

Department of Materials Science and Engineering

As the [Department of Materials Science and Engineering \(DMSE\)](#) responded to the continued Covid-19 pandemic, our community overcame significant challenges to create new curricula, hire new faculty, and launch new initiatives. In our educational programs, we launched a new undergraduate curriculum and are rolling out a new graduate curriculum as well, both with added emphasis in communications, career development, and better alignment with the state of the field. Our students continue active engagement in recruitment and mentorship efforts, programming in diversity equity and inclusion, and building support structures for stress reduction. Within our faculty, two new hires were made with research areas focused on energy technologies and semiconducting polymers that complement the department's ongoing efforts in climate and sustainability, health and medicine, manufacturing, computing, and infrastructure.

Diversity, Equity, and Inclusion

Community response to national, local, and campus events led to the formation of a DMSE Diversity, Equity, and Inclusion (DEI) Collaborative to develop a foundation on which the department can begin to assess, engage, and advance activities that foster and encourage a diverse, welcoming, respectful, caring, supportive, and engaged community. The collaborative is chaired by Christine Ortiz, Morris Cohen Professor of Materials Science and Engineering, with administrative and advisory support from Jennifer Camacho, manager of external relations in the Office of International Activities, and Ellan Spero, instructor and historian of science and technology. Collaborative members are drawn from the key stakeholder groups of faculty and instructional staff, graduate and undergraduate students, administrative and support staff, and postdocs. The collaborative members individually chair subcommittees of interested members drawn from their stakeholder group.

Educational Initiatives

During the 2020–2021 academic year, DMSE launched a revised undergraduate curriculum that was developed after a long process of review and with input from current students, faculty, teaching staff, alumni, and industry leaders. The new curriculum incorporates laboratory activities and computational thinking throughout the core subjects when appropriate, is taught through cross-cutting themes such as structure and mechanics, and requires a balance of student effort to align with other School of Engineering and MIT schedules. All three undergraduate degree tracks now require the same core subjects (18.03 Differential Equations, 3.010 Structure of Materials, 3.019 Introduction to Symbolic and Mathematical Computing, and 3.020 Thermodynamics of Materials). The sequence of required subjects now better meets student needs for further study and internships. The department will continue to assess and refine the curriculum, specifically considering new upper-level electives (including offerings from the Schwarzman College of Computing) and integrating thesis and internship work with industry and academia collaborations.

In fall 2021, DMSE will pilot a new internship program, the Materials Initiative for Comprehensive Research Opportunity (MICRO), a semester-long research and education

program directed at undergraduate students from underrepresented minority groups and other groups who have been historically underserved in science and technology. The program aims to attract talented, motivated students with an interest in pursuing a research career in a STEM (science, technology, engineering, math) field. MICRO programming will take place entirely online and is accompanied by a research stipend.

DMSE has maintained its top position in *US News and World Report's* graduate and undergraduate lists and in the Shanghai Ranking.

Undergraduate Education

With an incoming sophomore class of 23 students, DMSE's undergraduate enrollment will be 81 students, with 69% women, 27% underrepresented minorities, and 4% international students. Twenty-two students are designated Course 3-A (a flexible degree program often taken by students intending to continue their education in the fields of medicine, business, or law). This past academic year, three students graduated with a double major, and four current students are declared double majors.

Graduate Education

The department's graduate enrollment remains strong, numbering 180 in fall 2020. Approximately 33% of our graduate students are women, 8% are underrepresented minorities, and 57% are international students. Twenty-two DMSE students participate in the Program in Polymers and Soft Matter. For AY2022, we anticipate an incoming class of 34, 41% of whom are women.

DMSE and the MIT Center for Computational Science and Engineering started accepting applications for an interdisciplinary Doctoral Program in Computational Science and Engineering (CSE), to launch this fall. One student has been admitted to the program, which will award degrees under the thesis field "Computational Materials Science and Engineering."

Student Organizations

As ambassadors for the department and the field, DMSE's student organizations took on a more important role than ever this year as they developed creative and new ways to maintain student connections to MIT and to the department. The First-Year Pre-Orientation Program, Graduate Orientation, Career Fairs, and recruiting events were all held remotely using a variety of platforms and creative thinking from staff and students.

The 2021–2022 Society of Undergraduate Materials Scientists (SUMS) officers are President Thomas Sierra, Vice President Udochukwu Eze, Career Development Chairs Ian Chen and Jeremy Dudo, Social Chairs Tess Buchanan and Katherine Lei, Publicity Chair Eyosias Genremeskel, Commons Chair Jess Arbuckle, Outreach Chair Mollie Wilkinson, Sophomore Representative Katherine Lei, Junior Representative Tess Buchanan, and Senior Representative Alana Chandler.

With most students facing a virtual AY2021, SUMS had to reinvent the ways in which the undergraduate community could stay connected.

- **SUMS DEI Team:** Following ShutDownSTEM in June 2020, SUMS launched a student-led team dedicated to DEI issues, consisting of Flor Garza, Kierstin Torres, James Philips, and Raima Mahmud. The team organized a movie night in the spring to stream *Picture a Scientist*, with a fruitful discussion afterwards with Lorna J. Gibson, the Matoula S. Salapatias Professor of Materials Science and Engineering, who shared her firsthand story of how the female faculty in the School of Science and the School of Engineering came together to push for gender equity. Following a SUMS forum focused on DEI issues, the team compiled responses from students and identified undergraduate advising as an area of improvement within the department. They put together recommendations for undergraduate advising and presented the concerns to the Undergraduate Committee. Broadly, the team has collaborated with graduate students on Graduate Materials Council to plan and organize future events, including a high school outreach program.
- **Communications:** SUMS vice president Nicholas Ignario rebuilt the SUMS website. Danielle Grey-Stewart launched a SUMS Slack with various channels for announcements, including an Ask an Upperclassman channel. SUMS ran town halls to collect student questions and concerns surrounding the virtual semester and various Covid-related changes and formally launched an Instagram account for Course 3 undergraduates (@course3best3), where they posted student spotlights and highlights from events.
- **Social Events:** SUMS organized online events, including a trivia night with DMSE graduate students, lunches with faculty and students, a Zoom holiday party and New Year's celebration, game nights, and baking sessions.
- **Career Development:** Without in-person networking sessions, the SUMS team ran student-led panel discussions on applying to graduate school and distinguished fellowships. Ava Waitz took on the new role of undergraduate representative to the DMSE Seminar Series Committee to connect the undergraduate community to the seminar series and its speakers.
- **Mentorship:** A Big/Little Mentorship program successfully set up one-on-one mentor pairings between the class years.
- **Swag:** Over the course of the pandemic, the students very much appreciated distribution of care packages that were delivered directly to them. At different times during the year, students received snacks, DMSE blankets, pajama pants, sweatshirts, tote bags, leather-bound notebooks, folders, and water bottles.

This past year, the Graduate Materials Council (GMC) has been actively involved in bringing the community together at the graduate, undergraduate, and postdoctoral levels. Their community-building efforts included welcoming incoming graduate students to the department with gifts and handwritten notes from continuing graduate student mentors, organizing mentor-mentee interactions throughout the year, planning graduate admissions events with DMSE administration for a Virtual Visit Weekend, and organizing virtual coffee hours and socials with games and other activities. In addition, the GMC outreach chairs organized a team of students who produced videos that teach materials science to a general audience using food science and cooking. This channel and

its videos gained popularity and were featured on MIT News, MIT's Twitter, and with a *Joule* publication about teaching materials science.

The DMSE Resources for Easing Friction and Stress (REFS) team for AY2021 saw the arrival of two new trained REFS students, Amina Matt and Sonia Zhang, who played an important role in promoting the program to younger DMSE graduate students and organizing key events. Department-specific training sessions included case studies, emphasis on the difference between confidential resources and responsible employees, and guiding students through advisor-advisee relationships. While Amina will graduate with her master's degree in summer 2021, two additional graduate students are being trained as REFS and will start their role in fall 2021. This will bring the total number of DMSE REFS to four representing three different cohorts.

During AY2021, DMSE REFS continued to adapt to remote activities. Their main role has been to support graduate students with confidential one-on-one sessions, with a doubling of requests for individual support in fall 2020. Based on issues identified in the one-on-one sessions, DMSE REFS organized two spring 2021 workshops open to the graduate student community. The first workshop—on strengthening community resilience—discussed difficulties in preserving relationships in the remote setup of the Covid-19 pandemic and presented general tips and tricks on how to stay connected with the different communities we belong to. The second workshop focused on providing students with resources and insights on navigating advisor-advisee relationships, the primary reason students request a one-on-one session with DMSE REFS. In this workshop, DMSE REFS introduced the main causes of advisor-advisee conflicts through Christopher Moore's circle of conflict framework and taught the audience basic conflict resolution skills to navigate conflict resolutions conversations. Additionally, information was given about MIT resources relevant to advisor-advisee relationship, including Office of Graduate Education GradSupport and the DMSE Transitional Support Coordinators.

This past year, Women and Gender Minorities of Materials Science (WXOMS) piloted a number of new events and initiatives. To foster community, WXOMS organized Gather. town virtual meetups, Thirsty Ear trivia teams, and a Secret Santa gift exchange, as well as several discussions around DEI and graduate student advocacy co-hosted with the RISE (Recognizing Individuals Supporting Equity) efforts and led by Graduate Students for a Healthy MIT, the Black Graduate Association, and the Graduate Student Council Diversity, Equity, and Inclusion committee. Food reimbursements were offered for WXOMS members who attended the 2021 gwaMIT Leadership Conference, and a discussion panel was hosted for junior and senior undergraduate students on how to navigate the graduate school applications and decisions process.

The DMSE Application Assistance Program (DAAP) was led by DMSE graduate students Elad Deiss-Yehiely, Eesha Khare, Katherine Mizrahi, Amina Matt, and Tunahan Aytas. This program provides tailored application mentorship to prospective underrepresented minority students from DMSE graduate students, with 56 mentees and 38 mentors in the inaugural year. Initial feedback was collected from 93% of mentees, who unequivocally expressed that they benefited from this program. The results confirmed that the program helped increase the prospective students' willingness

to apply to MIT and their self-confidence in building relationships in this institution and other institutions in the physical sciences overall. Prospective students also appreciated meeting with DMSE grad students and receiving general advice about the graduate admission process and personal feedback on their applications. Ultimately, eight DAAP mentees were admitted into DMSE and comprise 15% of the new cohort, a percentage not previously seen in other departments' application assistance program.

Facilities

Facilities efforts over the past year focused on several areas, including providing access to vendors and contractors and working with MIT Facilities during the pandemic to keep research operating safely and efficiently. In Building 4, a lab was renovated for C. Cem Taşan, the Thomas B. King Associate Professor of Metallurgy, by adding several pieces of equipment, upgrading the 480-volt power, and reworking the exhaust to accommodate the new machines. In Building 8, Toyota Professor of Materials Science and Engineering Caroline A. Ross's lab's infrastructure was upgraded, including electrical, exhaust, gasses, and chilled water to accept two new PLD machines. Also in Building 8, a graduate student office was remodeled for the Taşan Group. Kevin Rogers, DMSE facilities manager, is working with staff in MIT.nano to install two new microscopes for Frances M. Ross, the Ellen Swallow Richards Professor in Materials Science and Engineering. The DMSE Space Committee gathered information for two new principal investigator hires and is evaluating space in Building 13 to accommodate their needs.

Fundraising

While Covid-19 and the resulting travel restrictions severely impeded the department's fundraising efforts, progress was still made on some important priorities for the department. DMSE received a generous gift from Ashish Kelkar to endow a graduate student support fund in honor of his advisor, Professor Emeritus Joel Clark. Although travel was not possible, the department's community of supporters were introduced in virtual meetings to Jeffrey C. Grossman, the Morton and Claire Goulder and Family Professor in Environmental Systems, in his new role as department head. We also created a comprehensive strategic plan to guide our fundraising efforts in the coming year and are beginning to build out fundraising travel plans.

Personnel

Alfredo Alexander-Katz has been promoted to full professor effective July 1. The research in his group is highly interdisciplinary and lies at the interface of materials, biology, physics, chemistry, and medicine. One of the group's recent areas of study uses physics technology to test for Covid-19 and another recent focus is self-assembled block copolymers. He is the current director of the Program in Polymers and Soft Matter.

Polina Anikeeva has been promoted to full professor effective July 1. Her current research is focused on development of optoelectronic and magnetic materials and devices for recording and modulating activity of neurons in the brain, spinal cord, and peripheral organs. She is also a professor in the Department of Brain and Cognitive Sciences, has an appointment in the McGovern Institute for Brain Research, and is associate director of the Research Lab for Electronics.

Elsa Olivetti, the Esther and Harold E. Edgerton Associate Professor, has received tenure effective July 1. Professor Olivetti's research focuses on improving the environmental and economic sustainability of materials in the context of rapid-expanding global demand, both through increasing and understanding the effects of recycling and through considering the implications of substitution, dematerialization, and waste mining on materials markets. She is co-director of the MIT Climate and Sustainability Consortium and is the founding leader of the New Engineering Education Transformation Advanced Materials Machines thread.

Rafael Jaramillo has been promoted to associate professor, without tenure, effective July 1. He has also been appointed to the Thomas Lord Career Development Chair. The Jaramillo group is working with photoresponse materials, layered and phase-change materials, and complex chalcogenide semiconductors. Over the past year, Professor Jaramillo launched 3.012Tx Thermodynamics of Materials on edX.

The Provost's Office will appoint Julia Ortony to the Samuel A. Goldblith Career Development Chair for a three-year term. The chair was established in 1993 with generous gifts from corporations and individuals to honor Professor Goldblith, professor of food science emeritus and former vice president for resource development at MIT. The School of Engineering will appoint Rafael Gomez-Bombarelli to the Jeffrey Cheah Career Development Chair.

In January 2021, Rodrigo Freitas joined DMSE as the AMAX Assistant Professor of Materials Science and Engineering. Professor Freitas received BSc and MSc degrees in physics from the University of Campinas in Brazil and MSc and PhD degrees in materials science and engineering from the University of California at Berkeley. During his PhD, he was also a Livermore Graduate Scholar in the Materials Science Division of the Lawrence Livermore National Laboratory. As a graduate student, he investigated the thermodynamics, kinetics, and mechanics of extended defects in metals (such as grain boundaries and dislocations) using atomistic simulation methods, i.e., methods in which the behavior of each atom is explicitly considered. Prior to joining DMSE, he was a postdoctoral researcher at Stanford University where he worked to leverage machine learning tools to perform physics-based modeling of materials kinetics. His research will be focused on elucidating the fundamental mechanisms of microstructural evolution for systems of relevance in materials science broadly construed, and his research group will employ a range of computational techniques with the goal of bridging the gap between the all-atom information gathered from simulations and the mesoscale description of microstructural elements employed in materials science.

During the past year, two successful faculty searches were conducted. Aristide Gumyusenge and Iwnetim Abate have accepted offers to join the DMSE faculty. Gumyusenge will be appointed the Merton C. Flemings (1951) Assistant Professor of Materials Science and Engineering in January 2022. Gumyusenge is currently a postdoctoral researcher at Stanford University; he received a BS in chemistry from Wofford College in 2015 and a PhD in chemistry from Purdue University in 2019. He is originally from Rwanda, where he grew up and attended primary and secondary school. His research background and interests are in semiconducting polymers, their processing and characterization, and their unique role in the future of electronics. Through novel

processing strategies—especially large-area manufacturing of electronic devices—he is interested in relating molecular design to device performance. He is excited to bring those interests to MIT to further develop his ideas.

Iwnetim “Tim” Abate has a BS in physics from Minnesota State University, an MS in materials science and engineering from Stanford, and a PhD from Stanford, where he worked with Professors William Chueh and Thomas Devereaux. His thesis research was on improving the energy capacity of batteries using X ray and electrochemical characterization combined with quantum mechanical simulations to design next-generation lithium- and sodium-ion energy storage devices. He is a co-founder and president of SCIFRO, a nonprofit organization working on empowering African youth to solve local problems through scientific research and innovation. The organization is generously supported by the Bill and Melinda Gates Foundation, the National Science Foundation, the American Physical Society, and others. He has been awarded both a Miller and Presidential Fellow at the University of California at Berkeley, where he will spend the next two years as the Toyota Assistant Professor of Materials Science and Engineering. He will join DMSE in July 2023.

Krystyn Van Vliet, the Michael (1949) and Sonja Koerner Professor of Materials Science and Engineering, has assumed the role of associate vice president for research in addition to her previous role as associate provost. Professor Van Vliet is now overseeing Research Administration Services, Research Development, Research Facilities, and related areas of research administration systems and reporting.

Effective July 1, Professor Michael Cima will step down as associate dean of innovation in the School of Engineering. Beginning with the next academic year, Christopher Schuh, the Danae and Vasilis Salapatas Professor of Metallurgy, will serve as associate chair of the faculty.

Casey Johnson has been promoted to human resources administrator. Johnson joined DMSE in 2018, and her knowledge and innovative approaches have been invaluable to faculty and staff.

Research Highlights

DMSE research is central to world-wide challenges that are critical for future health and wellness. Recently, we have organized our messaging and communications around these central research topics.

- **Climate and sustainability:** In January, MIT launched the Climate and Sustainability Consortium, led by Professor Grossman with Elsa Olivetti, in an effort to bring industry and academia together to address the global climate emergency. MIT and Imperial College awarded seed funds to collaborative projects that will create climate solutions and pursue zero pollution. Two of the projects have DMSE affiliates: Professor Jaramillo, “Developing a new technology for low-cost chemical sensors for environmental monitoring,” and W.M. Keck Professor of Energy Yang Shao-Horn, “Green nitrate electrosynthesis using metal oxide electrocatalysts.”

- **Energy:** Kyocera Professor Yet-Ming Chiang and POSCO Professor of Materials Science and Engineering W. Craig Carter worked with a team to publish research on preventing dendrites in electrodes, thereby bridging, which shorts out the battery.
- **Health and medicine:** Professor Anikeeva is working with the Yang-Tan Center in the McGovern Institute, which studies CRISPR gene therapies and develops innovative engineering and medical techniques to treat brain diseases.
- **Manufacturing technologies:** Professor Taşan's group performed scanning electron microscopy examinations to determine how steel can be chipped and deformed by materials as soft as a human hair. Their research on razor blades was published in *Science* and widely reported.
- **Sensing and computing:** Associate Professor of Materials Science and Engineering Juejun "JJ" Hu and his collaborators have published a series of papers documenting their development of etched surfaces with patterns that reflect and refract light in unique ways, creating "metalenses" that can change focus in response to heat, as opposed to using mechanical components. These materials have remarkable potential application in drones, cameras, and more.
- **Simulation and data science:** Professor Schuh and other MIT researchers have combined computer simulations and a machine-learning process to produce detailed predictions of grain boundaries properties and behaviors that could guide the development of new alloys for a wide variety of applications.
- **Transportation and infrastructure:** Professor Shao-Horn is part of a team funded by the Mobility Systems Center, one of the MIT Energy Initiative's Low-Carbon Energy Centers, to pursue research on alternative forms of hydrogen for use in transportation.

Awards and Honors

Professor Geoffrey S.D. Beach was elected a 2020 Fellow of the American Physical Society for "pioneering contributions to the understanding of chiral exchange interactions, spin-orbit torques, domain wall and skyrmion dynamics in magnetic thin film materials, heterostructures and nanostructures."

Battelle Energy Alliance Professor of Nuclear Science and Engineering and professor of materials science and engineering Ju Li was elected a fellow of the American Association for the Advancement of Science.

Professor Olivetti was named a MacVicar Fellow and was awarded the School of Engineering Bose Award for Excellence in Teaching.

Donald R. Sadoway, the John F. Elliot Professor of Materials Chemistry, was named a TMS Fellow.

Professor Shao-Horn was elected a Fellow of the National Academy of Inventors.

Undergraduate Awards

Priya Ganesh '23 was named Outstanding Sophomore.

Danielle Grey-Stewart '21 received the Outstanding Senior Thesis Award for "Synthesis of guanidinium-functionalized amphiphiles for the exploration of chaotropic supramolecular nanoribbons." Danielle also received the Undergraduate Student Teaching Award in Teaching an Undergraduate Subject for her work in 3.091 Introduction to Solid State Chemistry. Next fall, she will attend Oxford University as a Rhodes Scholar pursuing an MPhil in nature, society, and environmental governance. Danielle was also the recipient of MIT's Priscilla King Gray Award for Public Service.

Alby Joseph '21 received the Horace A. Lubin Award for Service to the DMSE Community. Alby was also awarded an National Science Foundation Fellowship.

Grace Moore '21 was named Outstanding Senior. Grace is also the first MIT recipient of the Michel David-Weill Scholarship, which provides funding for graduate study at Sciences Po in Paris.

Rahul Ramakrishnan '21 received the Joseph M. Dhosi Outstanding Internship Award for his work at Desktop Metal in summer 2020.

Kierstin Torres '22 received the Julian Szekely Award for the Outstanding Junior.

Alana Chandler '22 and Kathryn Tso '22 were selected as Burchard Scholars for their demonstrated academic excellence in both humanities and STEM fields.

Richard Colwell '21 was a recipient of the MISTI (MIT International Science and Technology Initiatives) Ambassador Award. During his time at MIT, Richard traveled to France, Israel, India, South Africa, and the UK with MISTI.

Flor Garza '21 received MIT's Albert G. Hill Prize in recognition of her efforts to improve diversity, equity, and inclusion at the Institute.

Ava Waitz '21, will attend Tsinghua University in Beijing this fall as a Schwarzman Scholar.

Christopher Eshler '21, Alexander Evanchik '21, Alby Joseph, and Grace Moore were all invited to join Phi Beta Kappa.

Graduate Awards

George Varnavides received the John Wulff Award for Excellence in Teaching for his work as a teaching assistant (TA) in 3.042 Materials Project Laboratory, the Course 3 capstone subject. He also received a Hugh Hampton Young Fellowship from MIT's Office of Graduate Education.

Jatin Patil was awarded the Graduate Student Community Service Award.

Jonathan Paras was awarded the Graduate Student Teaching Award in Teaching a Graduate Subject for his TA position in 3.20 Thermodynamics of Materials.

Edward Pang was given the Best PhD Thesis Award for his thesis “Towards Crack-Resistant Polycrystalline Zirconia Shape-Memory Ceramics with Low Hysteresis.”

Cecile Chazot was one of the 2020–2021 School of Engineering MathWorks Fellows.

Ty Christoff-Tempesta placed third in the J-WAFS (Abdul Latif Jameel Water and Food Systems Lab) World Water Day video competition.

Staff Awards

School of Engineering Infinite Mile Awards were presented to Mary Lindstrom, environmental health and safety coordinator for Biological Engineering, DMSE, and the MIT Center for Environmental Health Sciences, and to John Ohrenberger, senior administrative assistant in the DMSE Academic Office.

Future Plans

To address the need for professional development and career advising, the department will launch the DMSE Alliance, a new program to engage with alumni and industry, leading to stronger ties to collaborators and better information and opportunities for undergraduate and graduate students as they considering their futures. DMSE has received permission to hire a staff for this program, and we expect to have someone in place before the school year begins.

Working with committees in the Departments of Biological Engineering and Chemical Engineering, the DMSE DEI Collaborative has created and posted a job description to hire a diversity, equity, and inclusion specialist to be shared among the three departments. We eagerly look forward to the resources and support this individual will provide.

To develop further hands-on prototyping opportunities for both undergraduate and graduate students, the department will direct efforts towards a “materials breaker space.” This will involve a testing and characterization suite, furthering students’ understanding of materials properties and failure conditions.

Our faculty have identified future hiring opportunities in the intersection of manufacturing science and materials for advanced microsystems. This area bridges the synthesis of materials to end-device applications, an area of expertise that has a strong connection to broader initiatives and will amplify other efforts within our department as well as the growing community working on next-generation manufacturing programs across the Institute.

Jeffrey C. Grossman

Department Head

Morton and Claire Goulder and Family Professor in Environmental Systems

Professor of Materials Science and Engineering