

## **Materials Processing Center/Microphotonics Center**

This report discusses the FY2004 activities of the Materials Processing Center (MPC) and its major affiliate, the Microphotonics Center (MPhC). The Materials Processing Center is an interdisciplinary center within MIT's School of Engineering. Currently directed by Professor Lionel C. Kimerling (Department of Materials Science and Engineering [DMSE]), the MPC was established in 1980 in response to a recognized national need to improve the materials processing knowledge base and streamline technology transfer within the materials science and engineering field. Materials science traverses all the physical sciences. The MPC defines "materials processing" broadly, as it covers a wide range of materials types and crosses traditional departmental and school boundaries.

The mission of the MPC is to facilitate relationships among researchers from academia and industry, enabling them to collaborate on pivotal issues in materials science. We wish to create new knowledge, produce knowledgeable and capable graduates/employees, and promote the exchange of knowledge in the service of our country and in the context of the global community. The MPC is a "virtual center," without facilities, laboratory space, or equipment as such; it acts by bringing people and resources together in "intellectual space" to examine problems and pursue opportunities from a science-to-systems perspective.

The Microphotonics Center (MPhC) is a center within the MPC that builds interdisciplinary teams focused on advancing basic science and emerging technology to enable the evolution of photonics from single discrete devices to strongly integrated microphotonic systems. The MPhC and MPC share a common staff in a single headquarters office.

### **Relationships**

The MPC/MPhC builds relationships with faculty by familiarizing itself with their current research projects, future interests, and resource needs; by bringing industries' materials needs and interests to them; and by inviting them individually or in teams to collaborate with industry. MPC provides seed research program development funding to new faculty members and teams and assists with proposals and the administration of research accounts. During FY2004, there were 50 faculty and senior research staff with active accounts in the MPC; there were 70 who are included in the MPC's research digest *Materials Research at MIT*, produced in collaboration with the Center for Materials Science and Engineering (CMSE). The faculty who have had some affiliation with the MPC over the years hail from nine departments from the Schools of Engineering, Science, and Sloan.

The MPC provides industry with guided access to MIT's materials research community via its Industry Collegium (MPC) and Industry Consortium (MPhC). The MPC Industry Collegium is made up of roughly 25 domestic and international companies in a range of industries, from traditional structural materials to biomaterials. The MPhC Industry Consortium consisted in FY2004 of 13 member companies from the telecommunications sector; the consortium's Communications Technology Roadmap Project involves

personnel from about 30 telecom-related companies in its technology working groups. For member companies, both the collegium and the consortium help to enable the realization of groundbreaking MIT research into market-changing products. The MPC/MPhC strategy includes leveraging core federal research funding into expanded industrial-academic collaborations. In addition to its collegium and consortium, the MPC and MPhC also have two major research alliance partnerships, as well as traditional programs with individual companies.

The MPC seeks to collaborate with other materials-related centers on campus, including the Center for Materials Science and Engineering, the Institute for Soldier Nanotechnology (ISN), the Research Laboratory for Electronics, Microsystems Technology Laboratories, and the Media Lab. Campus materials research volume across MPC, CMSE, ISN, and DMSE has steadily increased each year since FY1999, reaching \$45 M for FY2003.

## Activities

### Research Activities

MPC and MPhC total research volume was \$11 M in FY2004. The MPC/MPhC staff during FY2004 numbered seven, including the director, Professor Lionel Kimerling. During much of FY2004, the MPC continued to focus on the development of MPhC projects.

Detailed summaries of research by MPC-affiliated faculty can be found in the 2004 edition of *Materials Research at MIT*, available soon in electronic format at our website.

One particular focal area for the Microphotonics Center research is in new materials, structures, and architectures for planar lightwave circuits. The goal is fully integrated photonic functionality for these tiny, potentially low-cost units, thereby enabling their deployment in metropolitan area and fiber-to-the-X applications. Our areas of emphasis include dense wavelength-division multiplexing (a way of increasing signal capacity), optical signal conditioning, and on-chip optical clock distribution and I/O for microprocessors. Our research has set a number of world records for device performance and size. The Microphotonics Center has several major research thrusts, in addition to individual faculty members' research; within the Industry Consortium there are the Communications Technology Roadmap Project and five consortium-funded seed projects. In addition, in FY2004 the MPhC had two major programs with research alliance partners Pirelli and Analog Devices. These programs generated 12 new pieces of IP in FY2004.

The Microphotonics Center Industry Consortium (see below) began its key initiative, the Communications Technology Roadmap Project (<http://mph-roadmap.mit.edu/>) in the fall of 2000. This ongoing study will give a 10-year view down the rapidly changing microphotonics technology highway by interviewing industry leaders at all levels of management and developing a picture of areas of consensus and conflicting opinion on how technology and business issues will play out. Consortium members will use the

study findings in optical network architecture, component design and manufacturing, market analysis, technical supply chain analysis, and geographic analysis to focus their R&D and business strategies. The Communications Technology Roadmap (CTR) Project is chaired by Professor Rajeev Ram (Department of Electrical Engineering and Computer Science [EECS]), and has Elizabeth Bruce as its program manager. The CTR working group presented interim reports to consortium members at the November 2003 and May 2004 meetings, and has made a number of white papers and reports available online to Industry Consortium member companies. The CTR group continues to maintain four technology working groups (TWGs), with a total of 47 participants from MIT and 30 companies from startups to industry leaders in the telecom industry. The TWGs bring together the thought leaders from both industry and academia, in particular areas of expertise, to discuss technology evolution in those areas. These groups each had meetings both at MIT and at company sites and produced reports on their findings. The subject areas for the TWGs are next-generation transceivers, Si optoelectronics, III-V optoelectronics, and next-generation transceivers.

### **Education Activities**

One pillar of the Materials Processing Center is the education of the next generation of materials processing research scientists, engineers, and leaders. To this end, the MPC initiates programs to enhance the intellectual vitality of the materials processing community at MIT. We measure the value of these programs by the breadth of the materials arena they address, by the new and creative collaborations among faculty and students they catalyze, and by the degree of attention to the multidisciplinary—but at the same time fundamental—nature of the materials science, engineering, and processing they generate.

### ***Seminars***

We are increasingly archiving seminars, with the speakers' assistance, on our website in the form of a PowerPoint presentation with audio track. In this way we hope to capture our seminars as an ongoing information resource to the community.

### ***Materials Unlimited Seminar Series***

Now in its 5th year, the Materials Unlimited Seminar Series highlights the research of senior graduate students identified by faculty members as being among the best in MIT materials-related research. These seminars include a half-hour talk by the featured graduate student, followed by a half-hour panel discussion. Panelists are drawn from MIT and other university faculty, as well as from companies appropriate to the topic. Seminars are well-attended by a diverse audience of faculty, postdocs, graduate students, and undergraduates.

FY2004 featured four talks. Todd Zion (Chemical Engineering [ChemE], Ying Group) spoke on "Glucose Responsive Nanoparticles for Self-regulated Insulin Delivery." Professor Jackie Ying (ChemE) and Dr. Gordon Weir (Joslin Diabetes Clinic) served as panelists for his talk. Joy Cheng (DMSE, Ross Group) gave her talk on "Nanostructures from Templated Self-assembled Block Copolymers: An Example of Bottom-Up Meets Top-Down," with professors Caroline Ross (DMSE) and Henry Smith (EECS) as

panelists. Kevin Turner (Aeronautics and Astronautics [Aero/Astro], Spearing Group) spoke on “Direct Wafer Bonding: Mechanics-Based Process Models and Experiments,” with panelists Professor Mark Spearing (Aero/Astro) and Jack Martin (Analog Devices). Dr. Monica Rixman (DMSE) talked about “Investigating the Molecular Origins of Biocompatibility: Intermolecular Interactions between Human Serum Albumin and Various Chemically Modified Surfaces via High-Res Force Spectroscopy,” with professors Christine Ortiz and Darrell Irvine (both DMSE) as panelists.

#### *Microphotonics Seminar Series*

The MPhC sponsors a seminar series on topics of interest to those doing research on microphotonics-related subjects. A list of topics plus abstracts can be found via our website.

#### **Materials Day**

Materials Day is an annual event, usually in the fall, that celebrates the MIT materials research community. It features a daylong workshop on a featured topic, followed by a graduate student/postdoc poster session and dinner for participants. The next Materials Day is scheduled for October 19 and will cover the topic of materials modeling.

#### **Summer Research Internship Program**

The MPC and Center for Materials Science and Engineering cosponsor and manage the MPC–CMSE Summer Research Internship Program. This 10-week program brings outstanding juniors and seniors in science or engineering majors from academic institutions around the United States to MIT to work in the laboratories of participating faculty. The summer of 2004 brought 13 students attending from schools as far-flung as Virginia Tech, Carnegie Mellon, Johns Hopkins, Olin College, and Lewis & Clark. These students worked with faculty from ChemE, the Biological Engineering Division, DMSE, EECS, the Technology Laboratory for Advanced Composites, Aero/Astro, and Physics on a wide variety of projects.

#### **Outreach Activities**

The second pillar of the MPC is its outreach to new (either to MIT or to the MPC) faculty and researchers, as well as to the global materials community. MPC has a dozen visiting scientists from industry working within the center. The center is proactive in inviting faculty to participate in its activities, whether through our publications, educational programs, or research sponsorship.

#### **Industry**

The MPC Industry Collegium maintained its full complement of activities while simultaneously maintaining the industrial support base of the Microphotonics Center in a recovering economy. Collegium membership currently exceeds 25 companies, domestic and international. We added several new collegium members during AY2004. At the same time, we maintained our MPhC Consortium membership at 12 companies and initiated activities with several other companies through the MPhC’s Communications Technology Roadmap Project. The MPhC also maintained its

relationship with the sponsors of its two major research alliances: Pirelli and Analog Devices. Meanwhile, there are a dozen visiting industrial scientists appointed through the MPC.

### **Information Management**

The MPC produces several publications, brochures, conference booklets, and three websites in pursuit of its outreach goals. Distribution for the main publications includes MPC-affiliated MIT faculty and staff (> 200) and members of the MPC Collegium mailing list (> 400). One publication, *Materials Research at MIT*, is a digest of materials research performed at MIT by MPC-affiliated faculty and others during the previous calendar year. It provides a short summary of each project being researched by faculty members, along with a list of their personnel and publications. *Materials Research at MIT 2004* will provide the reports of roughly 70 faculty members. The 2004 research digest, produced together with the Center for Materials Science and Engineering with input from the Department of Materials Science and Engineering, will be produced in CD-ROM format only, in addition to web distribution. Information from our research digest is used by CMSE in its NSF reporting responsibilities, DMSE in its recruitment and placement of new graduate students, and the Industrial Liaison Program for its KnowledgeBase database.

The MPC's newsletter, the *Industry Collegium Report*, has transitioned to web-based news articles posted frequently to the website. During FY2004 we have begun, and in FY2005 we will complete, extensive revamping of our website's appearance and functionality. The web is currently our main mode of information distribution to our MPhC Industry Consortium members, particularly for the Communications Technology Roadmap Project.

The most important new project in MPC publications, in collaboration with CMSE, is the creation of a new website, "Materials at MIT." This site is intended to provide a gateway to materials science and engineering activities across the MIT community. Some of the primary features being designed include links to all MIT faculty performing materials science research, a calendar listing materials-related events throughout MIT, and links to all materials facilities on campus. This initiative will bring the MIT materials community closer together over the course of AY2005. The first phase of this project is already underway and will conclude with the launch of the "Materials at MIT" site at the beginning of the fall 2004 semester. After working with the site and collecting some feedback in the fall months, a second design phase is planned, to result in more functionality being added near the beginning of the spring 2005 semester.

### **Equipment and Facilities**

Industry partners have supported the MPhC with \$8.5 M in equipment acquisitions over the last couple of years. We are actively supporting the Capital Campaign in a major effort to secure support for dedicated space for this equipment. Over FY2004, we continued to seek both distributed "migration" space and work with MIT Facilities personnel on construction of facilities for this equipment. We have commenced work jointly with CMSE and DMSE to renovate lab space to create a new Substrate

Engineering Lab with a metal-organic chemical vapor deposition instrument from Thomas Swan, an ultrahigh vacuum chemical vapor deposition from Unaxis, and a reactive-ion beam deposition tool from Veeco. We anticipate that all of this equipment will be brought online in 2004. We have successfully installed and brought online our Applied Materials Centura dielectric plasma-enhanced chemical vapor deposition tool in Microsystems Technology Laboratories Room 39-ICL.

## **Outlook**

The MPC/MPhC is expanding its collaborations with other materials-related centers across the campus to provide a common and guided gateway to the current maze of possibilities outside visitors face when they approach MIT with a materials problem. In addition, our moving closer to other centers, particularly CMSE, will create synergies both intellectually and administratively. Our strategy is to improve our position as an information resource for the campus community and portal for consortium/collegium member companies. Meanwhile, with our program sponsors and research alliance partners, we face the ongoing challenges of program and intellectual property management and are developing the tools and processes for meeting these challenges. We consider our key value our building of interdisciplinary faculty teams to develop new areas for intellectual activity and research.

## **Tamarleigh Lippegrenfell** **Publications Editor**

*More information about the Materials Processing Center can be found on the web at <http://mpc-web.mit.edu/>. Links to the Microphotonics Center website and the dedicated Communications Technology Roadmap Project website can be found at the main MPC site.*