Department of Materials Science and Engineering

The Department of Materials Science and Engineering (DMSE) is healthy, strong, and growing. Recent faculty hires have energized the department, bringing in new research interests and programs. The external perception of DMSE's academic and research reputation continues to be strong, with top rankings in *US News and World Report*'s graduate and undergraduate lists and in QS World University rankings by subject. The department's visiting committee came to campus this past fall and was pleased by the state of the department, particularly the successful efforts made to improve the quality of life for students and postdoctoral associates, the increased enrollment in 3.091 Introduction to Solid-State Chemistry, and improvements to the physical facilities.

Educational Initiatives

DMSE has continued to add to its online offerings through edX and MITx, including 12 classes based on DMSE subjects, a guide to creating visual images to communicate materials science and engineering concepts, and a special series on why woodpeckers don't get brain injuries. These offerings have worldwide enrollment, meet academic requirements at other universities, and complement residential learning for MIT students. DMSE faculty members participate in workshops and seminars to share their experiences with creating and using online content.

Undergraduate Education

With an incoming sophomore class of 34 students, DMSE's undergraduate enrollment will be 106 students, with 64.15% women, 24.5% members of underrepresented minority groups, and 3.77% international students. Eleven students are enrolled in Course 3-A, which is 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, six students graduated with double majors, and four current students have declared double majors.

The first DMSE students participated in MIT's University of Tokyo exchange program this spring. Jessica Sun '18 and Erick Hernandez '18 each took classes with content ranging from biomaterials to semiconductors, all taught in English, as well as a Japanese language course. The opportunity allowed them to meet students not only from Japan, but from all over the world. They both were enthusiastic about their experiences and will be excellent trailblazers for future student participants.

Graduate Education

The department's graduate enrollment remains strong, numbering 170 in fall 2016. Approximately 25% of the graduate students are women and 4.1% are from underrepresented minority groups. Eleven DMSE students participate in the Program in Polymers and Soft Matter. For AY2018, DMSE anticipates an incoming class of 40, 35% of whom are women.

Student Organizations

DMSE's student organizations plan events and develop activities for their fellow students and for the community, including a preorientation program for first-year students, orientation, recruiting efforts, the Cambridge Science Festival, and lunch and dinner events with faculty and alumni.

The 2017–2018 Society of Undergraduate Materials Scientists officers are president Erick Hernandez, vice president Emma Vargo, and career development chairs Sara Wilson and Allie Sourakov. The webmaster is Lisa Kong, the publicity chair is Maddie Sultana, the social chairs are Andres Galindo and Alex Zele, the historian is Carolyn Jons, and the lounge chair is Neils Aggarwal.

The Graduate Materials Council officers for 2017–2018 are Hugo Uvegi, president; Peter J. Santos, vice president; Emiko Zumbro, treasurer; and Owen Morris, secretary. The academic committee includes Paul Gabrys, Yusu Liu, and Ethan Rosenberg. Jérôme Michon is athletics chair and Isabel Crystal, Richard Park, Brian Traynor, and Leonardo Zornberg are social chairs. The alumni committee includes Xueying Zhao. Coffee-hour chairs are Shayna Hilberg and Hejin Huang. Kevin Bogaert, Seth Cazzell, and Jérôme Michon are representatives to the departmental Committee on Graduate Students. Skylar Deckoff-Jones and William Lindemann are Graduate Student Council representatives; Josh Kubiak and Eddie Pang are on the outreach committee; and Irina Rasid is the president of the Materials Research Society student chapter. Some offices were not filled.

Facilities

DMSE is continuing a strategic effort to survey office and laboratory staff to meet the needs of changing technologies and incoming faculty and staff. As part of this work, several laboratories and offices have been renovated. Assistant Professor Robert Macfarlane's lab in Building 13 was renovated for use in chemistry-based research, with eight fume hoods and new benches. In Building 8, Assistant Professor Ortony's lab was also renovated for chemistry-based research with two new fume hoods, light-sensitive work areas, and a separate instrumentation lab space. Professor Ortony and her students also have newly renovated office spaces. An important improvement was in the lab spaces used by Professor Harry Tuller and Assistant Professor Jennifer Rupp in Building 13, including a shared furnace lab, a shared chemistry lab, a lab for the Rupp Pulsed Laser Deposition equipment, and the main Rupp Laboratory with laser table and dedicated microscope room. Office space was also renovated for Professor Rupp and her students.

The initiative to improve office spaces for graduate students and postdocs that began last year has continued. These members of the DMSE community spend a great deal of time on campus and the department recognizes that working in a comfortable environment will much improve their quality of life. Not all spaces require improvement but those in need are receiving the following work: replacement of flooring, general office cleaning, a fresh coat of paint, and adding and replacing window treatments.

Fundraising

The Michael (1949) and Sonja Koerner Professorship of Materials Science and Engineering was created through a gift by MIT alumnus Michael Koerner, president of Canada Overseas Investments Ltd. Koerner received his SB in 1949 from the Sloan School of Management, and for several decades he has been a leader in the MIT alumni community. Koerner has served on the MIT Corporation since 1985 and chaired the DMSE Visiting Committee from 1993 through 2002. He and his wife Sonja are long-time supporters of health, education, culture, and the arts. In addition to this extraordinary contribution to Materials Science and Engineering at MIT, the Koerners have also made a gift to fund the first-ever endowed professorship in music composition in MIT's Music and Theater Arts Department.

The Kavanaugh Translational Innovation Fellows Program was created through a generous grant from the Saks Kavanaugh Foundation. The Kavanaugh Fund for Translational Innovation Fellows provides competitive grants to at least one postdoctoral associate per year, fully supporting them as they do further work on technical and business development. Two fellows were supported this year.

DMSE is delighted to announce the establishment of the Julian Szekely Fellowship, thanks to the generosity of Mrs. Elizabeth Joy Szekely. Professor Szekely joined our faculty in 1975 and was a beloved teacher and mentor until his death in 1995.

Professor Ioanna Kakoulli of the University of California, Los Angeles, was the inaugural Archeological Visiting Faculty Fellow in DMSE, supported by a gift last year from Vasilis (SM '61 and PhD '66) and Danae Salapatas. During spring 2017, she taught Plasters and Pigments: Ancient Greek and Roman Painting Materials and Technology and led a laboratory in which students recreated an ancient plaster fresco. Professor Kakoulli was educated at the Courtauld Institute of Art, University of London, and the Research Laboratory for Archaeology and the History of Art, University of Oxford. She is an expert in the application of technology for the study of material culture from the macro- to the nano-length scale and in the research and development of portable noninvasive, nondestructive multispectral imaging and spectroscopic systems for field applications.

Personnel

Over the past academic year, we have successfully added to the department's roster and increased our teaching and research depth and breadth. We are pleased by the results of this search and expect that future searches will bring new talent, interests, and expertise to DMSE.

Jennifer L.M. Rupp officially joined DMSE during this past year. Before coming to MIT, Professor Rupp was a non-tenure-track assistant professor at ETH Zurich (Eidgenössische Technische Hochschule Zürich). Professor Rupp's current research interests are solid-state material design and tuning of structure-property relations for novel energy and information devices and operation schemes. This ranges from alternative energy storage via batteries or catalytic convertor systems processed by smart material design for solar light and carbon dioxide to renewable synthetic fuels, or novel types of neuromorphic memories and computing logic entities for data storage

and transfer beyond transistors. Her team at MIT works on material design, creating novel processing techniques, and making ceramics, cermets, and glass-type ceramic structures. Her team also works on device prototypes—specifically their operation and characteristics. She holds the Thomas Lord Career Development Chair.

Dr. Rafael Gomez-Bombarelli will start as assistant professor in DMSE in January 2018. He received a BS, MS, and PhD in chemistry from Universidad de Salamanca in Spain, which was followed by postdoctoral work at Heriot-Watt University and Harvard University. He is currently a senior researcher at Kyulux NA. Dr. Gomez-Bombarelli's research trajectory has evolved from experimental mechanistic studies of organic molecules with emphasis on environmental toxicity to computer-driven design of molecular materials. By combining first-principles simulation with machine learning on theoretical and experimental data sets, he aims to accelerate the discovery cycle of novel practical materials. At MIT, he will address the role of molecular transformation in materials discovery in areas such as catalyst design, the environmentally minded development of novel and replacement chemicals, and in designing for stability in advanced materials.

Silvija Gradečak will be promoted to full professor effective July 1, 2017. She joined DMSE in 2006, was promoted to associate professor in 2012, and received tenure in 2013. She holds a PhD in physics from the Interdisciplinary Center of Electron Microscopy, Swiss Federal Institute of Technology (École Polytechnique Fédérale de Lausanne), and a diploma in physics from the University of Zagreb, Croatia. Her research focuses on nano-photonics and electronics and is based on the synthesis, characterization, and integration of low-dimensional systems. By taking advantage of unique material properties on the nanoscale, her group explores novel optoelectronic applications such as nanoscale light-emitting sources, single photon sources, and nanowire lasers.

Polina Anikeeva will be awarded tenure effective July 1, 2017. She joined the DMSE faculty in 2011 and now holds the Class of 1942 Career Development Professorship. Professor Anikeeva's research is at the interface of materials science, electronics, and neurobiology with the goal of advancing understanding and treatment of disorders of the nervous system. Her group designs, synthesizes, and fabricates optoelectronic and magnetic devices that record and manipulate neuronal activity and development.

Antoine Allanore will be promoted to associate professor effective July 1, 2017. He joined the DMSE faculty in 2012. He holds a diploma in chemical engineering from the École Nationale Superieure des Industries Chimiques in Nancy, France, and an MSc and PhD from the Institut National Polytechnique de Lorraine, Nancy. Professor Allanore's research applies to the development of sustainable materials extraction and manufacturing processes. His research combines a theoretical approach (e.g., how current flow affects the performance of an electrolytic process) with a phenomenological approach (e.g., actual laboratory performance of the electrolytic process).

Neils Holten-Andersen will be promoted to associate professor effective July 1, 2017. He arrived in DMSE in 2012. He holds a BSc in biology from the University of Copenhagen, a BSc (Hon) in molecular biology from the University of Canterbury, an MSc in cell

biology from the University of Copenhagen, and a PhD in biomolecular science and engineering from the University of California, Santa Barbara. Inspired by the self-healing, adhesive, and tunable properties of biological material interfaces, Professor Holten-Andersen and his group design and characterize molecular material systems for novel uses in medicine, adhesive technology, and metal sequestration.

Krystyn J. Van Vliet was named the Michael (1949) and Sonja Koerner Professor of Materials Science and Engineering. Elsa Olivetti was named the Atlantic Richfield Assistant Professor of Energy Studies, effective July 1, 2017. Julia Ortony was named the Finmeccanica Assistant Professor of Materials Science and Engineering, effective July 1, 2017.

Professor Angela Belcher will co-direct the pre-K-12 special interest group of the Abdul Latif Jameel World Education Lab.

Professor Joel Clark is retiring at the end of this academic year after nearly five decades in and around DMSE. During his tenure at MIT, Professor Clark developed the field of materials systems analysis, including the application of operations research, microeconomic analysis, and engineering fundamentals to the study of the production and use of materials. Through his research, he demonstrated that providing a systemic consideration of potential market implications of new materials and materials processing technologies was not only feasible, but also yielded critical insights into the challenges of bringing materials out of the laboratory and into industry. He made significant intellectual contributions to our understanding of the interplay between materials technologies, engineering applications, and market dynamics over a wide range of domains, including structural ceramics, automobile manufacture, advanced materials substitution, and the economics of deep sea mining of manganese nodules. At MIT he was also dedicated to the Technology and Policy Program—with which he was involved since its inception—the MIT Portugal Program, and MIT's Center for Technology, Policy, and Industrial Development.

Jeffrey C. Grossman, the Morton and Claire Goulder and Family Professor in Environmental Systems, and Yang Shao-Horn, the W.M. Keck Professor of Energy, became co-directors of the MIT Energy Initiative Center for Energy Storage Research.

The MIT Quarter Century Club recognized Professor Heather Lechtman for 50 years of service to MIT.

Su Chung, director of the Administrative Services Organization (ASO), retired in March after more than 30 years at MIT. DMSE worked with personnel from the School of Engineering on a review of ASO and the department's administrative needs and processes, deciding to disband the Administrative Services Organization and assign administrative functions to the Department of Materials Science and Engineering headquarters. A search for a new administrative officer will occur shortly and some of the ASO human resources and financial staff will be assigned to DMSE. Although the dedication of the ASO staff for many years was greatly appreciated, DMSE looks forward to working with an integrated headquarters team.

Research Highlights

Nationally, the Manufacturing USA Institutes are bringing attention to the materials science and engineering field. For many years, Professor Van Vliet has worked on this federal initiative, which promotes public-private partnerships of academia, industry, government, and nonprofits to encourage innovation and manufacturing in the US. To date, 14 institutes have been created, and DMSE faculty had key roles in establishing four of them: Advanced Functional Fabrics of America, the American Institute for Manufacturing Integrated Photonics, the National Institute for Innovation in Manufacturing Biopharmaceuticals, and Reducing Embodied-Energy and Decreasing Emissions. Advanced Functional Fabrics of America, led by Professor Yoel Fink, has opened a center near MIT's campus.

DMSE's depth and breadth in research excellence was evident this year as faculty, students, and staff received funding awards and professional honors for their work. MIT's current research thrusts in cancer and energy are important areas of effort for DMSE faculty. Professor Michael Cima and collaborators had a breakthrough in a drug delivery device for ovarian cancer; Polina Anikeeva and her group developed a nanosensor for determining appropriate cancer treatments; and Professor Darrell Irvine is continuing his groundbreaking efforts in battling cancer through the immune system. On the energy front, Professor Yet-Ming Chiang has developed glassy electrode materials for batteries, Professor Van Vliet is working on solid lithium batteries, and Professor Shao-Horn and her students have published on a surprising phenomenon of metal oxide catalysis that may result in improving energy storage and retrieval.

Antoine Allanore was awarded an Abdul Latif Jamel World Water and Food Security Lab award for his project, Affordable Potassium Fertilizer from K Feldspar for Africa.

Angela Belcher was awarded a Bose Grant to develop environmentally friendly, on-demand biological systems for cleaning up the environment.

The Toyota Research Institute will fund the work of Professors Grossman and Shao-Horn on a project focused on the design principles of polymer stability and conductivity for lithium batteries.

The Air Force Office of Scientific Research awarded a grant to Robert Macfarlane for his research on DNA-programmed epitaxy of nanoparticle superlattices. He was also winner of a National Science Foundation CAREER Award for his work on nanocomposite structure control via nanoparticle self-assembly.

DMSE Senior Technical Instructor Michael Tarkanian is collaborating with the conservators in the MIT Library's Wunsch Laboratory, with support from the Seaver Institute, to fabricate a new tool to facilitate the digitization of letters without flattening them.

Awards and Honors

The National Academy of Inventors named Michael Cima a 2016 fellow for his lifetime achievements.

Professor Yet-Ming Chiang delivered a lecture on the future of energy storage systems as part of the RENEW Institute's ongoing Distinguished Lecture Series. He was named an Innovation All Star by the *Boston Business Journal*, and was the Da Vinci Lecturer for Tau Beta Pi.

TMS (the Minerals, Metals, and Materials Society) presented the Ellen Swallow Richards Award to Professor Lorna Gibson in recognition of her role in helping others overcome personal, professional, educational, cultural, or institutional adversity to pursue a career in minerals, metals, or materials. Her role as an educator was recognized with the Bose Award for Excellence in Teaching from MIT's School of Engineering, and she was a panelist at the MIT Festival of Learning.

Professor Juejun Hu was the recipient of the American Ceramic Society Robert L. Coble Award for Young Scholars.

Professor Darrell Irvine was an invited speaker for the National Academy of Engineering's 2016 US Frontiers of Engineering Symposium, held in Irvine, California, in September. He presented a talk on "Engineering Immunity Against Cancer."

Professor Klavs Jensen was elected to the National Academy of Sciences. He was also the winner of the American Institute for Chemical Engineers 2016 Founders Award for Outstanding Contributions to the Field of Chemical Engineering.

Professor Robert Macfarlane is the American Chemical Society's 2017 Unilever Award Winner.

Professor Donald Sadoway was named the 2017 Association for Iron and Steel Technology John Elliott Lecturer.

The American Society for Materials elected Professor Christopher Schuh a fellow of the society. He was also the 2017 Van Horn Lecture speaker at Case Western University.

Professor Yang Shao-Horn joined the 2017 Class of Electrochemical Society Fellows.

Principal Research Scientist Ming Dao was elected a fellow of the American Society of Mechanical Engineers.

Undergraduate Awards

Teresa de Figueiredo '17 and Victoria Petrova '17 are part of Tech Twinkles, which won the 2017 MIT Outstanding Events Award. Teresa also won the 2017 Laya W. Weisner Award for the undergraduate woman who has most enhanced MIT community life.

Lisa Kong '17 and Tiffany Yeh '17 were named Burchard Scholars by the School of Humanities, Arts, and Social Sciences.

MIT's chapter of the Society of Women Engineers, including Rebecca Gallivan '17 and Jae Hyun Kim '18, received the Golden Beaver Award—Group.

Rachel Osmundsen ’17 was a recipient of the 2017 Laya and Jerome B. Wiesner Student Art Award. These awards are presented annually to up to four students (undergraduate or graduate), living groups, organizations, or activities for outstanding achievement in and contributions to the arts at MIT.

Abdullah Alsalloum ’17, Rachel Osmundsen ’17, and Nagisa Tadjfar ’17 were invited to join Phi Beta Kappa.

Chen “Bonnie” Wang ’17 was part of a team that won the $10,000 “Use It!” Lemelson-MIT Student Prize for a portable, real-time text-to-braille converter.

The Horace A. Lubin Award for DMSE Community Service was presented to Rebecca Gallivan ’17 for roles in student government and her enthusiastic support of all events and activities. George Varnavides ’17 was also presented with the award for his dedication to the DMSE community through several teaching assistant positions, including 3.016 Computational Methods for Materials Scientists and Engineers, and 3.024 Electronic, Optical, and Magnetic Properties of Materials.

Tiffany Yeh was named Outstanding Senior for being “a true renaissance woman,” holding high academic marks while simultaneously engaging in the arts, community service, teaching, and research.

Eveline Postelnicu ’17 was presented with the Undergraduate Teaching Award for her role as a TA in 3.091 Introduction to Solid-State Chemistry and 3.024 Electronic, Optical, and Magnetic Properties of Materials. Students praised her optimism, energy, and helpfulness.

The Joseph M. Dhosi Outstanding Internship Award went to Rachel Osmundsen for her internship at Nature Works LLC and her report, “Melt Strength Fundamentals,” which was supervised by Assistant Professor Elsa Olivetti.

Abdullah Alsalloum was awarded the Outstanding Senior Thesis award for “Optimizing the Synthesis Process of Wood-Derived Biomorphic Silicon Carbide,” supervised by Michael Tarkanian.

Emma Vargo ’18 received the Julian Szekely Award for her academic performance and dedication to the DMSE community.

Ximena Hasbach ’19 was named Outstanding Sophomore for her community and research activities, as well as her academic performance.

Graduate Awards

Four women from DMSE were honorees of the 2017 biennial celebration of Graduate Women of Excellence, including Sarah Goodman and Olivia Hentz, from the Gradečak group; Erica Lai, from the Holten-Andersen group; and Priya Moni, from Professor Linda Gleason’s group in Chemical Engineering. These women have all demonstrated exemplary leadership and outstanding accomplishments.

Mary Elizabeth Wagner won the School of Engineering Graduate Student Award for Extraordinary Teaching and Mentoring.

Thomas Hardin, a student advised by Professor Schuh, was selected for the Singapore University of Technology Graduate Fellowship. He was resident in Singapore in spring 2017 and assisted at Singapore University as a teaching assistant.

At the Materials Research Society spring meeting, Qiyang Lu of Professor Bilge Yildiz's group received a Gold Award.

Joshua Kubiak and Leonardo Zornberg were awarded the Exceptional First-Year Performance Award.

The Graduate Student Community Service Award went to Michael Campion for co-teaching a late afternoon/evening course on green technology to high-school students.

Daniil Kitchaev won the Graduate Student Teaching Award for his role as a teaching assistant in 3.20 Materials at Equilibrium. His students recognized his knowledge of the subject and his ability to communicate ideas in an easily understood way.

Alina Rwei received the John Wulff Award for Excellence in Teaching an Undergraduate Subject for her role as a teaching assistant in 3.044 Materials Processing. Students lauded her enthusiasm and her willingness to go beyond what was asked of her.

The Best PhD Thesis Award went to Sai Gautam Gopalakrishnan for "Thermodynamics and Kinetics of Mg Intercalation for Multivalent Cathode Applications," which was supervised by Visiting Professor Gerbrand Ceder.

The three winners of the 2016 Materials Day Poster Session were Ping-Chun Tsai, advised by Professor Chiang; Frank P. McGrogan, advised by Professor Van Vliet; and Roberta Polak, co-advised by Professor Michael Rubner and Professor Robert Cohen of the Department of Chemical Engineering.

Peter Su was a trip organizer for the Science Policy Initiative's 2017 visit to Capitol Hill on Science-Engineering-Technology Congressional Visits Day.

MADMEC has continued to be a successful program in DMSE, bringing students an opportunity to pursue their ideas in sustainability while learning about prototyping, teamwork, and design. Karim Raafat Gadelrab and Mukarram Tahir of team PolyClean won the $10,000 first-place prize for their super hydrophobic transparent coating. Cynthia Lo '18, Erick Hernandez, and Jaz Harris '18 were on the Soil Network team, $6,000 second-place winners, for designing a topsoil hydrogel additive that significantly decreases erosion. Seth Cazzell, Jérôme Michon, and Jonathan Hwang were on team Hydroglass, the $4,000 third-place winners, for a hydrogel window insert that switches from transparent to opaque in response to temperature fluctuations.

Previous MIT and Dow Materials Engineering Contest winners are continuing to develop and promote their projects. The AquaFresco team was a finalist in the 2016 $100,000 Entrepreneurship Competition and received a $150,000 grant from the Massachusetts Clean Energy Center's InnovateMass program. They also won $10,000 at the Open Innovation Pitch Contest held by Panasonic in January and were Gold Winners of MassChallenge Boston. The CoolComposites team were Gold Winners of MassChallenge Boston.

Future Plans

DMSE continues to assess and examine the graduate and undergraduate curricula, working to ensure that the department is preparing students in the best possible ways for their careers in academia and industry. DMSE believes that a strong community is critical for building strong relationships in the classroom and in the laboratory. DMSE will work to improve daily life for all of the department, whether through resources for teaching support, for office furnishings, or for networking and career development activities.

As MIT.nano nears completion, DMSE is evaluating equipment currently in use on campus and considering purchases of analytical equipment that may be shared for research in the department, in the school, and across MIT. DMSE expects many opportunities for collaboration and are looking forward to the new facility, which will be a landmark for years to come.

Christopher A. Schuh
Department Head
Danae and Vasilis Salapatas Professor of Materials Science and Engineering