Microsystems Technology Laboratories

The Microsystems Technology Laboratories (MTL) conduct research and education with an intellectual core of semiconductor industry process and device technology and integrated circuits and systems design. MTL also leverages its infrastructure to foster new initiatives at the Institute and to support the general micro, and nanofabrication needs of MIT.

The MTL carries out graduate and undergraduate research activities in circuits and systems that are built using microsystems technology for applications such as wireless sensing networks and intelligent vision systems. Additionally, researchers are investigating the fabrication and study of small (i.e., micrometer to nanometer) structures and their use for the implementation of interesting integrated devices from nanometer, scale electronic devices to optical switches to displays to biosensors to micropower generators. The MTL facilities include laboratory space for electronics test and assembly, computation and communication, and microfabrication. The MTL microfabrication facilities include three clean rooms with a total of 6,500 sq ft: the state, of, the, art class, 100 Integrated Circuits Laboratory, the flexible process environment Technology Research Laboratory, and the Exploratory Materials Laboratory. The equipment in MTL facilities has a replacement value far in excess of $60M. In AY2004, the MTL fabrication facilities were utilized by more than 400 students and staff. The laboratory manages a contract research volume of approximately $11M/year. Approximately $40M of contract research (primarily managed in other departments/labs/centers) relied on the MTL facilities as an integral part of their research. The fabrication and computation facilities of the MTL are maintained and operated by a full, time technical staff of 25 technicians and engineers.

Beyond the research programs, the MTL supports several educational initiatives that leverage the research infrastructure of the labs. Chief amongst these is the undergraduate microfabrication laboratory, a lecture/laboratory course in which 100 students per year are afforded the opportunity to micro, and nanofabricate electronic, mechanical, and biochemical devices in the state, of, the, art MTL facilities. Additionally, we offer a project laboratory for team, based design of microfabricated structures. Lastly, via the iCampus initiative, Professor del Alamo is developing a series of web, based laboratory tools that permit testing of microfabricated structures.

MTL maintains a strong and vibrant interaction with industries that value not only the research output but also the students that are educated in state, of, the, art microsystems technology. The MTL facilities are supported in part by industry through the MIT Microsystems Industrial Group (MIG), whose current members include Advanced Micro Devices, Analog Devices, Applied Materials, Hewlett, Packard, IBM, Intel Corporation, Motorola, National Semiconductor, Novellus Systems, and Texas Instruments. Three industry, funded centers are also housed in the MTL: the Center for Integrated Circuits and Systems, the Intelligent Transportation Research Center, and MEMS@MIT.

Highlights

The research activities of the MTL can be viewed online by exploring our annual report at the lab's website. The MTL research spans an extraordinarily broad set of activities. If one were to identify a unifying theme associated with these projects, it would be the system, level interest in micro, and nanotechnology. The MTL represents a community that brings experimentalists skilled in materials and technology at the micro and nano levels together with circuits/systems researchers to realize visions for new systems that are enabled by the integration of these disciplines.

The integrated circuits and systems research efforts address a wide range of applications with several common themes: wireless, low, power, mixed, signal and analog design, and circuit issues in advanced technologies (scaled CMOS, photonics, organics) and applications (intelligent transportation). The microelectromechanical systems (MEMS) program has several major thrusts: power MEMS, optical MEMS, RF MEMS, bioMEMS, microfluidics and chemical systems, and micromechanical devices (valves, actuators, switches). In addition, there are programs on materials/process characterization and metrology. Electronic devices research in MTL is focused on advanced devices and materials including Si/SiGe, SOI, heterostructures, power MOS, compound semiconductors (InP, GaAs), and magnetics. The quantum effect devices area includes programs in superconducting devices, quantum computing technologies, quantum dots, and organic optoelectronics. A defining element of submicron and nanometer structures research is the emphasis on patterning methods at the nanometer scale. In addition to these efforts on lithography, there are projects on self, assembling, 3, D folded structures, nanotubes and wires, and various nanostructured photonic elements. The manufacturing/modeling/simulation research is primarily focused on developing a modeling framework for characterizing and predicting the performance of various micro/nanofabrication processes. In fabrication technology, we see efforts on new processes such as through wafer vias, etching processes, lithography methods, and deposition processes. The materials area includes projects on 3, D integrated circuits, materials growth (Ge, GaN, InGaP), characterization (deformation, stress), magnetic technologies, and bonding. Optoelectronics programs include a substantial effort in silicon/silica waveguide technology and devices, photonic crystals, integration of photonic and electronic devices, and various light emitters (diodes, lasers).

Two major activities reached a conclusion this year. First, a comprehensive evaluation of the facilities infrastructure was conducted and a detailed expansion plan for the clean room was developed. Second, our major industrial consortium, the Microsystems Industrial Group, was restructured to more effectively engage our internal and external communities.

The facilities evaluation was driven by the desire to develop a complete plan for revitalization of the clean room infrastructure combined with an opportunity to expand the facilities to meet emerging research needs of the Computational Systems Biology Initiative, the Institute for Soldier Nanotechnologies, and the Nanomanufacturing Program in Mechanical Engineering. The evaluation and planning exercise led to a four, phase recommendation. The first phase involves overhaul of key building infrastructure to address deferred maintenance issues as well as position the building for expansion.

The second phase involves creating new wet lab space in an adjacent building (Building 38) to accommodate faculty labs to be displaced in phase three. The third phase will create approximately 12,000 sq ft of new Class 1000 clean room space on the 5th floor of Building 39. The final phase (optional) identifies a means to create an additional 2,500 sq ft of clean room if needed in the future. We are currently securing commitments from the Institute to implement this plan.

The Microsystems Industrial Group has been the primary industrial engagement of the MTL since its inception. This group of companies have annually provided more than $1.5M/year to offset the cost of maintaining the MTL infrastructure and to seed research activities. A restructuring of the MIG value proposition was undertaken to enhance the value to these member companies. In addition, we wished to create more alignment of interests amongst the MIT faculty and research centers that interact with MTL. Under the new value proposition, which was enthusiastically supported by our Industrial Group, companies will have the chance to direct some of their membership fees to specific faculty or affiliated research centers.

Finally, in terms of highlights, the fabrication facilities continued to see growth in usage. We had another record year, both in terms of individual user statistics but also in overall usage fees. In FY2004, $2.39M in lab fee revenue was generated, an approximate 10 percent growth over last year.

Future Plans

Our plans for the coming year follow directly from the activities of the previous year. Specifically, we will focus on implementation of the phases of our facilities expansion. We hope in the next year to complete the first two phases and to be well on our way for the third phase. Second, we will be focusing on marketing the new MIG value proposition. Our goal is to add several new members in the coming fiscal year.

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More information about the Microsystems Technology Laboratories can be found on the web at http://www-mtl.mit.edu/.