MIT Industrial Liaison Program Faculty Knowledgebase Report

2025 MIT Japan Conference

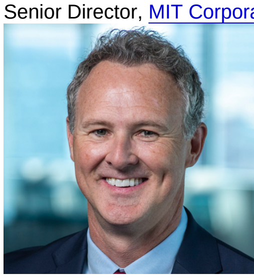
January 24, 2025 8:15 am - 7:00 pm

8:15 AM

Registration

9:00 AM

Welcome & Introduction
Steven Palmer
Senior Director, MIT Corporate Relations



Steven Palmer
Senior Director
MIT Corporate Relations

Steve Palmer is a Senior Director within MIT’s Office of Corporate Relations. Steven comes to OCR with many years of experience building relationships, advancing diplomacy, and seeking new business initiatives in both the public and private sectors. He has spent his career highlighting and translating technological issues for policy makers, engineers, analysts, and business leaders. Steven has worked in government, industry, and academia in the U.S. and abroad. He is also an Executive Coach at MIT Sloan and Harvard Business School. Steven earned his Bachelor of Science at Northeastern University, and his M.B.A. at MIT Sloan where he was in the Fellows Program for Innovation and Global Leadership.

9:15 AM

Innovations at Interfaces: Energy & Sustainability to Biomedical Technologies

Kripa Varanasi

Physico-chemical interactions at interfaces are ubiquitous across multiple industries, including energy, decarbonization, healthcare, water, agriculture, transportation, and consumer products. In this talk, Professor Varanasi summarizes how surface/interface chemistry, morphology, and thermal and electrical properties can be engineered across multiple length scales to achieve significant efficiency enhancements in a wide range of processes. These approaches involve both passive and active manipulation of interfaces.

Varanasi first describes a variety of slippery interfaces that can significantly reduce interfacial friction for efficient dispensing of viscous products, enhance thermal transport in heating and cooling systems, provide anti-icing solutions, and create self-healing barriers for protection against scaling. Active strategies are also discussed, such as engineering charge transfer to alter multiphase flows for applications like water harvesting, anti-dust systems for solar panels, and reducing agricultural runoff to address critical challenges at the energy-water and water-agriculture nexus. Varanasi highlights efforts in decarbonization and the energy transition, focusing on CO? capture and conversion as well as battery energy storage systems. These efforts include enhancing electrochemical and biological methods for CO? capture and conversion, with recent advancements in CO? capture from point sources and direct air capture (DAC), marine CO? removal via a pH-swing process using electroactive materials, and electrochemical CO? conversion to fuels, ethylene, and other valuable products. Additionally, Varanasi introduces a high-performance rechargeable battery energy storage solution that is free of lithium and cobalt, intrinsically non-flammable, and ideal for stationary storage applications, including utility grids, home storage, microgrids, data centers, warehouses, manufacturing facilities, and chemical plants.

In parallel, Varanasi discusses ongoing research in biomedical technologies, spanning biomanufacturing to ovarian cancer treatment. Surface engineering strategies are presented to prevent thrombosis and biofilm formation, tailor cell adhesion and protein adsorption, and enhance the biomanufacturing value chain. Inspired by slippery surface technologies, Varanasi introduces a novel methodology for subcutaneous injection of highly viscous biologics, expanding the range of injectable formulations and improving healthcare accessibility. Innovative approaches to protein separation via undersaturated crystallization, promoted through in-situ templating, are also described, enabling continuous biomanufacturing. Passive and active techniques for enhancing bioreactors by preventing foam buildup are detailed, with a non-invasive approach that eliminates the need for defoamers, preventing cell death caused by bubble rupture and optimizing reactor space utilization.

Throughout the talk, Varanasi addresses manufacturing and scale-up strategies, robust materials and processes, and entrepreneurial efforts to translate these technologies into impactful products and markets. Insights from the start-up companies co-founded by Varanasi are interwoven with these discussions.

9:55 AM

Innovation in Manufacturing Biomedicines: From New Modalities to Scalable, Accessible Therapeutics

Stacy Springs
Executive Director
MIT Center for Biomedical Innovation (CBI)

Biologic medicines (e.g., monoclonal antibodies, gene and cell therapies, vaccines) are critical to treating and preventing disease. Recent regulatory approvals of exciting new biomedicines such as cell and gene therapies provide new hope to patients who have exhausted alternative therapies or suffer from a rare disease with no other treatment. To help patients access these medicines, biopharmaceutical companies must be able to manufacture very complex molecules safely, reliably, and in the quantities needed, which can range from the very large (industrialized) scale to the very small (personalized) scale. This presentation will review the challenges in manufacturing these complex biologic medicines as well as approaches to modernization of biomanufacturing with the goal of providing broadened access to biologic medicines. Dr. Springs will describe multiple approaches that MIT's Center for Biomedical Innovation and collaborators are taking to achieve this goal, including continuous manufacturing, novel purification strategies, novel analytical technologies for assessing novel product quality attributes, and rapid methods for sterility and viral safety assessment.

10:35 AM

Networking Break

11:00 AM

Merging Humans and Machines: Innovation and Translation

Xuanhe Zhao
Uncas (1923) and Helen Whitaker Professor
MIT Department of Mechanical Engineering

Whereas human tissues and organs are mostly soft, wet, and bioactive, machines are commonly hard, dry, and abiotic. Merging humans and machines is of imminent importance in addressing grand societal challenges in health, environment, sustainability, security, education, and happiness in life. However, merging humans and machines is extremely challenging due to their fundamentally contradictory properties. At MIT Zhao Lab, we invent, understand, and facilitate the translation of soft materials and systems to form long-term, robust, non-fibrotic, and high-efficacy interfaces between humans and machines. In this talk, I will discuss three examples of innovation and translation for merging humans and machines:

- the first fast and tough bioadhesive capable of replacing sutures for hemostasis and wound sealing (paper in *Nature* 2019, 2024; translation by SanaHeal Inc).
- the first soft neurovascular robot capable of remotely treating stroke patients (paper in *Nature* 2018; translation by Magnendo Inc).
- the first wearable ultrasound capable of imaging diverse human organs over 48 hours (paper in *Science* 2022; translation by Sonologi Inc).

I will conclude the talk with a vision for future human-machine convergence – aided by and synergized with modern technologies such as artificial intelligence, synthetic biology, and precision medicine.

11:40 AM

MIT Startup Exchange Lightning Talks

Josh Santos
Co-Founder & CEO
Noya

Evan Haas
Co-Founder & CEO
Helix Carbon

Maher Damak
Co-Founder & CEO
Infinite Cooling

Abhi Yadav
Co-Founder & CEO
iCustomer

Sean (Shunsuke) Matsuoka
Co-Founder & COO
GPx

12:20 PM

Lunch with Startup Exhibit

1:45 PM

Factories on the Frontier: Risk and Innovation in Manufacturing

Ben Armstrong
Executive Director
MIT Industrial Performance Center

How have some companies experienced dramatic growth and productivity improvement in manufacturing even as their peers struggle to compete? What explains how some manufacturing firms have been faster to adopt new technologies or workforce practices than other firms? This presentation will focus on understanding the operational and technological patterns of high-performing manufacturing firms in the United States. It will emphasize particularly the way that these firms have built on – and in some cases departed from – the Toyota Production System, which has for decades been the paradigm for manufacturing excellence in the United States and abroad.

2:25 PM — Optical Neural Networks and Computing with Light

Ryan Hamerly
MIT Quantum Photonics & AI Group

The rise of LLMs and generative AI has caused a dramatic increase in the energy consumption of data centers, a problem that will continue to grow as AI becomes more ubiquitous. Our group studies the use of photonics as an enabler for next-generation AI accelerators that can be orders of magnitude faster and more efficient than electronic processors, leveraging the bandwidth, latency, and low-loss interconnection advantages of optically encoded signals. I will discuss our work addressing the main challenges of photonic computing, including (i) scalability, where we are developing time-multiplexed and free-space optical systems to overcome area bottlenecks, (ii) noise and imperfections, where we have developed new hardware error correction algorithms for photonics, (iii) the use of delocalized computing to overcome von Neumann bottlenecks (with additional applications in quantum-secure computation), and (iv) training, where we have demonstrated a forward-only training algorithm for photonic neural networks.

3:05 PM — 99% Air: Nano-Engineering the Materials of the Future

Carlos M. Portela
Robert N. Noyce Career Development Assistant Professor
MIT Department of Mechanical Engineering

Architected materials—i.e., materials whose three-dimensional (3D) micro- or nanostructure has been engineered to attain a specific purpose—are ubiquitous in nature and have enabled properties that are unachievable by all other existing materials. Their concept relies on maximizing performance while requiring a minimal amount of material. Several human-made 3D architected materials have been reported to enable novel mechanical properties such as high stiffness-to-weight ratios or extreme resilience, especially when nanoscale features present. However, most architected materials have relied on advanced additive manufacturing techniques that are not yet scalable and yield small sample sizes. Additionally, most of these nano- and micro-architected materials have only been studied in controlled laboratory conditions, while our understanding of their performance in real-world applications requires attention.

In this talk, we will explain the concept of architected materials, providing various examples that we routinely fabricate and test in our laboratory at MIT, and we will discuss how nanoscale features significantly enhance their performance. We will also discuss ongoing research directions that will not only allow us to scale-up their fabrication, but also understand how they perform in realistic conditions outside the laboratory—towards contributing to more efficient material solutions in industry and beyond.

3:45 PM — Networking Break

4:05 PM — Getting from the Computer to Real World Materials Faster with Machine Learning

Heather J. Kulik
Lammot du Pont Professor of Chemical Engineering
MIT Department of Chemical Engineering

Prof. Kulik will describe their efforts to accelerate the discovery of novel transition metal containing materials using machine learning. She will discuss how they have leveraged experimental data sets through both text mining and semantic embedding to uncover relationships between structure and function in molecular catalysts and metal-organic frameworks. Then she will describe how they have leveraged large datasets of synthesized materials to uncover those with novel function in polymer networks. She will describe how they demonstrate the success of their design strategy through macroscopically visible changes in network scale properties.

4:45 PM Innovating Materials and Chemistry for a Decarbonized Future

Iwnetim Abate
Chipman Career Development Professor, Assistant Professor of Materials Science and Engineering
MIT Department of Materials Science and Engineering

Decarbonizing transportation, the grid, and heavy industries depends on the success of both short- and long-duration energy storage solutions. Through novel material design and chemistry, my lab addresses critical challenges in developing affordable, sustainable, and reliable energy storage technologies. For short (to medium)-duration storage, we design and develop new cathode materials for sodium-ion batteries rich in manganese and iron. Our goal is to achieve energy densities comparable to lithium-ion batteries but at lower costs, without relying on critical minerals, thereby accelerating the transition to more sustainable energy storage. For long-duration storage, we have developed groundbreaking pathways for producing hydrogen (H?) and ammonia (NH?) using subsurface chemistry. By harnessing redox reactions on Fe-rich rocks and utilizing the Earth's natural heat and pressure, we demonstrate the potential for stimulated geological H? and NH? production. These methods achieve near-zero CO? emissions while remaining cost-competitive with existing technologies. Our work integrates advanced materials design with sustainable chemistry to provide scalable, impactful solutions for a decarbonized future.

5:25 PM Closing Remarks

5:30 PM Networking Reception with Light Dinner