Materials Processing Center

The Materials Processing Center (MPC) was established as an interdisciplinary center within the School of Engineering in response to a recognized national need to improve the materials processing knowledge base and to streamline the process of translating materials research results into industrial innovations and applications. MPC is now in its 37th year.

Following a science-to-systems approach, MPC works with faculty to assemble resources and leverage existing knowledge to help companies and federal agencies address fundamental challenges through research and create opportunities through technology transfer. MPC supports about 60 faculty and senior research staff with proposals for research and post-award program management. In addition, we provide administration services and liaison support with industry contacts outside of MIT. The center also organizes events for the broader materials research community at MIT, which includes more than 150 faculty.

The MPC staff went through a transition this year. Long-time employee Frances Page, who was the assistant to the director and human resources administrator, had been with MPC for 36 years before her retirement on September 15, 2016. Fran joined MIT 52 years ago and held various other positions throughout the Institute before joining MPC in 1980. Lisa Sinclair joined the MPC staff as senior administrative assistant on January 1, 2017. Lisa previously worked in the Microphotonics Center and has been at MIT for 10 years.

Industry Collegium and External Advisory Board

The MPC Industry Collegium consists of nine companies that provide direct financial support for the center's discretionary activities through annual donations. Representatives from these companies work with MPC throughout the year to identify opportunities for collaboration and participate in MPC's annual Materials Day symposium and poster session. Current collegium members are as follows: Agoria-Belgium Consortium, Applied Materials, Ishikawajima-Harimi Heavy Industries, Merck KGaA, Michelin, Raytheon, Shanghai Banzan Macromolecule Materials, Stanley Black & Decker, and SunEdison Semiconductor.

The MPC external advisory board meets for a full day after the Materials Day event each year. The MPC director and staff report on the prior year's activities and present on planned initiatives and goals for subsequent years. In addition, new faculty present their planned research for the year and senior faculty discuss major new initiatives. The external advisory board provides valuable advice on program development and management. It also assists in identifying opportunities for interactions with industry. The board meeting culminates in an oral and written report to the vice president for research or a designated representative. Current board members represent 3M Corporate Research Laboratory, Applied Materials, Boston University, Compaq Computer Corporation, Gateway for Accelerated Innovation in Nuclear, General Motors, Lockheed Martin Corporation, Lord Corporation, Midrange Systems EMC, Novartis Pharmaceuticals, Saint-Gobbain, Sandia National Laboratories, Solvay Advanced Polymers, and SunEdison Semiconductor.

Faculty members who spoke at this year's board meeting included Vice President for Research Maria Zuber, Professor and Department Head Chris Schuh (Materials Science and Engineering), Associate Professor Nuh Gedik (Physics), Assistant Professor Jeehwan Kim (Mechanical Engineering), Assistant Professor Julia Ortony (Materials Science and Engineering), Assistant Professor Nikta Fakhri (Physics), and Assistant Professor Rafael Jaramillo (Materials Science and Engineering).

Center for Electrochemical Energy Storage

The Center for Electrochemical Energy Storage (CEES) continued into its fourth year in 2017. CEES is one of approximately 10 centers for research, education, and innovation (CREIs) that provide support for research and teaching at the Skolkovo Institute of Science and Technology (Skoltech), which was founded in close collaboration with MIT (through the MIT Skoltech Initiative) in 2011. Each of the original CREIs is based on collaborations among Skoltech, a Russian university (Moscow State University in the case of CEES), and an international university (MIT in the case of CEES).

The CEES team is highly interdisciplinary and involves faculty from the MIT Departments of Mechanical Engineering, Chemical Engineering, Materials Science and Engineering (DMSE), and Chemistry as well as faculty from the Departments of Physics and Chemistry at Moscow State University. As of the end of FY2016, a total of five MIT faculty were involved in CEES, including the center director.

Research in CEES is focused on three thrusts—advanced metal-ion batteries, rechargeable metal-air batteries, and fuel and electrolysis cells—chosen to target the technologies that will replace the current Li-ion battery technology. The center is also conducting a project addressing general methods for systems-level analyses. Research on advanced metal-ion batteries focuses on electrode and electrolyte materials for earth-abundant ions such as Na^+ as replacements for more expensive Li^+ ions, as well as on improved materials for Li-ion batteries such as dual electronic and ionic conducting polymer materials. Activity was recently initiated on the development of new metaphosphate compounds for redox flow batteries. Research on reversible metal-air batteries included mechanistic studies of the effects of electrolyte solvents on discharge product morphologies that lead to high volumetric capacities in both Li-air and Na-air batteries. Modeling and experimental studies also focused on catalytic materials for oxide reduction reactions, which are important in metal-air batteries as well as electrolysis. Other research directed toward coupled solid oxide fuel and electrolysis cells included an investigation of materials with mixed ionic and electronic conduction to enable high performance of solid oxide fuel cells that operate at reduced temperatures.

Microphotonics Center

The Microphotonics Center (MPhC) was established in 1999 based on research on silicon photonic device integration and applications to support the demand for exponential growth in communication bandwidth that has enabled the information age. MPhC performs research and technology supply chain studies utilizing a technology working group (TWG) model. These studies were originally incorporated in official releases of the MIT Communication Technology Roadmap (CTR). This effort has now expanded to a global industry roadmap labeled the Integrated Photonics System Roadmap (IPSR

International). The center's industrial advisory board commissions working groups that operate with active participation of members and allied industrial partners. The center supports multiple working groups addressing a wide range of technology issues including materials platforms, power efficiency and bandwidth performance, electronic-photonic convergence, and scalability.

In 2014, the Microphotonics Center and the International Electronics Manufacturing Initiative (iNEMI) were awarded a grant from the National Institute of Standards and Technology to address the technology gaps and challenges that are limiting the advance of hardware technology for integrated photonic system manufacturing. In addition, a federal Manufacturing USA award to the American Institute for Manufacturing Integrated Photonics (AIM Photonics), based in Rochester, NY, has enhanced support for MPhC manufacturing roadmap activities. TWGs have been established through project awards with AIM Photonics.

The center maintains excellent and growing representation and participation from industry, in addition to academic and government agencies. The IPSR 2016 release represented the combined efforts of more than 700 contributors from 256 organizations in 16 countries. In addition to regular meetings of the MPhC board and TWGs, the center membership meets twice each year to review silicon microphotonics research (in the fall) and the CTR (in the spring).

AIM Photonics

On July 27, 2015, the Obama administration announced the award of the Integrated Photonics Institute for Manufacturing Innovation to AIM Photonics, a $600 million public-private partnership that will help strengthen high-tech US-based manufacturing. AIM Photonics brings government, industry, and academia together to advance domestic capabilities in integrated photonic technology. The lead institution in this partnership is the University of New York Polytechnic Institute (SUNY Poly). The AIM Photonics executive management team includes Professor Michael Watts as chief technology officer and Professor Lionel Kimerling as education, workforce development, and roadmap executive. AIM Photonics is now in its second year of operation. MPC supports Professor Kimerling as the lead principal investigator (PI) for MIT with AIM Photonics.

The AIM Photonics Academy, based at MIT, has been established under the leadership of Professor Kimerling as the organization leading the development of education, workforce development, and roadmap content and services addressing manufacturing technology issues for the integrated photonics industry. Funding of its activities is supported by project awards approved through the AIM Photonics annual call for proposals. The academy leadership team includes participating members from iNEMI, SUNY Poly, the University of Rochester, the Rochester Institute of Technology, Boston University, the University of Arizona, and the University of California, Santa Barbara.

The AIM Academy's execution of its responsibilities is closely coordinated with local and state agencies and institutions (e.g., the Massachusetts Department of Housing and Economic Development and the Massachusetts Technology Collaborative) in support of education and workforce development programs and tools for photonics at universities

(MIT, University of Rochester, Rochester Institute of Technology, SUNY Poly, and Boston University) and community college consortia (Quinsiggamond Community College and Worcester Polytechnic Institute).

The AIM Summer Academy provides weeklong instruction in integrated photonics fundamentals and manufacturing technology. The highly successful 2017 session accommodated 100% overbooking. Online specialization courses, on-site industry campus workshops, and regional instruction classes will be offered in early 2018.

The AIM Photonics Academy leverages and builds on the ongoing success of the Microphotonics Center and the CTR program through its participating members from industry, academia, and government and semiannual meetings held at MIT.

Advanced Functional Fabrics of America

MIT was the lead institution for a successful proposal to create the Advanced Functional Fabrics of America (AFFOA) Manufacturing Innovation Institute, which was launched in April 2016. The AFFOA program functions through a partnership with the Department of Defense (DOD), 32 universities, 16 industry members, 72 manufacturing entities, and 26 startup incubators spread across 27 states and Puerto Rico. AFFOA's mission is to enable the transformation of traditional fibers, yarns, and textiles into highly sophisticated integrated and networked devices and systems.

The AFFOA headquarters and research facility opened in Cambridge on June 19, 2017. The facility includes a fabric discovery center that provides end-to-end prototyping from fiber design to system integration of new textile-based products. It also includes a startup incubation space for companies spun out from MIT and other partners that are innovating advanced fabrics and fibers for applications ranging from apparel and consumer electronics to automotive and medical devices.

The MIT component of the AFFOA program is led by Professor Gregory Rutledge of Chemical Engineering and is administered through MPC. MIT-based research programs are currently under development.

Lightweight Innovations for Tomorrow

The Materials Systems Laboratory (MSL), directed by Professor Joel Clark (Materials Science and Engineering), continues to be a key participant in the Lightweight Innovations for Tomorrow (LIFT) Manufacturing Innovation Institute. LIFT provides a national focus on expanding US competitiveness and innovation by facilitating the transition of advanced lightweight and modern metals manufacturing capabilities and new technologies to the industrial base. Federal support is provided through the Office of Naval Research. Principal Research Scientist Randolph Kirchain is leading the MIT component of the LIFT activity, which focuses on cost, value, and life-cycle analyses as well as implementation strategies for both primary and secondary weight automobile savings. MSL faculty and staff recently published an extended commentary on environmental life-cycle analysis in *Nature Materials*.

Reducing Embodied Energy and Decreasing Emissions Institute

The Reducing Embodied Energy and Decreasing Emissions Institute (REMADE) is one of the latest program awards under the Manufacturing Innovation Institutes (MII) initiative supported by the US government. The award for the REMADE proposal was announced in January 2017. REMADE is led by the Sustainable Manufacturing Alliance, based at the Rochester Institute of Technology. It will leverage federal funding of $70 million over five years and is matched by an additional $70 million in private cost shares from industry and other organizations. The institute will focus on driving down the costs of technologies essential to reuse, recycle, and remanufacture materials such as metals, fibers, polymers, and electronic waste, with the objective of achieving a 50% improvement in overall energy efficiency by 2027.

MPC is supporting Elsa Olivetti, MIT lead professor, as details of MIT's participation in the institute are defined. The REMADE kickoff meeting was held in June 2017 following a six-month "stand-up" period in which organizational details and agreements were established. Professor Olivetti is actively working with the REMADE organization, in coordination with more than 10 professors at MIT, in preparation for the call for proposals planned for the fall of 2017. MIT's research activities related to sustainability include materials optimization for manufacturing, systems analysis, and recycling.

Singapore-MIT Alliance for Research and Technology Low Energy Electronic Systems

The Singapore-MIT Alliance for Research and Technology (SMART) Low Energy Electronic Systems (LEES) interdisciplinary research group, directed by Professor Eugene A. Fitzgerald and managed through MPC, completed its phase 1 activity in 2016. The five-year phase 2 program was approved in fall 2016 and began in January 2017. This program has a budgeted research volume of approximately $1.3 million per year for the first four years and a ramp-down budget of $650,000 for the fifth and final year. The Singapore-based volume is approximately three times greater.

The goal of the LEES program is to demonstrate a research paradigm in which specialists in materials processing, device and circuit design, and systems architecture work in close concert to develop new integrated circuit technologies that will enable new applications. The key feature is that these specialists work jointly in the iterative process that leads to innovation that has impact. Toward achieving its goals, in phase 1 LEES developed a 200-mm wafer processing facility in Singapore that includes two state-of-the art metal organic chemical vapor deposition systems as well as other components such as wafer bonding, chemical mechanical polishing tools, and tools for materials and device characterization. Coupled with other facilities available through collaborations with the Nanyang Technical University (NTU) and the National University of Singapore (NUS), full capabilities for III-V device processing on silicon substrates have been developed. Collaborations with two semiconductor integrated circuit foundries have also been established. Through these collaborations, LEES compound semiconductor devices and circuits have been integrated with silicon complementary metal-oxide-semiconductor circuits to produce new circuit architectures for new functionalities.

Key features of the new platform developed by LEES include the following:

- Seamless integration with Si foundry processes
- Core III-V and Si integration-enabling process technologies
- Heterogeneous III-V and Si process design kits for circuit designers
- Initial demonstrations of integration possibilities
- Advanced material options and complementary technologies for optical/electrical/wireless integrated circuits

In addition, research is being carried out on photovoltaic devices, microbatteries, and thermal management systems for future integration into the LEES platform.

The SMART program involves seven MIT faculty and several MIT senior research scientists, as well as their students and postdocs based at the Institute. Eleven faculty from NTU and NUS are also involved in collaborative research. Twenty-four MIT staff and postdocs are now supported in Singapore for research based there. A number of NTU and NUS graduate and undergraduate students supported by fellowships are also involved in the program.

Center for Integrated Quantum Materials

Entering its fifth year, the Center for Integrated Quantum Materials (CIQM) is a National Science Foundation (NSF) science technology center led by Harvard University, with principal partners at MIT, Boston's Museum of Science, and Howard University. The center focuses on discovering new quantum materials that will transform signal processing and computation. MIT's CIQM effort pulls together 10 PIs in various fields including quantum materials, quantum electronics and photonics, and atomic scale networks. Support is provided to seven graduate students, five postdoctoral associates, and a number of undergraduate students from MIT; additionally, graduate students are involved in exchange programs throughout the network of partner institutions.

Quantum Science Summer School

The NSF/Department of Energy (DOE) Quantum Science Summer School is a four-year program with the mission of training graduate students and postdocs in condensed matter physics, materials science, and disciplines of quantum science in engineering, chemistry, and related fields. NSF solely funded the program's first year, but it is expected that DOE will also contribute in future years, with total funding of $1 million.

The annual summer school focuses on key topics of interest in quantum science and their applications to new technologies in academic and industrial contexts. The goal is to provide training to participants in these subfields by experts in an intensive two-week format. The 2017 program focused on quantum computing and was held in June at Johns Hopkins University. Program organizers included Professor Joe Checkelsky (MIT), Associate Professor Natalia Drichko (Johns Hopkins University), Associate Professor Liang Fu (MIT), Assistant Professor Kyle Shen (Cornell University), and Associate Professor Jun Zhu (Pennsylvania State University). More than 170 students applied for the program, and 52 were accepted. The program covered students' expenses, including travel, housing, and meals.

Selected New Programs with Industry

MPC continues to support faculty research efforts with industry collaboration over a wide range of materials science–based applications, from metallurgical coatings for strength and corrosion resistance to integrated photonics, solar cells, and batteries. MPC supports many ongoing research programs with faculty, including Professor Christopher Schuh's research with Mitsubishi Materials and ORMCO, Professor Lionel Kimerling's programs with iNEMI and AIM Photonics, Professor Antoine Allanore's program with Tavarua and Sumitomo, Professor Donald Sadoway's research with NorCo, Randy Kirchain's research with the Hangzhou Jinjiang Group and Rio Tinto, Professor Elsa Olivetti's program with Advanced Micro Devices, Professor Cem Tasan's research with Metalsa, and Senior Research Scientist Jurgen Michel's programs with Futurewei and the Advanced Research Projects Agency-Energy. MPC, working with faculty, will seek to engage individual companies for future development of research.

MPC also supports faculty with the establishment and operation of consortium research programs with industry. Two ongoing programs for 2016 and 2017 are the Materials Systems Laboratory (Professor Joel Clark and Randolph Kirchain) and the Microphotonics Center (Professor Lionel Kimerling, director).

MPC partners with MIT Industrial Liaison Program (ILP) officers in support of company inquiries and ILP members' interests in faculty research. MPC support includes coordination with ILP officers and faculty for meetings as well as technical briefings and seminars offered by the MPC director and associate director. Significant company meetings coordinated with ILP officers throughout the year were held for senior executives and researchers from 3M, Applied Materials, CBMM, Comcast, Global Foundries, Metalsa, Michelin, Microsoft, Mitsubishi Heavy Industries, NTT NEL America, the SNCF French Railways Group, Stanley Black & Decker, and Sun Edison Semiconductor. All are either members of ILP or participants in the MPC Industry Collegium or Microphotonics Center Consortium. MPC also supports other major events sponsored by ILP, including its research and development conferences in Japan and at MIT.

Promotions and Selected Grants, Honors, and Awards

MPC faculty received numerous awards and honors, as individually described in the reports of their home academic departments. Some highlights are listed below.

Associate Professor of Metallurgy Antoine Allanore (DMSE) will receive a two-year grant of up to $200,000 per year for his project "Affordable Potassium Fertilizer from K Feldspar for Africa." The grant, provided by the Abdul Latif Jameel World Water and Food Security Lab, is part of MIT's Institute-wide initiative to promote, coordinate, and lead research related to water and food that will have a measurable and international impact.

Liang Fu, assistant professor of physics, was granted tenure. Fu is interested in theories of topological insulators—a new class of materials whose surfaces can freely conduct electrons even though their interiors are electrical insulators—and topological superconductors, with a focus on predicting and proposing their material realizations and experimental signatures. He is also interested in potential applications of topological materials ranging from tunable electronics and spintronics to quantum computation.

Associate Professor Jeff Gore (Department of Physics) was also granted tenure. He uses experimentally tractable microcosms such as bacterial communities to explore the physics of complex living systems, examining how interactions between individuals drive the evolution and ecology of communities. Gore's primary areas of research include the behavior of populations near tipping points that lead to collapse, the evolution of cooperative behaviors within a species or community, and the determining factors for multi-species diversity within a community.

Tomás Palacios, professor of electrical engineering and computer science, was named a 2017 IEEE (Institute of Electrical and Electronics Engineers) Fellow. The IEEE fellows program honors "those who have contributed greatly to the advancement of engineering, science, and technology." Palacios was honored for his contributions to gallium nitride electron devices and two-dimensional materials. His research focuses on the combination of new semiconductor materials and device concepts to advance the fields of information technology, biosensors, and energy conversion.

Communications and Outreach

Communicating online is crucial in today's social media environment. The MPC website is a campus-wide materials reporting resource and has become a hub where information is shared not only with other materials researchers at MIT but also with the world. The website is updated daily and highlights the latest news stories being generated for our e-newsletter, as well as related news from the MIT News Office. This year the newsletter format changed, and in addition to featuring faculty members we also communicate new research being conducted by graduate students and postdocs. Faculty profiles in 2016–2017 included Robert Macfarlane (DMSE), Antoine Allanore (DMSE), and Senthil Todadri (Physics). This year 37 original articles were written and photographed for the e-newsletter, and 24 of those articles were picked up by the MIT News Office for use on its own website. Other departments within the Institute as well as organizations outside MIT also picked up our articles. In addition, we produced 16 videos with a total of 9,157 views on YouTube.

We continue to use social media (Twitter, Facebook, and Google+) to communicate with and expand our audience. As a result, we have grown our following by almost double from last year, and now other MIT organizations are sharing our Twitter posts with their followers.

Summer Research Internship Program

MPC does not limit its educational outreach to the MIT community. For 33 years, it has co-sponsored with the Center for Materials Science and Engineering (CMSE) a summer internship program for promising undergraduate researchers from other colleges and universities nationwide. The MPC-CMSE summer internship is an NSF Research Experiences for Undergraduates program. The program brings the best science and engineering students in the country to MIT for graduate-level materials research in the laboratories of participating faculty. The program culminates in a poster session held in the lobby of Building 13, where students present their research to the MIT community.

The 2017 nine-week program ran from June 15 to August 5 and involved 14 faculty and 14 students from schools including the University of South Florida, Northwestern University, the University of Michigan, California State University, the University of Puerto Rico-Mayaguez, Howard University, Pennsylvania State University, the University of New Mexico, the University of Virginia, Rutgers University, the University of Wisconsin, the University of Connecticut, and the New Mexico Institute of Mining and Technology.

2016 summer scholars.

Materials Day

Sharing knowledge and insight with others in the materials science and engineering field can lead to new ideas, collaborations, and breakthroughs. Once a year, the materials community is invited to Materials Day, a celebration to recognize and honor the many important accomplishments and achievements of the past year and to talk about the future.

Held in the fall, Materials Day is a daylong symposium on a featured topic related to materials science and processing, followed by a graduate student/postdoctoral associate poster session. The Materials Day 2016 symposium focused on materials for electrochemical energy storage. Seven presentations were offered over the course of the day, by both faculty and industry professionals, drawing a crowd of more than 140 attendees.

Invited speakers (and the titles of their talks) were as follows: Professor Jessica Trancik of MIT ("Evaluating Storage Technologies for Solar and Wind Energy"), Kevin Eberman of 3M ("3M's Battery Materials—Still Room for More Energy in Li-ion"), Boris Kozinsky of Bosch ("Materials Challenges for Next-Generation Batteries and Opportunities Using Computational Design"), Professor Yang Shao-Horn of MIT ("Activating Oxygen Chemistry for Sustainable Energy"), Glen Merfeld of GE Global Research ("Capturing the Value of Energy Storage"), Professor Yet-Ming Chiang of MIT ("Ultralow Cost Electrochemical Storage to Turn Renewable Energy into Reliable Energy"), Professor Martin Bazant of MIT ("Control of Phase Transformations in Rechargeable Batteries"), and MPC director Carl V. Thompson, who led the opening welcome presentation.

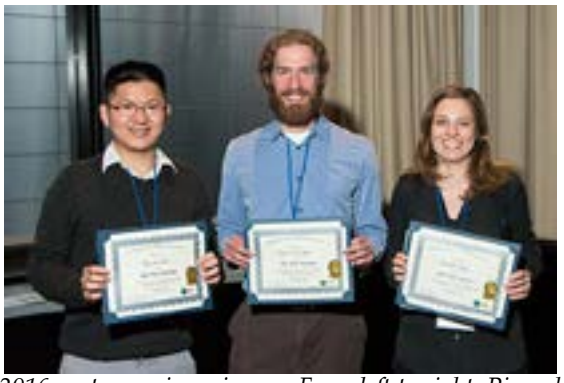
The poster session that followed panel presentations and discussions included over 50 posters presented by graduate students and postdoctoral associates from departments such as Chemical Engineering, Chemistry, Civil and Environmental Engineering,

Electrical Engineering and Computer Science, Aeronautics and Astronautics, Materials Science and Engineering, Mechanical Engineering, Nuclear Science and Engineering, Biological Engineering, and Physics. The posters were judged by a panel of representatives from industry as well as members of the MPC advisory board. Winners received award certificates and $500 prizes. Poster session winners were as follows:

Ping-chun Tsai, Bohua Wen, Hui-Chia Yu, Min-Ju Choe, Mark Wolf, Jordi Cabana, and Katsuyo Thornton, DMSE
"Interfacial Kinetics and Electrochemical Shock in Battery Electrode Particles"
Faculty advisor: Professor Yet-Ming Chiang

Frank P. McGrogan, Tushar Swamy, Sean R. Bishop, Erica Eggleton, Lukas Porz, and Xinwei Chen, DMSE
"Coupling between Electrochemistry and Mechanics for All-Solid-State Li-ion Battery Electrodes and Electrolytes"
Faculty advisor: Professor Krystyn J. Van Vliet

Roberta Polak, Matthew J. Haney, Natalya L. Klyachko, Yuling Zhao, Reginaldo J. Gomes Neto, and Elena V. Batrakova, DMSE
"Polymer Backpacks for Cell-Based Therapies across the Blood-Brain Barrier"
Faculty advisors: Professors Michael F. Rubner and Robert E. Cohen



Materials Day 2016 poster session winners. From left to right: Ping-chun Tsai (Materials Science and Engineering), Frank P. McGrogan (Materials Science and Engineering), and Roberta Polak (Materials Science and Engineering).

Materials Day 2017 is scheduled for October 11, 2017, and the workshop will focus on frontiers in materials research.

Research Volume

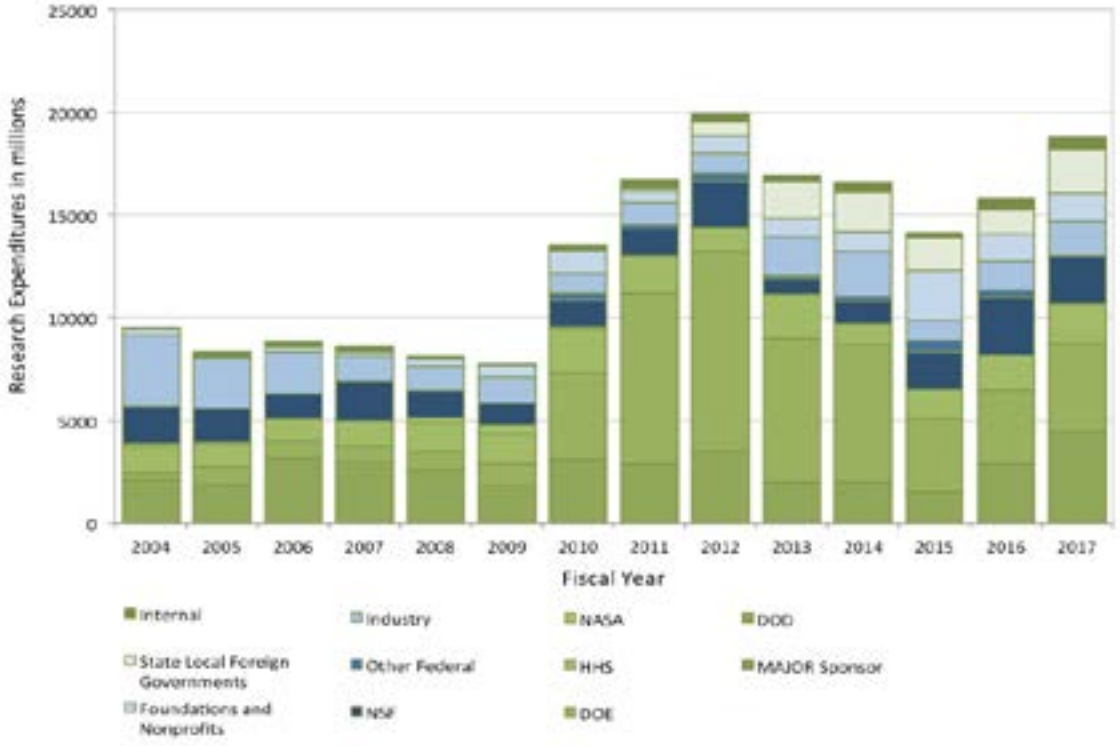
Total expenditures under MPC were $20.6 million in FY2017. Research expenditures from sponsored programs totaled $18.8 million, an increase of 18.9% over FY2016.

Major program expenditures included the Low Energy Electronic Systems program within SMART, led by Professor Eugene Fitzgerald and eight co-PIs; the Skoltech Center for Electrochemical Energy Storage, led by Professor Carl V. Thompson and five co-PIs; the Chemomechanics of Far-From-Equilibrium Interfaces program, supported by DOE and led by Professor Harry Tuller and five co-PIs; the NSF-supported Center for Integrated Quantum Materials, in collaboration with Harvard University and led by Professor Raymond Ashoori and seven co-PIs; and the American Institute for

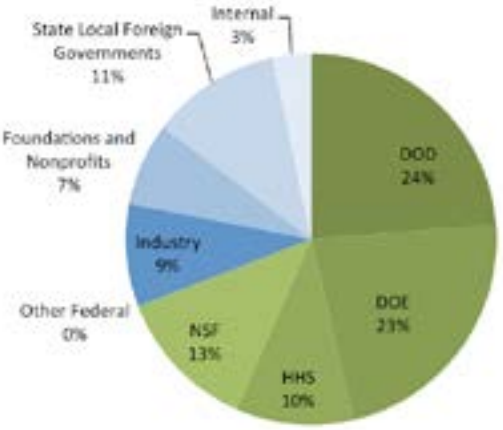
Manufacturing Integrated Photonics (in collaboration with the State University of New York Research Foundation), supported by DOD and led by Professor Lionel Kimerling and six co-PIs. Other significant faculty research groups included those of Associate Professor Pablo Jarillo-Herrero, Assistant Professor Ibrahim Cisse, Associate Professor Jeffrey Gore, Associate Professor Nuh Gedik, Senior Research Associate Jurgen Michel, Associate Professor J.J. Hu, and Assistant Professor Antoine Allanore.

MPC researchers are sponsored not only by a variety of companies but also by nearly every major federal research sponsoring agency, including NSF, DOE, the National Institutes of Health (NIH), the National Aeronautics and Space Administration, and multiple DOD agencies.

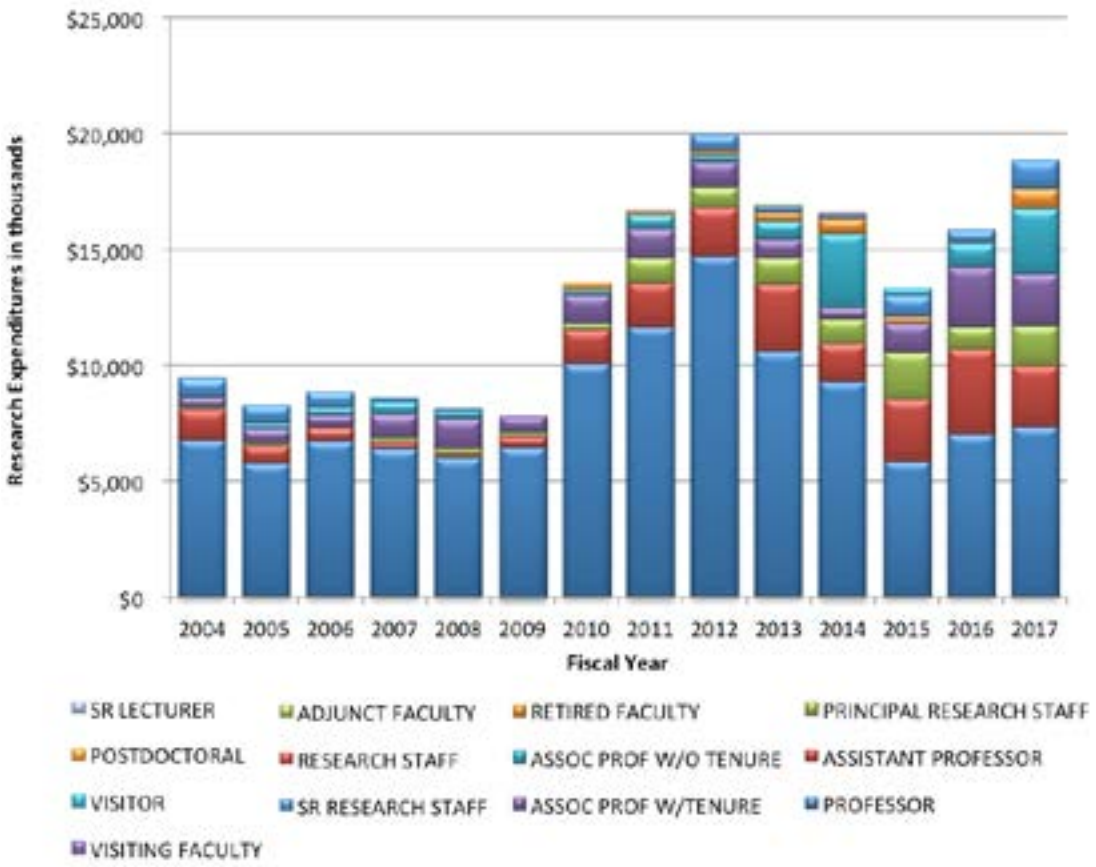
FY2004–FY2017 Materials Processing Center Sponsored Research Volume



2017 Materials Processing Center Major Sponsors



2017 Materials Processing Center Research Expenditures by Principal Investigator



Materials Research Laboratory

Detailed plans for the formation of the new Materials Research Laboratory (MRL) were developed over the past year, culminating in the generation of a formal memorandum of understanding among the current directors of MPC and CMSE as well as the vice president for research, the associate provost, and the director of MIT.nano. MRL will be formed through a merger of MPC and CMSE, which have separately served the broad MIT materials research community for over 35 years. MPC and CMSE have supported collaborative interdisciplinary research programs in different ways. CMSE serves as the home of MIT's NSF Materials Research Science and Engineering Center (MRSEC) and has managed MIT's shared experimental facilities for materials research, while MPC aids both individual faculty and interdisciplinary faculty teams in obtaining research support, serves as an interface with industry, and supports community-building activities within MIT. By combining the expertise and activities of these preexisting centers, MRL will provide a unified nexus for interactions among materials researchers within MIT and a portal for external interactions of that community with industry, government, and other academic institutions. Major goals for MRL will be to develop methods for creating and funding the formation of new teams of faculty focused on collaborative and interdisciplinary research in new areas and mechanisms for creating shared tools for use in materials research. Another important goal is to more effectively communicate to the public the profound role materials research plays in defining and enabling all of the technologies that affect our daily lives. Finally, MRL will also serve as a key partner for MIT.nano.

MRL will report to the vice president for research instead of the dean of engineering, and the current staff of MPC and CMSE will be merged and located in Building 13. MRL also will manage and assign space in Building 13, as CMSE has in the past, and will generate and manage research support in the same way MPC has in the past. Carl V. Thompson, current director of MPC, will serve as MRL's first director, and the principal investigator for the NSF MRSEC program will be the co-director. Michael Rubner, who has served as the director of CMSE and the MRSEC principal investigator for the past 12 years, will step down in the fall. A search for his replacement as MRSEC PI and MRL co-director is currently under way. An external advisory board composed of leaders from industry, academia, and national laboratories will meet annually to review MRL activities and report directly to the vice president for research as well as the MRL director. MRL will also have an internal advisory committee composed of MIT faculty. The formal announcement of the formation of MRL will coincide with the Materials Day event on October 11, 2017.

Overview and Outlook

MPC research volume increased for the second consecutive year, approaching its previous 2012 high, which coincided with the peak in the federal government's stimulus support for research. In 2012, 49% of MPC's research support came through the Department of Energy. MPC's research portfolio is now more balanced, with DOD and DOE each supporting about a quarter of the research volume. An important component of the recent uptick in volume is associated with the AIM Photonics Manufacturing Innovation Institute, especially the AIM Photonics Academy. It is expected that support for this activity will transition to industry and other private and non-federal public sources over the next few years. The SMART LEES program was renewed for five years at the beginning of 2017. However, the Skoltech CEES initiative will enter its fifth and final year in 2018. CIQM will enter its fifth and final phase of funding in 2018 and is up for renewal. In contrast to 2012, research volume from industry is up, but support from NIH and NSF is down. It can be seen that while MPC research volume is up this year and has been roughly steady over the last five years, it is volatile. It is anticipated that the formation of MRL and new collaborations with MIT.nano will allow opportunities for new mechanisms through which research support can be provided to faculty engaged in materials research, especially with industry. Greater engagement with the private sector is seen as especially important given current uncertainties about the levels and directions of future federal government engagement.

MPC's support of the Manufacturing Innovation Institutes program provides new opportunities and modes for interaction with industry as well as with other academic institutions and state governmental institutions. MPC involvement in the MII program has grown in the past year. MPC now supports the MIT components of the new AFFOA and REMADE MII programs. This is in addition to the AIM Photonics program, which was initiated in 2015, and the LIFT program, which was initiated in 2014. All of these programs individually involve partnerships with a number of companies, peer universities, and community colleges. In addition to creating new opportunities for research collaborations, the MII programs provide new modes for public engagement. All have activities in workforce development, which include collaborations with junior colleges and creation of new curricula targeted at community colleges and the currently active workforce. New courses and curricula are also being developed in four-year

undergraduate- and graduate-level programs. The Massachusetts state government has provided generous support for these programs and has remained engaged in their activities. As an example, the Massachusetts Technology Collaborative was the major source of funding for the MIT-based Education Factory, which is part of AIM Photonics. This laboratory, equipped with microphotonics packaging tools costing approximately $1 million, is available to MIT students at all levels.

The MII program itself is new, and each new institute has developed a somewhat different model for management of interactions among industrial partners and universities. In this sense, the MII program provides multiple experiments in efforts to engage academia in renewal of the manufacturing sector of the US economy. MPC is committed to supporting this important activity.

MPC is also actively engaged in other Institute initiatives. For example, in collaboration with Professor Scott Stern of the Sloan School of Management, Professor Gene Fitzgerald has developed one of the two core required subjects (15.373J/2.912J/3.085J Venture Engineering) for MIT's new undergraduate innovation minor. Professor Fitzgerald also teaches a restricted elective, 3.086x Innovation and Commercialization of Materials Technology. As part of the MIT Environmental Solutions Initiative, Professor Antoine Allanore has developed a program in metals and minerals for the environment that involves 16 faculty from across the Institute. Professor Allanore also initiated a new series of international workshops at MIT on alternatives to potash, an important issue for agriculture, especially in developing countries. In addition, Professor Allanore and Professor Elsa Olivetti are playing leadership roles in MIT's component of the new REMADE MII, which, as discussed above, focuses on clean energy sources for manufacturing.

Through the formation of MRL, the MPC community will have new opportunities and mechanisms to engage with the materials research community inside and outside of MIT. There will be challenges associated with this merger, but also excitement as we evolve into new roles in support of the Institute's goals for education and research.

Carl V. Thompson
Director
Stavros Salapatas Professor of Materials Science and Engineering