RESEARCH THEMES

The research in MTL 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 nano technology. The MTL represents a community which brings experimentalist skilled in materials and technology at the micro and nano-levels together with circuits/systems researchers to realize visions for new systems which are enabled by the integration of these disciplines.

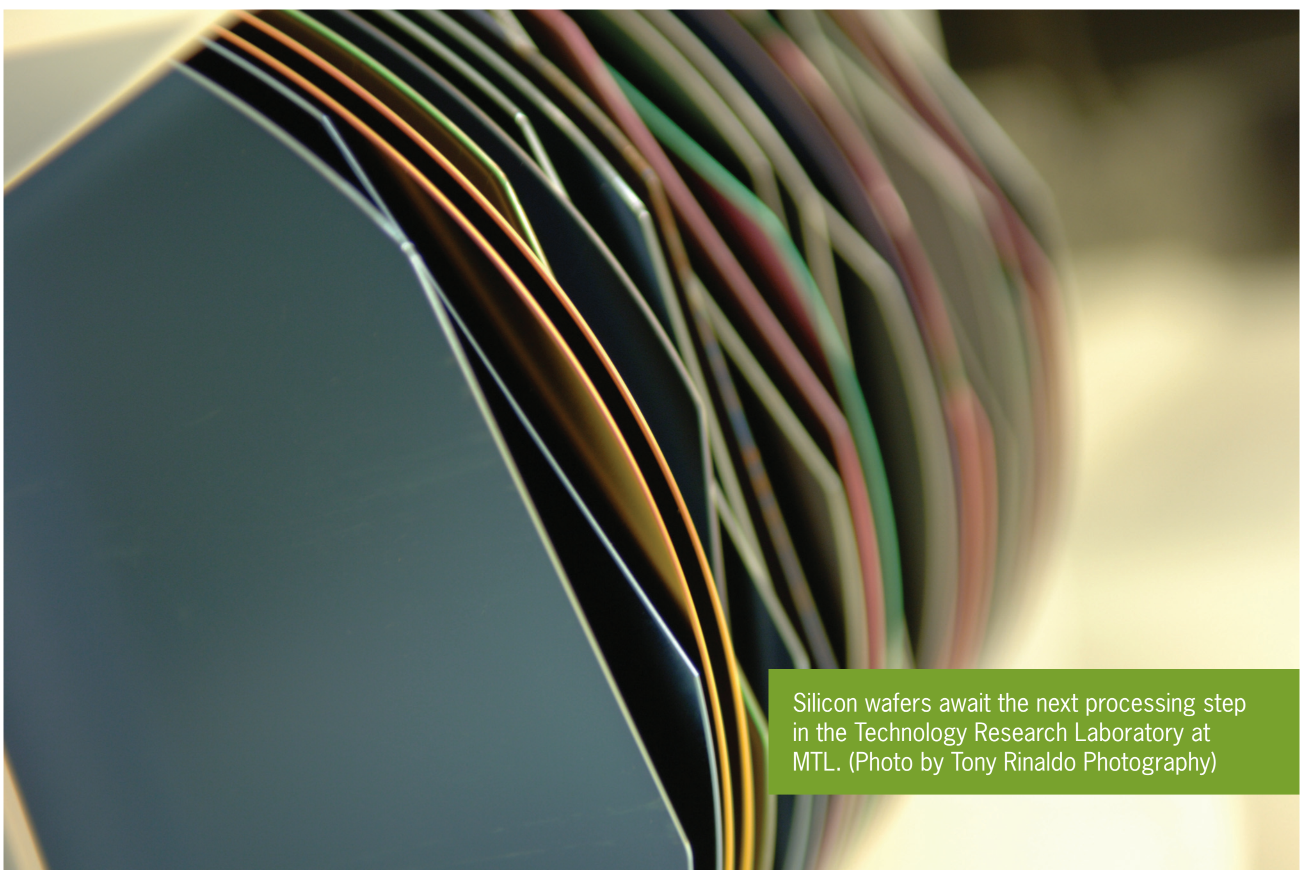
In the past year, the circuits and systems group engaged in research in the areas of RF design, including receivers, modulators and power devices. Wireless systems remained a major focus area in both the high performance and ultra-low power domains. The high performance wireless research was primarily directed towards gigabit LAN, whereas the low power systems were in support of wireless sensor networks primarily. This coupled to an extensive range of research on low-power design in general. Analog to digital conversion and mixed signal circuit design continue to be a major focus area. A new 'comparator-based' circuit architecture was introduced this year. Intelligent transportation systems, and vision systems in support of these were studied. As part of a larger overall effort on interconnect issues, there was considerable work on circuit/systems issues in interconnect and the investigation of 3D systems. Analysis tools for design of circuits and test devices to understand manufacturing issues provided core underpinning research for the entire circuits and systems area.

A wide range of electronic devices were explored and are reported in detail in our Annual Report. 'Substrate engineering,' or the development of optimized silicon-based hetero-structures, was a substantial activity, as was the exploration of novel means to achieve device isolation in integrated systems. Compound semiconductor systems such as InP/GaAs were explored for high performance RF devices. Field emission structures were studied for a variety of applications in devices and displays to name a few. In the areas of advanced fabrication technologies and materials, we saw exciting work on magnetics, metal interconnect materials, and environmentally-benign processes. Lastly, we saw substantial and growing focus on new non-silicon devices in organic and inorganic materials systems.

Photonic devices were studied for a wide range of applications. Quantum dots, photonic crystals and display materials and devices were explored, as well as J-aggregates. Lasers in compound semiconductor materials and heterogeneous integration methods for merging such devices with silicon platforms were pursued. Integrated silicon photonics and silicon-compatible optical interconnect methods were developed. MEMS structures were merged with optics to achieve new functionality in optical systems.

In the area of MEMS, the primary focus areas are; bio/chemical devices and systems, power devices, and a variety of enabling technologies. A large number of microfluidic devices are being developed for manipulation of cells, DNA, proteins, and other molecules. Microreactors are being designed which enable the synthesis of chemicals at a small scale, as well as microbioreactors which can be used in areas such as fermentation studies. Microchemical analysis systems such as portable gas analyzers are also studied. In the area of portable power generation, we are exploring both fuel-burning and energy harvesting approaches. The primary focus of the energy harvesting approaches is to utilize piezoelectric materials for vibration harvesting. In the area of fuel-burning systems, we are exploring microturbines as well as fuel cells and thermophotovoltaics. Beyond these systems focused projects, there are a wide ranging set of projects looking into the applications of MEMS technologies for mechanical devices such as switches, tweezers, and nano-assembly. Lastly, there are some core technology development efforts to understand better, model, and characterize MEMS materials and structures.

Molecular and nanoscale devices are a new and emerging area of work in the lab. Nanoscale assembly methods inspired by origami are studied, as well as nanoscale field ionizers. Nano-dimensioned fluidic channels enable manipulation of chemicals and molecules that are nanoscale. Organic and quantum dot structures are explored for many electronic and photonic purposes. Carbon nanotubes have emerged as potentially exciting structures to explore for many different applications. The work in this area includes not only studying the material, but developing means for fabrication and manipulation of the nanotubes. Magnetic nanoparticles hold great promise in advanced devices and are extensively explored. Self-assembly methods appear as promising methods for creating ordered nanostructures and these methods are being studied in detail. Quantum-effect devices are explored for a variety of applications including quantum computing.



Silicon wafers await the next processing step in the Technology Research Laboratory at MTL. (Photo by Tony Rinaldo Photography)