Department of Materials Science and Engineering

The Department of Materials Science and Engineering (DMSE) has continued its growth this year. We are pleased that our hiring goals are being met, with professor Elsa Olivetti joining our faculty in January and two new hires beginning in 2015. We are also making progress toward our long-range plans, determined at a faculty retreat two years ago. As a group, we agreed to increase the laboratory technical instructor staff to allow faculty to focus on lectures and small-group student interactions; also, we agreed to dedicate effort to creating online versions of the core undergraduate curriculum to be offered in the Semester from Anywhere program and on the MITx platform and to increasing public awareness of our field via media appearances, web outreach, and social media.

Last fall, professor emeritus Robert E. Ogilvie passed away at the age of 89. He came to MIT as a graduate student in 1950 and joined our faculty after completing his ScD. His diverse research interests brought him into contact with many communities in the Boston area and around the world; he was a metallurgist primarily, and he studied Japanese sword-making, the composition of meteorites, and the use of scientific instrumentation to authenticate and conserve works of art. His many friends and colleagues will miss him. We are also saddened by the death last winter of Lawrence Kaufman (ScD '55), a long-time visiting faculty member who taught DMSE's graduate students to use CALPHAD (CALculation of PHAse Diagrams, a highly regarded method of computational thermodynamics and a powerful tool for materials design).

Educational Initiatives

The department is continuing to develop an online component of core subjects, offering 3.032x Mechanical Behavior of Materials starting this fall through MITx. Professor Olivetti has created a new subject, 3.S01 Special Subject: Materials Selection and Design of Nanostructured Catalysts for Sustainable Energy, as part of Summer of Learning, a pilot program created by the Task Force Working Group on MIT Education and Facilities for the Future.

Undergraduate Education

With an incoming sophomore class of 37 students, DMSE's undergraduate enrollment will be 117 students, with approximately 71% women, 22% underrepresented minorities, and 6% international students. Six students are designated Course 3-A (a flexible degree program often taken by students intending to continue their education in the field of medicine, business, or law), and one student is designated Course 3-C (archaeological materials science). In addition, a steady number of students are completing a double major. This past academic year, four students graduated with a double major, and six current students are declared double majors.

Graduate Education

The department's graduate enrollment remains strong, numbering 204 in fall 2013. Approximately 22% of graduate students are women, and 3.9% are underrepresented minorities. Ten DMSE students participate in the Program in Polymer Science and Technology (PPST). For fall 2014, we anticipate an incoming class of 33, approximately 30% of whom are women.

Student Organizations

DMSE's student organizations organize events and develop activities for their fellow students and for the community. This past year, they again created a freshman pre-orientation program, welcomed new students to MIT during orientation, helped with recruiting efforts, and developed demonstrations for the Cambridge Science Festival and other venues.

The 2014–2015 Society of Undergraduate Materials Scientists (SUMS) officers are president Jennie Zheng, vice president Mary Beth Wagner, career development chairs Carolyn Joseph and Selda Buyukozturk, secretary/publicity chair Steph Chen, social chairs Mina Healey and Nikki Effenberger, webmaster Frances Lenahan, and lounge chair Kelsey Doolittle.

The Graduate Materials Council officers for 2014–2015 are president Thomas Batcho; vice president Olivia Hentz; treasurer Corentin Monmeyran; secretary Dina Yuryev; academic committee members Christopher Heidelberger, Scott Grindy, and Frank Fan; athletics chair Brendan Smith; social chairs Abigail Halim, Frank McGrogan, Danielle Raad, and Jeremy Poindexter; alumni committee members Brad Nakanishi and Alex Senko; coffee hour chair Yang Yang Zhao; Departmental Committee on Graduate Students representatives Paul Rekemeyer, Nancy Twu, and Sal Gopalakrishnan; Graduate Student Council representatives Ritchie Chen, Shuchi Ojha, and Astera Tang; outreach committee members Mike Campion and Alexandra Toumar; publicity chair Eugene Cho; and Materials Research Society (MRS) student chapter president Michelle Sing.

Personnel

Juejun (JJ) Hu will join our faculty in January 2015 and will hold the Merton C. Flemings Career Development professorship of materials science and engineering. He comes to us from the University of Delaware, where he was a tenure-track assistant professor. Prior to that, he was a postdoc in MIT's Microphotonics Center. As the Francis Alison Young professor at the University of Delaware, Hu initiated and led research projects involving environmental monitoring, renewable energy, biological sensing, and optical communications. He received the 2013 Gerard J. Mangone Young Scholars Award, which recognizes promising and accomplished young faculty and is the university's highest faculty honor. His proposed research is in three primary areas: substrate-blind multifunctional photonic integration, mid-infrared integrated photonics, and 3D photonic integrated circuits. Professor Hu's group has applied these photonic technologies to address emerging application needs in environmental monitoring, renewable energy harvesting, communications, and biotechnology. Professor Hu holds a BS in materials science and engineering from Tsinghua University and a PhD from our department.

Rafael Jaramillo will hold the Toyota Career Development professorship in materials science and engineering beginning in summer 2015. He received a BS summa cum laude and an MEng, both in applied and engineering physics, from Cornell University. He also holds a PhD in physics from the University of Chicago. Dr. Jaramillo is currently a senior postdoctoral fellow at MIT in the Laboratory of Manufacturing and Productivity (LMP). His interests in renewable energy and accomplishments

in developing materials systems and techniques for energy applications have led to him receiving the Energy Efficiency and Renewable Energy Postdoctoral Research Fellowship from the US Department of Energy.

Effective July 1, 2014, Jeffrey Grossman will be promoted to full professor, and Michael Demkowicz will be promoted to associate professor without tenure. Jeff Grossman joined our faculty in fall 2009. After receiving his PhD in theoretical physics from the University of Illinois, he held a postdoctoral position at the University of California, Berkeley, and then was a Lawrence Fellow at the Lawrence Livermore National Laboratory. Professor Grossman's group uses theory and simulation to gain fundamental understandings and develop new insights based on these understandings; then, working closely with experimental groups at each step, the group uses these insights to design new materials for energy conversion and storage with improved properties.

Michael J. Demkowicz first came to MIT as a graduate student in mechanical engineering and joined our faculty in 2008 after appointments at the Los Alamos National Laboratory. He did his undergraduate work at the University of Texas at Austin, with degrees in physics and aerospace engineering, and he holds a master's and PhD in mechanical engineering from MIT. He works at the intersection of fundamental materials physics and computational design of structural materials. His research addresses the need for rapid advances in structural material performance in the areas of energy, infrastructure, and transportation.

Professor Linn W. Hobbs retired this January, becoming professor without tenure retired. Professor Hobbs came to MIT in 1981 and has held joint appointments in DMSE and the Department of Nuclear Science and Engineering. He has served in many DMSE and Institute leadership and advisory roles, perhaps most notably as advisor for students applying to the Marshall, Rhodes, Gates, and Churchill programs. His colleagues and students will miss his wisdom and good advice but are grateful that he will continue to participate in departmental activities for the next few years.

Several new chair appointments were made this year. W. Craig Carter has been named the POSCO professor of materials science and engineering, Christine Ortiz is now the Morris Cohen professor of materials science and engineering, and Niels Holten-Andersen has been named to the Doherty Career Development professorship in ocean utilization. In addition, the School of Engineering awarded Alfredo Alexander-Katz with the Walter Henry Gale Career Development professorship in recognition of his excellence in teaching and research.

We were successful in hiring a staff person to assist with creating online versions of our curriculum; Jessica Sandland holds an SB (1999) and PhD (2005) from our department. Prior to accepting this position, she worked at Lincoln Laboratory and as an instructor at Lesley University. We were pleased that Tara Fadenrecht has joined the staff as a technical instructor, primarily working with the Metals Lab subjects. Tara received an MFA from the University of Pennsylvania and a BFA from the University of Kansas.

Bruce Siegal has left MIT. DMSE is now searching for a new development officer to work with the department head and School of Engineering development staff to build relationships with DMSE donors and alumni, which will help the department achieve a stronger financial foundation.

Research Highlights

DMSE's faculty and students believe that materials technology will be the source of solutions to societal needs, whether they be in energy storage, medicine, transportation, recycling, building materials, or communications. Over the past year, research breakthroughs have occurred in many areas; a few samples are described below.

Professor Gerbrand Ceder's group has determined how sodium manganese dioxide behaves during charging and discharging in battery devices; this is an immediate application of basic science research in energy storage. Professor Ceder's Materials Project has continued to grow, with more than 50,000 compounds and 14,000 band structures available, used by researchers worldwide. We expect the Materials Project to be one of the greatest contributions to knowledge to come out of our discipline.

Professor Michael Cima continues to develop new technologies that allow for medical monitoring and drug delivery inside the body. This year he published papers on a device that monitors oxygen levels at tumor sites in the body via magnetic resonance imaging (MRI), allowing physicians to determine treatment doses or chart new treatment plans without invasive biopsies.

Professor Jeffrey C. Grossman is a computational materials scientist with a focus in energy applications. Earlier this year, he published a paper demonstrating a way to store solar heat energy for later use. This work builds on previous research, successfully determining a method to close-pack molecules into the material, a more difficult task than expected. The breakthrough was in combining molecules and substrates, a technique with wide-ranging future applications.

Along with her responsibilities as dean for graduate education, professor Christine Ortiz continues her work with analyzing the structure of biological creatures to develop new materials. Her group recently published findings on the shells of the mollusk Placuna placenta, which are not only exceptionally durable but also transparent. The shells, which are 99% calcite and 1% other organic material, were examined via indentation tests, and a high-resolution analysis with electron microscopy and diffraction was conducted to assess the resulting damage. The group discovered that the material initially isolates damage through an atomic-level process called "twinning" within the individual ceramic building blocks: a crystal breaks up into a pair of mirror-image regions that share a common boundary. This twinning process occurs around the stressed region, forming a boundary that keeps the damage from spreading outward. These discoveries have potential applications in blast shields, windshields, and safety devices.

Awards and Honors

Professor Polina Anikeeva was the inaugural recipient of the Dresselhaus Award, established this year by Institute Professor Millie Dresselhaus with the proceeds of her

Kavli Award. Professor Anikeeva also participated in the MIT "Women in Academia" panel, presented by the Undergraduate Women in Physics group and held in honor of Professor Dresselhaus's contributions to women and junior faculty. Other panelists were former MIT president Susan Hockfield and professors Barbara Liskov, Paola Cappellaro, and Molly Potter; the moderator was professor Edmund Bertschinger, the Institute community and equity chair.

Professor Demkowicz was recognized with the Graduate Materials Council (GMC) Best Teaching Award this year. Also, in addition to teaching 3.22 Mechanical Behavior of Materials, he has created a new subject, 3.33 Defects in Materials.

Professor Grossman was the recipient of many honors this year recognizing his excellence in teaching, advising, and research innovations. He received the Bose Award for Excellence in Teaching from the School of Engineering in recognition of his work in MIT's undergraduate academic program. He also received the Frank E. Perkins Award for Excellence in Graduate Advising from MIT's Graduate Student Council; nominations for this award, which recognizes unbounded compassion and dedication toward students, are submitted by students across the Institute. GMC named Professor Grossman best advisor this year, and he was elected to join the American Physical Society Fellows. He received a Professor Amar G. Bose Research Grant for his proposal "Coal for Photovoltaics: Let It Shine Instead of Burn." Of the 100 proposals submitted, seven were selected for funding. Grant recipients receive $500,000 over three years.

Professor Hobbs was honored by the British government with a reception in his honor recognizing his many years of coordinating international collaborations between the United States and the United Kingdom. Professor Hobbs has advised the Marshall, Fulbright, and Gates scholarships. He is also the advisor for the MIT partnerships with Cambridge University and Imperial College London.

Professor Michael Rubner has been named a fellow of the Materials Research Society for "pioneering research in layer-by-layer assembly of functional thin films; inspirational mentoring of two generations of materials scientists; and visionary leadership in the materials community worldwide."

Professor Donald R. Sadoway received the 2014 Norm Augustine Award for Outstanding Achievement in Engineering Communication from the American Association of Engineering Societies.

Undergraduate Awards

At Commencement, Colleen Loynachan '14 was named outstanding senior and also received the award for the outstanding senior thesis. She was the SUMS president this academic year. Her thesis, "Targeted Magnetic Nanoparticles for Remote Manipulation of Protein Aggregation," was supervised by Professor Anikeeva. She presented her work at an MRS talk in late April. During her time at MIT, she participated in the Oxford exchange program, received the Barry Goldwater Scholarship, was elected to Tau Beta Pi, and was a teaching assistant (TA) in 3.014 Blacksmithing at MIT. She is also the recipient of the 2014 Henry Ford II Scholar Award, presented to "the senior in the School

of Engineering who has attained the highest academic record at the end of the third year and who has exceptional potential for leadership in the profession of engineering and in society." She will attend Imperial College next year as a Marshall Scholar before enrolling in Stanford University's materials science and engineering department.

DMSE's other outstanding senior award recipient was Sam Shames '14. Sam was a member of Professor Grossman's research group and a TA in 3.012 Fundamentals of Materials Science and Engineering. He was a championship wrestler, wrote for The Tech, helped with MIT's edX initiative, was an MIT tour guide, and in his spare time ran the 2014 Boston Marathon as a member of the MIT Strong team. Sam will work full time next year at Wristify, a start-up that grew out of his team's winning Making and Designing Materials Engineering Contest (MADMEC) project. He was also a Hertz Fellowship finalist.

Erica Lai '14 was the recipient of the Horace A. Lubin Award for DMSE Community Service. Erica served as the SUMS Career Development chair for two years. She initiated the Feast with Faculty program and organized graduate school and industry career panels.

Max Ramundo '14 won the Joseph M. Dhosi Outstanding Internship Award. His internship report, "Processing and Phase Transformations in Nano Ceramic-Reinforced Quasicrystalline Aluminum Alloys," was supervised by Dr. Marina Galino. His DMSE faculty internship advisor was professor David Roylance. After graduation, he will do a six-month internship with Ferrari SpA in Maranello, Italy, as part of the company's graduate program.

Inbar Yamin '15 received the Julian Szekely Award for Outstanding Junior. In addition to her outstanding academic performance, Inbar has taught Hebrew to beginners, been a departmental tutor, is involved with MIT Hillel, and has worked with the Undergraduate Research Opportunities Program (UROP).

Sarah Warkander '16 was named outstanding sophomore.

The department established an Undergraduate Teaching Award to recognize William Dickson '14 and Mary Breton '14 for their significant contributions to 3.091r Introduction to Solid-State Chemistry. Professor Cima wrote, "Will and Mary were my key collaborators last semester for the 3.091r experiment. I can say it would not have happened without their devotion to doing a great job."

Haewoo Kim, Colleen Loynachan, and Caitlin Sample were all invited to join Phi Beta Kappa.

Hanna Vincent '14 was named a 2014 honorable mention All-American by the Intercollegiate Sailing Association. She was captain of the MIT women's sailing team.

Graduate Awards

At Commencement, the department presented two awards for best PhD thesis: to Satoru Emori of professor Geoffrey Beach's group (for "Domain Walls Driven by Interfacial

Phenomena") and to Tongjai Chookajorn of professor Christopher Schuh's group (for "Enhancing Stability of Powder-Route Nanocrystalline Tungsten-Titanium via Alloy Thermodynamics"). Satoru is currently a postdoc at Northeastern University. Tongjai will be a postdoc at MIT and then work as a research scientist at the National Metal and Materials Technology Center in Thailand.

Jocelyn Newhouse received the PhD Distinction Award for her thesis, "Modeling the Operating Voltage of Liquid Metal Battery Cells," advised by Professor Sadoway. Currently, Jocelyn is a postdoc with Professor Olivetti.

The Graduate Student Teaching Award was presented to Oliver Kent Johnson for his work in 3.21 Kinetic Processes of Materials, taught by professor Carl Thompson. According to Professor Thompson, "without Oliver's outstanding assistance this term, 3.21 could have been a disaster."

The DMSE Community Service Award was presented to Alexandra Toumar for her dedication to the department and to the community around us. Since coming to MIT three years ago, she has been the GMC president, coffee hour coordinator, co-president of Women of Materials Science, GSC representative for the Title IX student working group, and Public Service Center liaison.

Wenxuan Huang received the First-Year Graduate Student Exceptional Performance Award. He came to MIT from the National University of Singapore; he was nominated for the award by his thesis advisor, Professor Ceder, who said that "Wenxuan has an intellectual depth that I rarely experience, even at MIT, and a research intensity that drives him to tackle important fundamental problems."

John Wulff Excellence in Teaching Awards were presented to Rachel Zucker and Donghun Kim. Rachel was a TA for 3.044 Materials Processing and 3.016 Mathematical Models for Materials Scientists and Engineers, and Donghun was a TA for 3.091 Introduction to Solid-State Chemistry.

Benjamin Grena from professor Yoel Fink's group was a runner-up at MIT's Polymer Day poster contest. Benjamin's poster was titled "Porous Polymeric Domains in Thermally-Drawn Fibers." Polymer Day is sponsored by PPST.

Two DMSE graduate students were included in Forbes magazine's annual "30 Under 30" lists, which recognize young innovators who will change the world. David Cohen-Tanugi and Sophie Ni were both included in the Energy and Industry list. David was recognized for his work with the MIT Water Club and for his participation in Wristify, this year's winning MADMEC team. Sophie is a co-founder of Takachar, an organization that is working to create valuable charcoal for home cooking from organic waste discarded in some of the world's poorest cities.

Abishek Kashinath received one of the three graduate student awards presented at the Department of Energy (DOE) Energy Frontier Research Center (EFRC) conference in Washington, DC, in 2013. DOE has funded approximately 50 EFRCs at universities, and

all participants were invited to the conference. About 15 finalists were chosen to give presentations that were judged for scientific merit, clarity of communication, and how well they represented the effort of their respective EFRCs. Abishek is a member of the Demkowicz group. One of the other winners was Maria Luckyanova from professor Gang Chen's group in the Department of Mechanical Engineering.

Staff Awards

Gerry Hughes received the Ellen J. Mandigo Award for Outstanding Service at the School of Engineering's Infinite Mile Awards ceremony. Gerry joined DMSE as facilities manager in 2001, with responsibilities for repairs, renovations, maintenance, and relocations in labs and offices across five buildings. This year Gerry received a master of science in facilities management. We are proud of his accomplishments and grateful for the expertise, understanding, and good humor he brings to MIT every day.

Future Plans

In the coming year, we will complete the renovations to the forge, foundry, and glass facilities in the basement of Building 8. These teaching facilities are all important areas for hands-on educational experiences, and the renovations not only will improve air handling and provide new equipment but will also include installation of windows in the hallway to allow all passersby an opportunity to watch materials processing in action. With the rest of MIT, we are eager for completion of MIT.nano and are considering how to complement its facilities with our plans for lab renovations and equipment purchases.

The DMSE Visiting Committee will meet this fall, at which time we plan to discuss potential changes to our undergraduate and graduate curricula, future hiring needs, and fundraising priorities.

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