge AI. He has authored more than 700 publications and holds 96 U.S. patents. His research has been recognized with three Test-of-Time Awards and 15 Best Paper and Best Poster Awards. He is a recipient of the IEEE Circuits and Systems Society Charles A. Desoer Technical Achievement Award, the IEEE Computer Society Edward J. McCluskey Technical Achievement Award, and the IEEE Council on Electronic Design Automation A. Richard Newton Technical Impact Award. Chen is the founding Editor-in-Chief of the IEEE Transactions on Circuits and Systems for Artificial Intelligence (TCASAI) and the founding Chair of the IEEE Circuits and Systems Society's Machine Learning Circuits and Systems (MLCAS) Technical Committee. He is a Fellow of the AAAS, ACM, IEEE, and NAI, and a member of the European Academy of Sciences and Arts.

Energy-Efficient Hardware for AI: Subthreshold Silicon Neurons and Gain-Cell Analog In-Memory Computing

Yiran Chen

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| Abstract

Emerging devices and circuits open a path to energy-efficient AI hardware beyond what conventional digital accelerators reach. This talk presents two complementary efforts at Duke. The first is a compact subthreshold Izhikevich silicon neuron in the SkyWater SKY130 process, operating at 0.487 V with picoampere-level bias currents. Operational transconductance amplifiers set the recovery and coupling parameters through external tail currents, which eliminates the fixed transistor-ratio control of prior subthreshold neurons and holds biological time scales in an 18 umx 19 um footprint. The design reproduces seven canonical cortical firing patterns across five process corners in post-layout extracted simulation. The second effort is a 4T1C gain-cell for output-stationary analog in-memory computing in 40 nm CMOS. The cell accumulates a matrix multiplication inside the array over 29,000 analog states with a 50 ps, 0.02 fJ write, and per-cell calibration holds the result within two 7-bit codes of a digital baseline. The dataflow runs 1572x fewer multiply-accumulate cycles and uses 4.5x less energy than a weight-stationary baseline.

Prof. Kaustav Banerjee

· Electrical and Computer Engineering
· Director of the Nanoelectronics Research Laboratory
· University of California, Santa Barbara

| Biography

Kaustav Banerjee is Professor of Electrical and Computer Engineering and Director of the Nanoelectronics Research Laboratory at the University of California, Santa Barbara. His research has helped establish atomically thin two-dimensional (2D) materials as a leading platform for energy-efficient nanoelectronics. Through predictive, device-physics-driven frameworks, his group has revealed fundamental scaling and performance limits of silicon–copper technologies and developed physically realistic, manufacturable pathways beyond them.

His contributions include pioneering the understanding and engineering of metal–2D-semiconductor interfaces; advancing intercalation-doped multilayer graphene for energy-efficient, beyond-copper interconnects; inventing the graphene kinetic inductor for highly miniaturized radio-frequency electronics; and developing CMOS-compatible, transfer-free graphene synthesis. His graphene-interconnect technologies have been independently validated by leading semiconductor manufacturers and incorporated into advanced semiconductor technology roadmaps. Collectively, his work has influenced semiconductor pathfinding worldwide, helping define future directions in advanced logic, memory, heterogeneous integration, and energy-efficient AI computing. To accelerate translation into semiconductor manufacturing, he co-founded Destination 2D in 2021, which is developing 300-mm graphene platforms for interconnects, thermal management, and advanced packaging.

Professor Banerjee is a Fellow of IEEE, APS, AAAS, JSPS, and AIIA, and a Clarivate Highly Cited Researcher. His honors include the IEEE Kiyo Tomiyasu Award, one of IEEE's highest technical distinctions; the prestigious Friedrich Wilhelm Bessel Research Award from Germany's Alexander von Humboldt Foundation; and the JSAP Fellow International, a major international distinction of the Japan Society of Applied Physics.

From Atoms to Architectures: Two-Dimensional Materials for Energy-Efficient AI and Emerging Computing

Kaustav Banerjee

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| Abstract

As conventional silicon and copper technologies approach fundamental limits in scaling, power density, interconnect performance, and integration, two-dimensional (2D) materials offer new opportunities for energy-efficient information processing. Their atomically thin bodies, pristine van der Waals interfaces, tunable electronic properties, and compatibility with low-temperature processing enable innovations spanning nanoscale devices, beyond-copper interconnects, and monolithic three-dimensional (M3D) integration.

This talk will present an atoms-to-architectures research framework that connects the physics and engineering of 2D materials to the energy, communication, memory, and integration requirements of future AI and emerging computing systems. Topics will include predictive approaches to metal-contact and interface engineering in 2D semiconductors; ultra-low-power transistors enabled by atomically sharp electrostatics; intercalation-doped multilayer graphene for beyond-copper interconnects and ultra-compact graphene kinetic inductors; and low-temperature 2D-material integration for densely interconnected three-dimensional logic and memory. The talk will also highlight how the diverse electronic properties of layered materials can enable novel neuromorphic and quantum-device concepts.

Finally, Professor Banerjee will discuss the translation of these advances from fundamental materials discoveries to manufacturable semiconductor technologies, including CMOS-compatible graphene synthesis, foundry validation, technology-roadmap adoption, and commercialization. Together, these developments illustrate how atomically engineered materials, interfaces, and architectures can address the power, communication, memory, and thermal bottlenecks that increasingly limit the energy efficiency of AI-era computing.

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Prof. Sanghun Jeon

· KAIST, Republic of Korea

| Biography

S. Jeon is a Professor in the School of Electrical Engineering and the School of Semiconductor Systems Engineering at KAIST, Republic of Korea, where he leads the ANTONIS Laboratory. His current research spans neuromorphic devices, HfOz-based ferroelectric devices, nonvolatile logic and storage-class memory, and in-sensor computing, with a recent focus on memory-centric computing, processing-in-memory (PIM), and the monolithic 3D (M3D) integration of hafnium-based ferroelectrics with piezoelectric and optical sensors for in-sensor processing and bio-inspired artificial sensory systems. According to Google Scholar, his work has accumulated over 15,700 citations, with an h-index of 62 and an i10-index of 223 (nearly half of that citation count accrued since 2021 alone), reflecting sustained impact across both his earlier work on oxide-semiconductor/flexible sensors and his more recent ferroelectric-memory and neuromorphic-device research.

Over the past two years, he has published 12 papers at IEDM and VLSI, the two most prestigious conferences in the semiconductor field. One of his IEDM 2025 papers was selected as an IEDM Highlight Paper, and - ahead of the conference presentation - was separately and exclusively featured in the News & Views section of Nature Electronics on December 5, 2025. A companion paper presented at the same conference was selected as a Best Ranked Student Paper, together underscoring his group's leadership in this field on the global stage.

His research contributions have been recognized with the Minister's Commendation (2022) and Minister's Award (2023) from Korea's Ministry of Trade, Industry and Energy, and the President's Award from the Korea Evaluation Institute of Industrial Technology (KEIT) (2025).

Polarity-Configurable Photodiodes for In-Pixel Computing in Neuromorphic AI Vision

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| Abstract

The rapid expansion of AI applications across autonomous driving, robotics, and cloud computing has driven a steep rise in computational load and energy consumption. In hybrid CNN-SNN vision architectures, the feature-extraction stage dominates the power budget, consuming over 86% of total energy due to the conventional von-Neumann bottleneck between sensor, memory, and processor. Realizing spike-based, in-pixel feature extraction therefore requires a reconfigurable photodiode capable of generating optical convolution kernels directly at the sensor plane. Conventional PIN photodiodes, however, are limited to unidirectional (positive) photocurrent, making the signed-weight kernels required for edge detection physically unrealizable.

In this work, we propose a Polarity-Configurable Photodiode (PCPD) that electrically reconfigures the photocurrent polarity through a vertical N-I-P-I-N junction on an SOI substrate. The device shows near-zero dark current regardless of bias polarity and a linear, symmetric bipolar photoresponse under forward and reverse bias, enabling both positive and negative kernel weights within a single two-terminal pixel. A 3×3 PCPD array was used to implement Sobel, Laplacian, and Emboss spatial filters directly at the optical input stage, and edge features were experimentally extracted without digital post-processing. The PCPD was further monolithically integrated with a CMOS-compatible, poly-Si complementary-TFT Spike Enabler, converting the convolution photocurrent into a frequency-encoded spike train that scales linearly with illumination intensity. This CMOS-Compatible Spike-Embedded Neuromorphic Sensor (C-SENS) performs in-sensor blurring, smoothing, and noise suppression that improve the classification accuracy and noise robustness of a downstream spiking neural network. This work was selected as a 2025 IEDM Highlight Paper and separately featured in Nature Electronics' News and Views [1]. As future work, the PCPD will be extended toward megapixel-scale arrays through wafer-to-wafer (W2 W) hybrid bonding, enabling further scaling of the reconfigurable in-pixel neuromorphic vision platform beyond the thermal-budget limitations of monolithic-3D integration.

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Dhireesha Kudithipudi

· Director of MATRIX AI Consortium & NUAI Lab
· Professor, Departments of ECE/CS
· UT San Antonio

| Biography

Dr. Dhireesha Kudithipudi is the Robert F. McDermott Endowed Chair in Electrical and Computer Engineering at UT San Antonio and Founding Director of the MATRIX AI Consortium. Her interests are in brain inspired AI, neuromorphic computing, novel computing substrates (eg: memristors), energy efficient machine intelligence, and AI accelerators. Recognized for her research in continual learning and brain inspired AI architectures, she leads the national THOR infrastructure hub to democratize access to open access neuromorphic hardware. Her team fabricated the first spiking neural network accelerator designed for lifelong learning at the edge. As Co-PI on DARPA's Lifelong Learning Machines program, she published foundational perspectives on continual learning in Nature Machine Intelligence and Nature Electronics, alongside leading multiple centers of excellence in AI systems.

The Next Horizon of AI Hardware: Silicon That Learns Continually

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Abstract

Learning from streaming real-world data remains a core challenge for standard AI systems. Real-world environments generate nonstationary data that arrives incrementally, demanding models that can continually learn new knowledge without forgetting what was learned in the past. Conventional models, however, assume stationary data distributions and depend on high-precision, idealized weights. Although various algorithmic advancements have been proposed to mitigate forgetting, they become inefficient when deployed on emerging non-volatile memory devices like FeFETs and ReRAM whose limited weight precision and intrinsic stochasticity conflict with the assumptions underlying these methods. Overcoming catastrophic forgetting on edge hardware requires an algorithm hardware co design strategy that actively embraces these device non idealities within sub-watt power budget.

Grounded in our team's brain inspired continual learning framework, this talk presents how biological principles, such as metaplasticity, neuromodulation, near memory processing, and spiking neural architectures, can be natively mapped onto custom silicon to achieve continual learning.

Associate Prof. Jiyong Woo

· Kyungpook National University, South Korea

| Biography

Jiyong Woo received the Ph.D. degree in materials science and engineering from the Pohang University of Science and Technology, Pohang, South Korea, in 2017. He is currently an Associate Professor of Electronic and Electrical Engineering from the Kyungpook National University, Daegu, Republic of Korea.

Probabilistic Bits for Unconventional Computing Systems

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| Abstract

The rapid development of artificial intelligence in the big data era has increased the demand for solving complex combinatorial optimization problems (COPs) such as vehicle routing problem (VRP), which are difficult to efficiently handle with conventional von-Neumann computing systems. Quantum computing, which utilizes quantum bits (qubits) based on the superposition of spin, shows potential for solving COPs. However, the requirement of cryogenic operating environments-necessary for noise elimination and accurate spin detection-remains a significant drawback. To address these challenges, probabilistic computing (P-computing) has recently been proposed as an alternative approach to emulate quantum supremacy even at room temperature.

Here, we showed probabilistic bits (P-bits) with a novel Ti/SiO /Ti stack, which is a fundamental building block for P-computing. The SiOx layer typically exhibits reliable TS behavior, resulting in robust voltage oscillations. When a Ti scavenging layer was introduced at the interface, oxygen vacancies were provided to the SiOx causing oscillation to occur probabilistically. Through physical analysis and numerical calculations considering the charging and discharging process, we investigated the underlying mechanism of P-bit operation in the Ti/SiOx/Ti stack. This results in a sigmoidal probability curve for '1' over a wide range of input voltage. Finally, we verified that leveraging the developed SiOx-based P-bit can significantly accelerate the algorithm for finding the optimal path in the vehicle routing problem through MATLAB simulation.

Prof. Alper Bozkurt

· Associate Professor
· Electrical and Computer Engineering
· North Carolina State University

| Biography

Prof. Alper Bozkurt currently serves as the McPherson Family Distinguished Professor in Engineering Entrepreneurship in the Department of Electrical and Computer Engineering at NC State University. He received a doctorate in electrical engineering from Cornell University and a master's degree in biomedical engineering from Drexel University. He is the founder and Director of the Integrated Bionic MicroSystems (iBionicS) Laboratory, the Co-Director of the National Science Foundation Nanosystems Engineering Research Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) and the co-founder and Co-Director of the Institute of Connected Sensor Systems (IConS) at NC State University. Bozkurt is a recipient of the Donald Kerr Award at Cornell University, the Chancellor's Innovation Award (three times), the Outstanding Global Engagement Award, and the William F. Lane Outstanding Teacher Award at NC State University, several IBM Faculty Awards, the Faculty Early Career Development (CAREER) Award from the National Science Foundation and the IEEE Sensors Council Young Professional Award in addition to being included in Popular Science Magazine's "Brilliant 10" list in 2015. Bozkurt's team has received best paper awards from the U.S. Government Microcircuit Applications & Critical Technology Conference, IEEE Sensors Conference, IEEE Body Sensor Network Conference, FLEX Conference, and ACM Animal-Computer Interaction Conference. The innovations resulting from his team's work have led to the spin-off of six companies from NC State.

Designing for Energy Efficiency: Advances in Wearable Sensing from NSF ASSIST Center

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| Abstract

This talk summarizes key research advances from the NSF ASSIST Engineering Research Center in developing energy-efficient wearable and implantable sensing technologies for continuous health monitoring. The presentation highlights innovations in ultra-low-power sensor design, energy harvesting, embedded artificial intelligence, wireless communication, and multimodal physiological monitoring that enable long-term, unobtrusive operation. Selected examples demonstrate the translation of these technologies into applications ranging from personalized healthcare and rehabilitation to human-animal interaction and environmental sensing.

Prof. Young Min Song

· School of Electrical Engineering, KAIST, Republic of Korea

| Biography

Dr. Young Min Song is an Endowed Chair Professor in the School of Electrical Engineering at the Korea Advanced Institute of Science and Technology (KAIST), Korea. Prior to joining KAIST, he served as Assistant, Associate, and Full Professor at the Gwangju Institute of Science and Technology (GIST) from 2016 to 2025, and as an Assistant Professor at Pusan National University from 2013 to 2016. He received his B.S. degree in Biomedical Engineering from Yonsei University in 2004, and his M.S. and Ph.D. degrees in Information and Communications from GIST in 2006 and 2011, respectively. From 2011 to 2013, he worked as a postdoctoral research associate in the Department of Materials Science and Engineering at the University of Illinois at Urbana-Champaign. Dr. Song's research interests include advanced optoelectronic devices and systems, multi-functional nanophotonics, and optical healthcare technologies. He is a Senior Member of Optica, and a member of SPIE and the Materials Research Society (MRS). He currently serves as a Senior Editor of the IEEE Photonics Journal, and as an Editorial Board Member of the Journal of Optical Microsystems (JOMs) and Soft Science. He is also a member of the Young Korean Academy of Science and Technology (Y-KAST).

Bioinspired Vision Systems for Intelligent Robotics

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| Abstract

As robotic systems increasingly operate in unstructured and dynamically changing environments, there is a growing demand for vision systems that are not only multifunctional but also compact, energy-efficient, and manufacturable at scale. Conventional camera architectures, largely inherited from planar and monolithic design paradigms, face fundamental limitations in meeting these requirements. In this context, bio-inspired cameras-drawing inspiration from the diverse visual ecologies of animals-offer promising alternative design principles.

This talk highlights recent advances in bio-inspired electronic eyes, with a particular emphasis on how micro- and nano-fabrication technologies enable the translation of complex biological ocular architectures into functional artificial vision systems. By leveraging advanced fabrication strategies such as micro-optical components, nanoscale photonic elements, heterogeneous material integration, and mechanically deformable electronics, animal-inspired visual functions-such as wide field-of-view imaging, foveated and multispectral vision, and adaptive light management—can be realized in compact and integrable device platforms.

Through representative examples including feline-, avian-, and stretchable eye-inspired systems, this presentation discusses how micro/nano fabrication serves as a critical bridge between visual ecology and practical robotic vision hardware. The convergence of bio-inspired design and scalable fabrication technologies opens new pathways toward next-generation robotic vision systems that are both functionally rich and manufacturable [1-6].

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Paschalis Gkoupidenis

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| Biography

Paschalis Gkoupidenis is an Associate Professor at North Carolina State University and former Independent Group Leader at the Max Planck Institute for Polymer Research. His research lies at the intersection of materials science, electronics, and neuroscience, with a focus on organic neuromorphic devices and circuits for bioelectronics, robotics, and brain-inspired computing. He pioneered the development of organic electrochemical synapses and neuromorphic circuits that enabled autonomous learning in robotics, introduced electrolyte-based neuromorphic architectures, and developed organic artificial spiking neurons capable of biorealistic communication with living tissue. His work has established the foundations of organic neuromorphic electronics, opening new directions for bioinspired computing technologies. Gkoupidenis has authored more than 70 peer-reviewed publications, and his research has been featured in Scientific American, Yale Scientific, and Max Planck Magazine. In 2025, he received the Seligson Innovation Award in Organic Electronics from Universal Display Corporation in recognition of his pioneering contributions to organic neuromorphic electronics.

Organic neuromorphic electronics

Paschalis Gkoupidenis

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| Abstract

Organic neuromorphic electronics harnesses ionic and electrochemical processes to emulate core features of synaptic adaptation and neural computation in a bio-realistic and highly efficient manner. In this talk, we will explore how organic and iontronic materials enable the design of neuromorphic devices and circuits that can sense, process, and respond in real time, forming the foundation for both intelligent systems and efficient neuromorphic biointerfaces.

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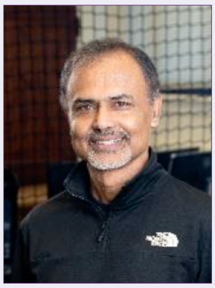

Kaushik Roy

· Professor of Electrical and Computer Engineering
· Purdue University

| Biography

Kaushik Roy is the Edward G. Tiedemann, Jr., Distinguished Professor of Electrical and Computer Engineering at Purdue University. He received his BTech from Indian Institute of Technology, Kharagpur, PhD from University of Illinois at Urbana-Champaign in 1990 and joined the Semiconductor Process and Design Center of Texas Instruments, Dallas, where he worked for three years on FPGA architecture development and low-power circuit design. His current research focuses on cognitive algorithms, circuits and architecture for energy-efficient neuromorphic computing/ machine learning, and neuro-mimetic devices. Kaushik has supervised 118 PhD dissertations and his students are well placed in universities and industry. He is the co-author of two books on Low Power CMOS VLSI Design (John Wiley & McGraw Hill).

Dr. Roy received the National Science Foundation Career Development Award in 1995, IBM faculty partnership award, ATT/Lucent Foundation award, 2005 SRC Technical Excellence Award, SRC Inventors Award, Purdue College of Engineering Research Excellence Award, Outstanding Mentor Award in 2021, Humboldt Research Award in 2010, 2010 IEEE Circuits and Systems Society Technical Achievement Award (Charles Desoer Award), IEEE TCVLSI Distinguished Research Award in 2021, Distinguished Alumnus Award from Indian Institute of Technology (IIT), Kharagpur, Fulbright-Nehru Distinguished Chair, DoD Vannevar Bush Faculty Fellow (2014-2019), SRC Aristotle Award in 2015, Purdue Arden L. Bement Jr. Award in 2020, SRC Innovation Award in 2022, honorary doctorate from Aarhus University in 2023, and best paper awards at 1997 International Test Conference, IEEE 2000 International Symposium on Quality of IC Design, 2003 IEEE Latin American Test Workshop, 2003 IEEE Nano, 2004 IEEE International Conference on Computer Design, 2006 IEEE/ACM International Symposium on Low Power Electronics & Design, 2005 and 2019 IEEE Circuits and system society Outstanding Young Author Award (Chris Kim, Abhronil Sengupta), 2006 IEEE Transactions on VLSI Systems best paper award, 2012 ACM/IEEE International Symposium on Low Power Electronics and Design best paper award, 2013 IEEE Transactions on VLSI Best paper award. Dr. Roy was a Purdue University Faculty Scholar (1998-2003). He was a Research Visionary Board Member of Motorola Labs (2002) and held the M. Gandhi Distinguished Visiting faculty at Indian Institute of Technology (Bombay) and Global Foundries visiting Chair at National University of Singapore. He has been in the editorial board of IEEE Design and Test, IEEE Transactions on Circuits and Systems, IEEE Transactions on VLSI Systems, and IEEE Transactions on Electron Devices. He was Guest Editor for Special Issue on Low-Power VLSI in the IEEE Design and Test (1994) and IEEE Transactions on VLSI Systems (June 2000), IEE Proceedings -- Computers and Digital Techniques (July 2002), and IEEE Journal on Emerging and Selected Topics in Circuits and Systems (2011). Dr. Roy is a fellow of IEEE.

From Devices to Algorithms: Neuromorphic Computing for Energy-Efficient Autonomy

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| Abstract

As autonomous systems become increasingly capable, their growing computational demands create a fundamental challenge: how can we deliver intelligence at the edge while operating within severe energy and resource constraints? Neuromorphic computing offers a promising path by rethinking computation across the stack—from emerging devices and circuits to architectures and learning algorithms—drawing inspiration from the efficiency of biological neural systems. In this talk, I will discuss our efforts to develop such cross-layer neuromorphic systems, with an emphasis on exploiting device characteristics and brain-inspired architectures to reduce the energy and latency of computation. I will highlight how algorithm–hardware co-design can enable adaptive, event-driven intelligence while minimizing data movement and computation. Autonomous aerial platforms, such as drones, provide a compelling example where these advantages can translate directly into longer flight times, faster response, and greater onboard autonomy.

Poster Session

Chair

Myung S. Jhon

Matthew Flavin

· Assistant professor
· School of Electrical and Computer Engineering
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| Biography

Prof. Matthew Flavin is an assistant professor in the School of Electrical and Computer Engineering at the Georgia Institute of Technology where he has led the Flavin Neuromachines Lab since Fall 2024. Before joining the faculty at Georgia Tech, he was a postdoctoral researcher at Northwestern University. He received his M.S. and Ph.D. degrees in Electrical Engineering in 2017 and 2021 from the Massachusetts Institute of Technology (MIT), and he received his B.S. in Electrical Engineering in 2015 from the University of Illinois at Urbana-Champaign (UIUC). Dr. Flavin is the Sutterfield Family Junior Professor in ECE. Dr. Flavin develops powerful peripheral neural interfaces and mechatronic wearables that leverage advanced embedded sensors and intelligent systems to address important and unresolved challenges in patient care. His work sponsored by ARPA-H and NSF aims to answer fundamental questions about the nature of cutaneous sensation, and it aims to introduce new clinical approaches for monitoring and treating sensory impairments.

Scalable networks of wearable bioelectronics for treating sensory impairments

Matthew Flavin

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Abstract

Just as our eyes perceive red, green, and blue as the basis for color vision, our skin perceives pressure, stretch, vibration, and temperature as the basis for understanding our physical surroundings. Skin-mediated perception is central to our everyday lives; for example, our feet provide the first point of contact with our environment during walking, and patients with conditions such as stroke and spinal cord injury, who have lost the ability to perceive this contact, often face major challenges with balance and mobility. Here, we introduce a wireless network of skin-conformable, multimodal haptic arrays that deliver high-density thermal and vibrotactile patterns anywhere on the body. These haptic arrays form the receivers in a sensory substitution system that delivers patterns of vibrotactile stimulation to mirror the distribution of pressure recorded from an insole-based array of pressure sensors. Exploratory case studies in individuals with spinal cord injury and stroke demonstrate feasibility and suggest improved performance during standing balance and walking tests. Altogether, this work highlights the potential of information-rich cutaneous interfaces to substitute plantar sensation, expanding the scope of somatosensory engagement for rehabilitation, entertainment, and education.

Tingjun Chen

· Assistant Professor
· Electrical & Computer Engineering
· Duke University

| Biography

Tingjun Chen is the Nortel Networks Assistant Professor of Electrical & Computer Engineering at Duke University. His research focuses on the networking, communication, sensing, and energy-efficient computing aspects of wireless, mobile, and optical networked systems, bridging both theoretical foundations and experimental platforms. He received his Ph.D. degree in Electrical Engineering from Columbia University in 2020, and his B.Eng. degree in Electronic Engineering from Tsinghua University in 2014. Between 2020–2021, he was a Postdoctoral Associate at Yale University. He has received multiple awards including the NSF CAREER Award, Google Research Scholar Award, IBM Academic Awards, NVIDIA Academic Awards, Columbia Engineering Morton B. Friedman Memorial Prize for Excellence, Columbia University Eli Jury Award, and the Facebook Fellowship. He is also a co-recipient of several paper awards from ACM CoNEXT, ACM MobiHoc, IEEE MTT-S IMS, IEEE/Optica OFC, and ECOC. His Ph.D. thesis was recognized by the ACM SIGMOBILE Dissertation Award Runner-up.

Radio Frequency Neural Networks

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| Abstract

Modern edge devices, including cameras, drones, and Internet-of-Things nodes, increasingly rely on machine learning to support intelligent applications. However, running machine learning models directly on resource-constrained edge devices often requires substantial memory and computational power, making real-time inference difficult with conventional digital computing architectures. In this talk, I will present WISE, a computing architecture for wireless edge networks that enables radio-frequency neural networks. WISE introduces two key ideas: first, disaggregated model access, where model parameters are delivered through over-the-air wireless broadcasting to support simultaneous inference across multiple edge devices; and second, in-physics computation, where general complex-valued matrix-vector multiplications are performed directly at radio frequency using a single frequency mixer. Together, these ideas point toward a new way of building low-power, scalable, and wireless-native machine learning systems at the edge.

Honggi Jeon

· Department of Electrical and Computer Engineering
· Duke University

| Biography

Honggi Jeon is a postdoctoral associate in the Department of Electrical and Computer Engineering at Duke University, where he develops barium-ion systems for quantum computing. He earned his Ph.D. in physics from Seoul National University and previously conducted research at MIT, Seoul National University, and Sungkyunkwan University. His research focuses on scalable trapped-ion quantum hardware, quantum control, and continuous-variable quantum information processing. His current research focuses on developing advanced control methods for trapped barium ions.

Robust meta-stable qutrit and mid-circuit cooling of barium ions

Honggi Jeon[1,2], Isaac Fouch[1,3], Kate Choi[1,2], Jungsang Kim[1,2,3]*

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| Abstract

Trapped ion qubits provide long coherence time and high-fidelity quantum operation. Many trapped-ion systems rely on qubits encoded in ground-state hyperfine levels, but they are only a part of the complex quantum structure of the trapped ion. More advanced control techniques that exploit metastable states and light shifts could advance the capabilities of trapped-ion quantum computers [1,2,3,4]. In this talk, I will discuss two on-going research efforts. The first uses three levels within a metastable manifold of the barium-137 ion to provide qutrit states that are nearly insensitive to magnetic field fluctuations. The characteristics of the qutrit states and methods for controlling them will be explored. The second uses a spatially selective light shift in a chain of ions to enable mid-circuit cooling that minimally affects the quantum information in the neighboring ions. This scheme enables coolant ions to be dynamically assigned in a single-isotope chain, avoiding the technical overhead of having to work with multiple isotopes or multiple atomic species for cooling.

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Inhee Lee

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| Biography

Inhee Lee is an assistant professor in the Electrical and Computer Engineering department at the University of Pittsburgh. Inhee Lee received his B.S. and M.S. degrees in electrical and electronic engineering from Yonsei University, South Korea, in 2006 and 2008, respectively, and a Ph.D. degree in electrical engineering from the University of Michigan in 2014. He was an assistant research scientist at the University of Michigan from 2015 to 2019. Currently, he is leading PITT Circuit Lab developing adaptive, energy-efficient reference circuits, sensor interfaces, energy harvesters, power management circuits, machine learning accelerators, emerging memory interfaces, and Cryogenic-CMOS circuits. Also, he is developing low-power millimeter-scale or even smaller sensing/computing systems for ecological, biomedical, energy exploration, and internet-of-things applications. Dr. Lee is an IEEE senior member and has been serving as a Technical Program Committee (TPC) Member for IEEE International Solid-State Circuits Conference (ISSCC), IEEE Symposium on VLSI Technology and Circuits (VLSI), IEEE Custom Integrated Circuits Conference (CICC), IEEE Asian Solid-State Circuits Conference (ASSCC), IEEE Circuits & Systems (CAS) Analog Signal Processing Technical Committee (ASPTC) and ACM/IEEE International Symposium on Low Power Electronics and Design (ISLPED).

Millimeter-Scale Neuromorphic Vision System

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| Abstract

Millimeter-scale sensing semiconductor devices offer a unique combination of features, including wireless communication, energy harvesting, and ultra-compact form factors. These capabilities enable non-invasive and secure deployment in next-generation Internet-of-Things (IoT) applications across biomedical, ecological, surveillance, and infrastructure domains. Significant progress in miniaturization has advanced the vision of “smart dust” at the millimeter scale. Meanwhile, emerging artificial intelligence (AI) technologies are enhancing the intelligence, accuracy, and reliability of traditional sensing systems. Motivated by these advances, I am investigating how to integrate advanced machine learning (ML) techniques to further expand the capabilities of millimeter-scale sensing platforms.

In this talk, I will highlight the key challenges involved in developing ultra-small sensing systems and introduce a millimeter-scale platform recognized as the world’s smallest computer. I will also present recent research advances in digital circuit design for implementing Dynamic Neural Fields (DNF) and Convolutional Neural Networks (CNN), enabling bio-inspired dynamic vision sensing (DVS) for low-power object classification and motion tracking.

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Wonjae Lee

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| Biography

Wonjae Lee is a Postdoctoral Fellow in the Department of Physics at Harvard University, where she is a member of the Norman Yao group. She will join the Department of Physics at Syracuse University as an Assistant Professor in January 2027. Her research focuses on quantum sensing and quantum simulation of many-body systems, with an emphasis on experimental platforms based on optically active spin defects in two-dimensional materials and alkali-vapor systems. Her current work investigates negatively charged boron vacancies in hexagonal boron nitride as a platform for nanoscale quantum sensing and strongly interacting spin systems.
She received her Ph.D. in Physics from Princeton University in 2022 under the supervision of Michael V. Romalis, where she developed ultra-high-sensitivity atomic magnetometers capable of operating in unshielded environments. She earned her B.A. in Physics, summa cum laude, from Amherst College in 2016, working with David S. Hall on synthetic gauge fields and topological spin textures in Bose–Einstein condensates.

Strongly-interacting, two-dimensional ensembles of spin defects in hexagonal boron nitride

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| Abstract

Conventionally, strongly interacting color center ensembles are three-dimensional in nature. While such systems have been used extensively as both quantum sensors and simulators of many-body dynamics, the ability to access lower dimensional physics using such solid-state color centers remains an exciting prospect [1]. Here, we investigate the many-body dynamics of ensembles of negatively-charged boron vacancy (VB−) defects in few-layer hBN flakes [2], where the flake thickness is smaller than the average inter-defect spacing. In this regime, we demonstrate that the emergent spin dynamics are governed by the native dipolar interactions between the VB− defects. In particular, we utilize a form of many-body noise spectroscopy where the dimensionality directly enters the temporal profile of the VB− decoherence dynamics [3]. Building on this, we perform measurements of local spin auto-correlation functions in order to explore and contrast spin transport in two-dimensional thin flakes and three-dimensional bulk ensembles [4].

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Dr. Robert A Nawrocki is an Associate Professor in the School of Engineering Technology (SOET) at Purdue University. He is a recipient of the 2021 Office of Naval Research, Young Investigator Award and the 2021 Ralph W. and Grace M. Showalter Research Trust Award. His current research interests include physically flexible organic electronics with the application in biopotential monitoring and soft robotics, as well as neuromorphic systems, chemical sensors, advanced manufactured functional materials and neuroscience. He completed his BS at New Jersey Institute of Technology (2004), PhD at University of Denver (2014), his internship at Eidgenössische Technische Hochschule Zürich, Switzerland (ETH) (2011), and his postdoctoral research at University of Colorado Boulder (2014), University of Nova Gorica, Slovenia (2015), and The University of Tokyo, Japan (2017). He was a visiting scholar at the Italian Institute of Technology, in Genoa, Italy between 2025 and 2026, and POSTECH, in Pohang, South Korea in 2026.

Organic, Spiking, and Flexible Embodied AI

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Abstract

Embodied AI refers to artificial intelligence that is physically integrated into and interacts with the real world through sensors, actuators, and adaptive control systems. Artificial neurons are key components of neuromorphic computing systems, a type of embodied AI system, which emulate the structure and function of biological neural networks to achieve efficient, brain-inspired computation. Most artificial neurons are implemented using rigid silicon-based technologies, limiting their integration with soft robotic platforms and biological tissues because of their lack of mechanical flexibility. Our research aims to develop networks of artificial spiking neurons based on physically flexible organic electronics for pattern recognition, sensor data processing, and the control of mechanical actuators in embodied AI systems. We have developed an electrical circuit that approximates the behavior of an Integrate-and- Fire (I&F) spiking neuron based on the Axon-Hillock model.[1] Using complementary p- and n-type organic transistors, the circuit integrates synaptic input currents and generates output voltage spikes with frequencies proportional to the input stimulus. We demonstrated its ability to encode the analog output of a chemical sensor into spike frequency, providing a biologically inspired interface between chemical sensing and neural computation.[2] We also verified that somatic circuit can generate tonic spike trains suitable for deep brain stimulation, with potential applications for treating neurological disorders such as Parkinson's disease.[3] To emulate synaptic processing, we fabricated physically flexible organic Log-Domain Integrator and Differential-Pair Integrator synaptic circuits.[4-5] These synapses convert input voltage spikes into output current traces and were characterized with respect to key synaptic parameters, including gain, weighting voltage, synaptic capacitance, and responses to input spike frequencies. The circuits exhibited biologically relevant time constants that are essential for processing real-world sensory signals. Finally, we reported the first fully organic spiking neuron integrating excitatory and inhibitory synapses with an I&F soma. This system reproduces key neural functions, including pre-synaptic signal integration, frequency modulation, adjustable synaptic weighting, and coincidence detection. As a proof of embodied interaction, the neuron was incorporated into a closed-loop light-control system that autonomously adjusts luminance in response to ambient light intensity.

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Dr. Demitry (Dima) Farfurnik is an Assistant Professor of Electrical and Computer Engineering and Physics at North Carolina State University. Farfurnik completed his Ph.D. in Physics at the Hebrew University of Jerusalem. Prior to joining NC State, he was a Postdoctoral Associate at the University of Maryland, College Park. His research focuses on the studies of fundamental science and development of novel quantum technologies utilizing optically-active spin systems in the solid-state such as quantum dots and color centers.

Toward scalable photonic entanglement using quantum dots coupled to inverse-designed nanophotonic cavities

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| Abstract

Photons entangled in complex graph topologies can enable a variety of applications including measurement-based quantum computing, all-photonic quantum repeaters, and heterogeneous quantum interconnects. Since photons do not interact with each other, the deterministic generation of scalable photonic entanglement requires an intermediate interface achievable by coupling a matter qubit to a photonic cavity with high cooperativity. In this work, we experimentally demonstrate the coupling of a quantum dot incorporated in a charge-stabilizing p-i-n-i-n diode to a periodic ("bullseye") cavity of rings with a cooperativity as high as 8. By using a guided mode expansion-based inverse-design algorithm, we show that a further X8 cooperativity enhancement is achievable by utilizing a novel cavity with a unique asymmetric ring geometry. The resulting cooperativity could lead to the deterministic entanglement of polarization-encoded photons with fidelity of > 95%, enabling the entanglement of photons in complex topologies. We present our future directions of generating and characterizing such photonic entanglement over a real quantum network in the North Carolina Research Triangle.

Michael Kuban

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Michael Kuban is a Ph.D. candidate in Electrical and Computer Engineering at Carnegie Mellon University and a National Science Foundation Graduate Research Fellow. His research in quantum photonics centers on solid-state single-photon emitters in silicon carbide for quantum networking and sensing. His current work involves first-principles modeling of defects in 4H-SiC and experimental characterization techniques for single-photon emitters. Michael earned his M.S. in Electrical and Computer Engineering from Carnegie Mellon and his B.S. in Engineering Physics from The Ohio State University. Before his doctoral studies, he was a quantum communications intern at NASA Glenn Research Center. He is a member of the Pittsburgh Quantum Institute and has authored technical papers in the fields of quantum communications and quantum-defect modeling.

Ab Initio Investigation of Erbium Point Defects in 4H-SiC for Quantum Emitters

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| Abstract

Erbium-doped 4H-SiC is a promising platform for integrated quantum photonics because the intra-4f transition of Er^{3+}enables telecom-wavelength emission near 1.55 μm, while the wide-bandgap SiC host offers excellent optical properties and compatibility with established semiconductor fabrication processes. However, photoluminescence measurements alone cannot uniquely identify the atomic configuration responsible for emission, limiting the ability to engineer emitters with tailored optical properties [1]. To address this deficiency, we performed first-principles density-functional theory calculations using ABINIT [2] with the Perdew-Burke-Ernzerhof (PBE) exchange–correlation functional, projector augmented-wave (PAW) pseudopotentials, and a Hubbard U correction applied to the Er 4f states [3,4].

Eight candidate erbium defect configurations, including substitutional, interstitial, vacancy-associated, and impurity-paired complexes, were screened in 32-atom supercells and ranked by their neutral formation energies. The four most favorable structures were subsequently relaxed in neutral 128-atom supercells and then vertically screened across charge states from q =−2 to +2. Charged relaxations were then performed for the stable charge states of the lowest energy configuration, and charge-transition levels were calculated, including the Madelung image-charge correction for a finite supercell [5]. For the same configuration, k-resolved Kohn–Sham eigenvalues and projected densities of states were used to characterize the defect levels, their occupations, and their orbital character.

The calculations reveal that isolated substitutional and interstitial erbium defects are energetically unfavorable and that erbium preferentially forms complexes with impurities and carbon vacancies. The lowest-energy configuration is the hexagonal Si-substitutional defect paired with a carbon-site oxygen impurity, Er_{Si} (h)+Oc, with a formation energy of 1.08 eV. This structure is energetically favored over the corresponding nitrogen complex (2.12 eV) and over the h- and k-site carbon-vacancy complexes (3.19 and 4.86 eV). The defect exhibits a partially occupied Er 4 f manifold consistent with the 4 f^{11} electronic configuration of Er^{3+}, producing strongly localized in-gap states 2.05–2.13 eV above the valence-band maximum, with approximately 94% of the projected orbital character originating from the defect. Furthermore, formation-energy calculations reveal negative-U behavior, with the neutral charge state never becoming thermodynamically stable within the band gap and a single (+/−)transition level predicted near 2.4 eV above the valence-band maximum. These results suggest that the Er_{Si} (h)+Oc impurity complex might be a leading candidate for optically active erbium centers in 4H-SiC for the design of quantum emitters near the standard telecom wavelength of 1.55 μm.

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Brittany N. Smith

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Brittany N. Smith joined the Department of Electrical and Computer Engineering at North Carolina State University (NCSU) as an Assistant Professor in Fall 2026 where she directs the Fabrication Laboratory for Active Microelectronics (FLAME). Prior to joining NCSU, she was a Postdoctoral Researcher in the Miskin Lab at the University of Pennsylvania where she fabricated microscopic actuators for micro-scale robots (2025 – 2026). Before that, she was a Postdoctoral Researcher and PhD student in the Franklin Group at Duke University in Electrical and Computer Engineering where she focused on depositing nanomaterial inks for transistors via aerosol jet and capillary flow printers (2020 – 2025). She received her B.S.E. degree from the University of Connecticut in 2020 and Ph.D. degree from Duke University in July 2024, both in Electrical and Computer Engineering. She is excited to establish her research program at NCSU and welcomes new interdisciplinary collaborations.

Pushing the Limits of Active Microelectronics via Additive Manufacturing

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Abstract

Traditional microelectronics rely on rigid silicon-based devices which are ideal for phones and computers but are ill-suited for wearable devices or microscopic robotics where there exists a need for flexible components that are resilient to potentially harsh environments. Additive manufacturing has been shown to produce flexible electronics using non-traditional materials such as electrolytes, but their applications are limited due to the resolution of the tools (~10 μm). Recent work broke through the as-printed submicron resolution limit by using a capillary flow printing technique, thus paving the way for us to explore unconventional materials for submicron transistors and memory devices with the ultimate goal of designing new architectures. We are also fabricating scaled printed devices for emerging fields such as micro-scale actuators for microscopic robotics that require patterned soft electrolytes for in-air operation. As a newly established lab, the Smith group is excited to push the limits of active microelectronics by leveraging cleanroom and printer-based fabrication techniques.

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Bokyung Kim is an Assistant Professor in the Department of Electrical and Computer Engineering (ECE) at North Carolina State University. She received her Ph.D. in Electrical and Computer Engineering from Duke University in 2024. Prior to joining NC State, she was an Assistant Professor at Rutgers University. Her research focuses on memory-centric design with full-stack co-optimization with broad experience in hardware design, spanning different hardware levels through device modeling, mixed-signal VLSI, architecture/system design, and real implementations in silicon. She received the Best Paper Award from the IEEE/ACM International Symposium on Low Power Electronics and Design in 2025 and was a selected fellow of the IEEE Laureate Forum in 2026, ACM Heidelberg Laureate Forum Young Researchers in 2024, and EECS Rising Stars in 2023. She serves as a member of Board of Governors in the IEEE Circuits and Systems Society, an Associate Editor TCAS-II, as a Secretary of the Machine-Learning CAS Technical Committee.

Dataflow-Aware Memory-Centric Computing: From Synaptic Devices to Practical AI Systems

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| Abstract

Neuromorphic computing is often motivated by synaptic devices that co-locate neural state and computation. Yet their energy advantage is not determined by device physics alone; it also depends on which data remain local, how intermediate results move, and how effectively the architecture exposes device-level parallelism. My research treats this as a cross-layer dataflow problem and pursues two complementary paths.

For long-term neuromorphic systems, memristive devices support bio-inspired functions such as artificial nociception, while 3D integration increases synaptic density. A 3D memristive convolution processor and an input-stationary ReRAM architecture demonstrate how vertical organization and operand placement can translate these device capabilities into scalable neural acceleration. In parallel, conventional memories provide a near-term path for pressing needs in biomedical intelligence and privacy-preserving learning while emerging devices continue to mature. An SRAM computing-in-memory chip co-designs model and dataflow for multi-class patient-independent seizure classification, while a DRAM processing-in-memory architecture reorganizes differentially private training around its per-sample computations.

Together, these efforts establish dataflow co-design as the bridge between neuromorphic device innovation and practical memory-centric systems for efficient and trustworthy AI.

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