

Report to the President year ended June 30, 2024, Department of Materials Science and Engineering

The Department of Materials Science and Engineering (DMSE) continues to lead in groundbreaking research, education, and community engagement. In 2023-2024, our faculty, students, and staff made significant strides across a wide range of fields, from clean energy and quantum computing to AI-powered lab tools and next-generation electronics. Highlights include prestigious faculty awards, innovative student projects, and impactful research breakthroughs that exemplify DMSE's dedication to advancing knowledge and addressing global challenges. These achievements reflect our ongoing commitment to pushing the boundaries of materials science and engineering.

Undergraduate education

DMSE has an incoming sophomore class of 30 students. Three seniors graduated in February 2024, and 20 graduated in June 2024. For the 2023-2024 academic year, 34 students were enrolled in Materials Science and Engineering (Course 3), 22 in Course 3-A, and 2 in Course 3-C.

New classes were added to the curriculum, including two that feature laboratory sessions in the newly opened Breakerspace. These are 3.000 (Coffee Matters: Using the Breakerspace to Make the Perfect Cup), a "discovery class" that combines coffee science and hands-on experimentation, and 3.040 (Introduction to Characterization), a primer on common experimental equipment used in materials science and engineering. Also new is the discovery class 3.002 (Materials for Energy and Sustainability), which examines materials for sustainable technologies that harvest, store, and conserve energy, with applications in both industry and startups.

Graduate education

The department's graduate enrollment remains strong, numbering 193 in fall 2023. Approximately 37% of the graduate students are women, 7.3% are underrepresented minorities, and 48% are international students. Seventeen DMSE students were in the Program in Polymers and Soft Matter. For academic year 2024, we anticipate an incoming class of 35, 23% of whom are women.

This was the fourth year DMSE and the MIT Center for Computational Science and Engineering (CCSE) accepted applications for an interdisciplinary doctoral program in computational science and engineering. One student is starting the program this upcoming fall; degrees will be awarded under the thesis field "Computational Materials Science and Engineering."

Diversity, equity, and inclusion

DMSE prioritizes diversity, equity, and inclusion across its undergraduate and graduate programs, with a focus on supporting underrepresented groups. Highlights include the end-of-spring Multicultural Potluck, hosted by the graduate student chairs of DMSE's DEI Collaborative, following the success of the inaugural event in 2023, and the thriving DMSE Application Assistance Program (DAAP), led by graduate student volunteers.

DMSE also hosted an MLK Visiting Scholar in 2023-2024, Denise Frazier, from the New Orleans Center for the Gulf South at Tulane University. She a cultural researcher and performer and during her year at MIT, conducted interdisciplinary research blending cultural studies, environmentalism, and materials science.

Student organizations

Tamar Zhitomirsky and Chris Mallia continued to lead **the DMSE Resources for Easing Friction and Stress (REFS)** for 2023-2024. They promoted the program to younger DMSE graduate students and organized key events, including multiple office hours throughout the year, offering students the opportunity to chat. They also met with students one-on-one for confidential listening sessions upon request. The team actively worked to recruit more DMSE graduates to join REFS and held a "Get to Know Us!" event. Two graduate students, Isabella Caruso and Heejung Chung, will join the team in the 2025 academic year.

Women and Gender Minorities of Materials Science (WXOMS) held their annual fall kickoff event, featuring dinner, drinks, and networking, to help build the WXOMS community. The group also organized faculty lunches to discuss graduate student experiences, advisor selection, and community development. Additional activities included arts and holiday events, professional headshots, an escape room outing, and a networking night. During these gatherings, members also discussed professional opportunities and career development.

The **DMSE Application Assistance Program (DAAP)**, led by graduate student volunteers to connect underrepresented minorities and underserved students with tailored guidance on their applications to DMSE's graduate program, has seen continued success, with consistently positive reviews from mentees. Nearly all had significantly more positive views of MIT after participating in the program and would recommend the program to their peers. These graduate students also participated in departmental recruiting activities and met with departmental leadership to give feedback about the program and other departmental initiatives. They provided feedback on the department's transition to Slate (the graduate admissions portal) and tested the application.

Facilities

Kevin Rogers, DMSE facilities manager, coordinated lab preparations for newly hired faculty. A lab for Assistant Professor Suraj Cheema is being set up in Building 13, while another for Assistant Professor Joseph Casamento is being prepared in Building 8. Upgrades to lab

infrastructure, including electrical, exhaust, gases, and chilled water, and equipment installation have begun. The department is remodeling its Academic Office suite to enhance the work environment and better serve students. A new space in Building 4 is being developed to support the DMSE teaching group and foster greater student interaction. Additionally, an office in Building 8 has been remodeled for the 3.091 instructor to improve student accessibility. Rogers is also assisting faculty with office and lab cleanouts for their relocations to other universities. The department is updating display cases in Buildings 4, 6, 8, and 16. The DMSE Space & Infrastructure Committee is evaluating spaces to accommodate two new hires.

Fundraising

Through the department's leadership transitions, DMSE made progress on several priorities and raised \$524,404. With a gift from a generous alumnus, DMSE created an expendable Faculty Research Innovation Fund, and also received gifts from foundations and industry leaders to support faculty research in sustainable metals processing, next-generation electronic materials, and proton electrolyte membrane fuel cells. Expendable gifts also supported important programs including the Kavanaugh Translational Fellowship program and MADMEC, a team-based contest that challenges students to design and execute materials prototypes to solve sustainability problems.

Personnel changes and promotions

Faculty

Caroline Ross served as Interim Department Head from July 2023 through June 2024. Ross is the Ford Professor of Engineering and served as associate head of DMSE from 2011 to 2023. She has been a member of DMSE's faculty since 1997.

Chris Schuh departed MIT in August 2023 to serve as dean of Northwestern University's McCormick School of Engineering and Applied Science. Schuh joined the DMSE faculty in 2000, gaining a reputation as an innovative metallurgy researcher and a dedicated teacher and mentor. He was department head from 2011 to 2020.

Joseph Casamento began as Assistant Professor in January 2024. Casamento specializes in semiconducting materials and dielectrics, focusing on nitride semiconductors for applications like LEDs, lasers, and RF amplifiers.

T.J. Wallin began as Assistant Professor in January 2024. Wallin's research centers on developing advanced soft wearable devices for human-computer interaction, integrating materials science, chemistry, and mechanical design.

Ming Dao was promoted to Senior Research Scientist in February 2024. Director of MIT's Nanomechanics Laboratory, Dao focuses on nanomechanics, cell biomechanics, and machine learning for engineering and biomedical applications.

Staff

Magdalena Rieb departed DMSE as Director of Administration and Finance position in August 2023 to become Assistant Dean for Human Resources and Administration in the School of Science. Rieb was with DMSE for more than seven years.

Eli Center was hired as Leadership Giving Officer in August 2023.

Cory James was hired as Coordinator of the Product Attribute to Impact Algorithm (PAIA) program in August 2023.

Bianca Sinausky was hired as a Graduate Academic Administrator in October 2023.

Erin Caples joined DMSE as the Director of Administration and Finance in November 2023.

Shannon Vittozzi was hired as a Financial Assistant in November 2023.

André Obin was promoted to Human Resources Administrator (Grade 8) in October 2023, and Human Resources Administrator (Grade 9) in January 2024.

Ryan Kendall was promoted to Senior Administrative Assistant in January 2024.

Priyanka Chaudhuri was promoted to Human Resources Coordinator in February 2024.

Cadence Seeger was promoted to Financial Assistant III in March 2024.

Jamie Krambeck was hired as a Simulation and Gameplay Programmer in April 2024.

Mike Coniglione was promoted to Senior Human Resources Representative in June 2024.

Deaths

Professor Emeritus Bernhardt Wuensch, a renowned crystallographer and educator, died April 3, 2024, at 90. He joined MIT as a student in the 1950s and later became a faculty member, contributing to materials science for 46 years before retiring in 2011. Wuensch served briefly as acting department head and directed the Center for Materials Science and Engineering from 1988 to 1993. He is remembered for his pioneering work in solid-state ionics and his dedication to teaching and mentorship.

Professor Emeritus John Vander Sande, a renowned microscopist and mentor, died June 28, 2024, at 80. After earning his PhD in materials science at Northwestern and a postdoctoral fellowship at Oxford, he joined MIT as an assistant professor in 1971. Vander Sande was celebrated for his teaching clarity and creativity. He brought the first scanning transmission

electron microscope (STEM) to the U.S. and served as associate dean of the School of Engineering from 1991 to 1999. After retiring in 2006, he pursued academic projects internationally and was acting provost at Reykjavik University from 2009 to 2010.

Research highlights

Assistant Professor **Iwnetim Abate**, DMSE postdoctoral fellow **Yifan Gao**, and others in the Abate Lab began formulating a recipe for a fluid that will induce the chemical reaction that triggers hydrogen production in rocks, potentially opening a new path to a carbon-free energy source. The main ingredient is water, and the team is testing “simple” materials for catalysts that will speed up the reaction and in turn increase the amount of hydrogen produced.

Professor **Polina Anikeeva** and her team made significant strides in soft robotics and biomedical applications this year. They developed tiny, soft-bodied robots controlled by a weak magnetic field, with graduate student **Youngbin Lee** strategically engineering the robots’ magnetization to allow a single field to generate movement-driving forces. These robots are particularly suited for transporting cargo through confined spaces, offering potential for biomedical applications. Professor **Yoel Fink**, alums **Gabriel Loke** and **Juliette Marion**, and graduate student **Keisuke Nagao** also contributed to this study. Additionally, Anikeeva and her collaborators created soft, implantable hydrogel fibers capable of delivering light to major nerves throughout the body. By genetically manipulating these nerves to respond to light, the fibers can send pulses to inhibit pain, providing a valuable experimental tool for investigating the causes and potential treatments of peripheral nerve disorders in animal models.

Professor **Yoel Fink** and a team of MIT researchers, along with other collaborators, engineered a hair-thin fabric to create a lightweight, compact, and efficient mechanism for reducing noise transmission in large rooms. The fabric suppresses sound in two ways: first, by generating sound waves that interfere with unwanted noise to cancel it out, and second, by remaining still to dampen vibrations that are key to sound transmission.

Associate Professor **Rafael Gómez-Bombarelli**, Professor **Bilge Yildiz**, DMSE postdoctoral fellow **Reisel Millan Cabrera**, and other MIT collaborators devised a new machine learning approach to designing new compounds or alloys whose surfaces can be used as catalysts, semiconductors, or battery components. The method, called an Automatic Surface Reconstruction framework, allows an estimate of all the configuration variations of material surfaces and can be extended to provide dynamic information about how the surface properties change over time.

Assistant Professor **Aristide Gumyusenge**, DMSE graduate student **Heejung Roh**, and a team of other MIT researchers developed a detector that could provide continuous monitoring in industrial or home settings for the presence of toxic gases, at low cost. The team used a material called a metal-organic framework which is highly sensitive to tiny traces of gas but whose performance quickly degrades, and combined it with a polymer material that is highly durable and easier to process, but much less sensitive.

Professors Juejun Hu partnered with DMSE postdoc **Jia Xu Brian Sia** and graduate student **Luigi Ranno** to create a compact, cost-effective technology for detecting and measuring lead in water. This innovative system can accurately detect lead concentrations as low as 1 part per billion, using a simple chip-based detector within a handheld device. Additionally, the system is adaptable for identifying other similar water contaminants. Former DMSE postdoc **Samuel Serna** also contributed to this study. On a separate project, Hu and Professor **Lionel Kimerling** began collaborating with Anuradha Agarwal from the Materials Research Laboratory to tackle a significant bottleneck in the scaling of microchip performance—balancing cost, power, and environmental impact. Their research focuses on developing advanced electronic-photonic integration technologies that facilitate high-bandwidth, low-latency data transfer while minimizing environmental footprint.

Professor **Darrell Irvine** and his team made groundbreaking advancements in cancer immunotherapy and immune system research this year. They enhanced the effectiveness of engineered T cells in treating solid tumors by utilizing CAR-T cells from their 2019 study. By administering two doses of a vaccine to mice, they induced metabolic changes in the CAR-T cells, boosting their production of interferon gamma and enabling them to overcome the tumor's immunosuppressive environment. Additionally, Irvine and his collaborators discovered that STING, a protein involved in the immune response, functions as an ion channel. This allows it to release protons from an organelle known as the Golgi body, marking it as the first known human immune sensor to translate danger signals into ion flow. This discovery opens new avenues for developing therapies that target STING to modulate the immune system.

Professor **Ju Li**, alongside DMSE graduate students **Hao Tang, Ariel Barr, Zhen Zhang,** and **Zhichu Ren**, and postdoc **So Yeon Kim**, has made significant research contributions. Tang and Barr helped develop a method to boost coherence times for nuclear-spin qubits, advancing quantum computing. Zhang and Ren worked on converting carbon dioxide into a solid fuel called formate for emissions-free energy and developed the AI-powered lab assistant CRES. Barr contributed to mapping crystalline materials for optimal thermal and electronic properties. Tang also collaborated on discovering “neutronic” molecules for quantum devices, while Kim focused on enhancing fusion reactor materials by mitigating helium buildup, extending their operational lifespan.

Professor **Robert Macfarlane**, postdoc **Xin Luo** and other MIT researchers came up with a new way to precisely assemble arrays of quantum rods using scaffolds made of folded DNA. Using a dehydration and rehydration process, they reduced manufacturing time from a few days to a few minutes. The ability to control the sizes, shapes, and placement of quantum rod arrays is a gateway to a broad range of electronics applications, including TVs and virtual reality devices.

Professors **Caroline Ross** and **Geoffrey Beach**, alongside DMSE graduate student **Allison Kaczmarek**, solved a 50-year-old mystery about the magnetic properties of artificial garnet thin films. By using advanced imaging techniques, they confirmed a theory proposed in 1971: the atoms in these films arrange themselves in specific patterns during growth, causing

directionally dependent magnetism. Their findings could lead to advances in magnetic devices, including spintronics and data storage technologies. DMSE alum **Ethan Rosenberg**, graduate students **Yixuan Song**, **Kevin Ye**, and **Gavin Winter**, and Associate Professor **Rafael Gómez-Bombarelli** also contributed to this study.

Professor **Frances Ross** contributed to research that unlocks new possibilities in magnet technology with their recent discovery of “strain-tunable” materials. By manipulating the Berry curvature in chromium telluride films, they demonstrated how stretching or compressing these materials can alter their magnetic properties. This breakthrough could revolutionize data storage, robotics, and health monitoring, paving the way for more versatile and sensitive technologies. DMSE postdoc **Alexander Foucher** also contributed to this work.

Professor **Christopher Schuh** and PhD candidate **Ian Dowding** discovered that when metals are deformed at an extreme rate by an object moving at high velocities, hotter temperatures make the metal stronger, not weaker. The new discovery could lead to new approaches to designing materials for extreme environments, such as shields that protect spacecraft or hypersonic aircraft, or equipment for high-speed manufacturing processes.

Professor **Yang Shao-Horn** and other MIT researchers found a way to combine cement and carbon black with water to make a supercapacitor that could provide cheap and scalable storage of electrical energy. The technology could facilitate the use of solar, wind, and tidal power by allowing energy networks to remain stable despite fluctuations in renewable energy supply.

Professors **Harry Tuller** and **Ju Li**, with DMSE postdoc **Thomas Defferriere** and other collaborators demonstrated a new way to detect radiation that could allow for much cheaper detectors. Expanding on a 2022 study showing how ultraviolet light can improve the performance of fuel cells based on the movement of charged atoms, the researchers showed that the same concept can be extended to the detection of gamma rays emitted by the radioactive decay of nuclear materials. Jennifer Rupp, a former associate professor at DMSE who is now a professor of electrochemical materials at Technical University Munich in Germany, also contributed to this work.

Professor **Bilge Yildiz** and Associate Professor **James LeBeau**, along with DMSE alum **Abinash Kumar** and colleagues, used ion irradiation—where beams of charged particles bombard a material—to precisely control the properties of nanoparticles. This method significantly improves the performance of nanoparticles, making them superior to those produced through conventional techniques, and is critical for various clean energy and environmental technologies.

Awards and honors

Faculty awards

Associate Professor **Rafael Gómez-Bombarelli** was named a 2023 Sloan Research Fellow on May 1.

Professor **Elsa Olivetti** won the McDonald Mentoring Award on August 9. The honor is given to faculty members who have shown exemplary commitment to guide and nurture their students. Olivetti's students, whose comments contributed to her nomination for the McDonald award, describe her as an exceptional mentor who has cultivated a caring and supportive environment.

Professor **Darrell Irvine** was elected to the National Academy of Medicine for 2023 "for the development of novel methods for delivery of immunotherapies and vaccines for cancer and infectious diseases."

Professor Emeritus **Subra Suresh** was awarded the National Medal of Science, the nation's highest honor for scientists, by President Joe Biden on October 24. Suresh was recognized for his dedication to research, education, and international collaboration, which have advanced the field of materials science and its applications to other disciplines, while fostering cooperation among people and nations.

Professor **Yet-Ming Chiang** was named to the 2023 Time 100 Climate List, the magazine's inaugural ranking of the 100 most influential climate leaders in business. Chiang is a serial entrepreneur, co-founder of the energy-storage company Form Energy, and co-founder of Sublime Systems, a leader in developing carbon-free cement that is scaling up to commercial production.

Assistant Professor **Aristide Gumyusenge** was named the Doherty Professor in Ocean Utilization. The award provides support to young faculty members at MIT so they can use their expertise to benefit the world's seas. Gumyusenge's research aims to develop better ways to detect toxic substances called PFAS, "forever chemicals," in seawater.

Professor **Bilge Yildiz** was chosen as the 2024 recipient of the Faraday Medal by the Royal Society of Chemistry. Yildiz focuses on the fundamentals of electrochemistry, studying the chemical reactions that use or produce electricity in materials that conduct ions. The Faraday Medal recognizes outstanding contributions and innovation in electrochemistry.

Assistant Professor **Iwnetim Abate** was named as one of *Chemical & Engineering News'* Talented 12, highlighting young scientists who are making the world a better place through chemistry.

Associate Professor **C. Cem Tasan** was named a TMS Brimacombe Medalist for his contributions to in-situ microscopy testing, which have advanced the understanding of microstructural mechanisms in metals and contributed to the development of high-performance alloys. The award, administered by The Minerals, Metals & Materials Society, recognizes scholars for "sustained excellence and achievement in business, technology, education, public policy, or science related to materials science and engineering."

Student awards

Louise Anderfaas and **Darshdeep Grewal** received the first-place award in ASM Materials Education Foundation's 2023 Undergraduate Design Competition in Detroit on October 16. Anderfaas and Grewal designed a high-strength aluminum alloy with potential use in transportation and aerospace.

(The following awards were distributed at DMSE commencement reception on May 30.)

Undergraduates

- **Jacqueline Prawira** won the Outstanding Sophomore Award.
- **Jordan Tierney** won the Julian Szekely Award for Outstanding Junior Award.
- **Katherine Lei** won the Outstanding Senior Award.
- **Maria Aguiar** won the Undergraduate Student Teaching Award in Teaching an Undergraduate Subject
- **Shu Yang Zhang** won the Outstanding Senior Thesis Award.
- **Ian Chen** and **Lucas Marden** won the Joseph M. Dhosi Outstanding Internship Award.
- **Kirmina Monir, Katherine Lei, Linnaea Uliassi, Daniel Tong, Melissa Stok, Sierra Green, Kimberly Cheng,** and **Lauryn Kortman**, seniors on the executive committee of the Society of Undergraduate Materials Scientists (SUMS), won the Horace A. Lubin Award for Outstanding Service to the DMSE Community. Hu said the group deserved the award for their collective community building and being "wonderful ambassadors for the major."

Graduate and postdocs

- **Tao Cai** won the John Wulff Award for Excellence in Teaching an Undergraduate Subject.
- **Juno Nam** won the Exceptional Graduate First-Year Performance Award.
- **Rachel Luu** won the Best Paper for a First- or Second-Year Graduate Student.
- **Eric Lee** and **Isabella Caruso** won the Graduate Student Community Service Award.
- **Pete Lauer** won the Graduate Student Teaching Award in Teaching a Graduate Subject.

- **Kate Reidy** won the Best Doctoral Thesis Award.

Staff awards

Human resources coordinator **André Obin** and lecturer **Jessica Sandland** were chosen as recipients of the 2024 Infinite Mile Award. The award recognizes people who have made extraordinary contributions in their organizations to help MIT carry out its educational mission.

Undergraduate academic administrator **Rebecca Shepardson** and financial coordinator **Mahia Brown** won the School of Engineering's 2024 Infinite Mile Award, which honors staff members for their extraordinary contributions to MIT's educational mission.

Victoria Bautista, Erin Caples, Sarah Ciriello, Priyanka Chaudhuri, Mike Coniglione, Bizi Kayumbi, Ryan Kendall, Angelita Mireles, Danforth Nicholas, Kevin Rogers, Cadence Seeger, Kathy Simons, Bianca Sinausky, Shannon Vittozzi, ShanTil Yell, and Nina Wu won DMSE Employee Applause awards.

Future plans

DMSE is poised for an exciting future, with plans to expand faculty, enhance research capabilities, and improve student support. New tenure-track faculty hires in metallurgy and biomaterials will bring fresh perspectives to critical fields like sustainable metal extraction, alloy design, and bioinspired materials. These additions will drive innovative research with far-reaching impacts, from energy to health care, while enriching the educational experience for students.

Polina Anikeeva, the new department head effective July 2024, brings a visionary approach and interdisciplinary expertise in bioelectronics and neural communication. Her leadership will inspire new collaborations and set a bold direction for DMSE's future.

To support these efforts, DMSE is upgrading facilities, including new labs and remodeled academic spaces to better serve both research and student needs. With these initiatives, DMSE is well-positioned to continue leading in materials science, driving innovation, and shaping the next generation of scientists and engineers.

Caroline Ross
Ford Professor of Engineering
Interim Department Head

Polina Anikeeva
Department Head
Matoula S. Salapatas Professor in Materials Science and Engineering

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