Microsystems Technology Laboratories

The Microsystems Technology Laboratories (MTL) is an interdepartmental laboratory with a mission to foster research, education, and innovation in materials and thin-film processing and related device technology, which is applied to the development of integrated circuits, systems design, and nanotechnology in general. MTL's leadership is committed to maintaining strong ties with industry to help ensure that MIT's educational, research, and innovation missions are industrially relevant and that advances in the state of the art are effectively transferred to industrial applications. MTL provides micro- and nano-fabrication, computer-aided design (CAD) infrastructure, and an institutional gateway to several foundry services that provide access to advanced semiconductor manufacturing processes. MTL includes 46 core faculty members working in research areas related to electronic device fabrication, integrated circuits and systems, photonics, microelectromechanical systems (MEMS), molecular electronics, and other nanotechnologies. The most recent additions to MTL's core membership are professor George Barbastathis and professor Tonio Buonassisi, both from the Department of Mechanical Engineering; professor Dirk Englund, Department of Electrical Engineering and Computer Science (EECS); professor Jeffrey Grossman, Department of Materials Science and Engineering (DMSE); professor Moungi Bawendi, Department of Chemistry; and professor Karen Gleason, Department of Chemical Engineering. In addition, 81 affiliate faculty members and senior research staff benefit from the fabrication facilities, CAD infrastructure, and foundry access provided by MTL. In FY2013, MTL supported 987 registered users from 40 departments, laboratories, and centers. These were primarily graduate students conducting research using MTL's advanced infrastructure. During FY2013, MTL recovered approximately 70% of operating expenses through charges to users and underwrote the remaining balance through unrestricted funds (approximately $1.45 million for FY2013). Sponsored programs administered directly through MTL have an annual research volume of approximately $14.3 million (FY2013). Sponsored programs billed for services provided through MTL had an aggregate FY2013 research volume of $81.1 million.

MTL's fabrication environment includes three clean rooms totaling 7,800 square feet: the class-10 Integrated Circuits Laboratory capable of handling 6-inch wafers, the class-100 Technology Research Laboratory, and the flexible Exploratory Materials Laboratory. The computational environment provides access to advanced electronic design automation for device-, circuit-, and system design. The fabrication and computation facilities of MTL are maintained and operated by approximately 20 full-time technical staff members.

Research conducted at MTL can be broadly classified into the following categories: circuits and systems, electronic devices, energy, materials, medical electronics, MEMS and BioMEMS, nanotechnology, and photonics. MTL has five affiliated research centers with focused themes: the Center for Integrated Circuits and Systems, the Center for Graphene Devices, MEMS@MIT, the Medical Electronic Devices Realization Center and the Center for Excitonics.

MTL engages users in a number of technical events. MTL hosts a regular seminar series that covers diverse technical areas related to devices and circuits. A committee chaired by professor Tomás Palacios organizes the seminar series, which is open to the public. In addition, MTL hosts one doctoral dissertation seminar each semester featuring a recent MTL graduate, as well as occasional distinguished and executive seminars featuring a leading figure from one of the MTL member companies. Most recently, MTL hosted the visit of Tunç Doluca, president and chief executive officer (CEO) of Maxim Integrated Products. Every January MTL holds its MTL Annual Research Conference (MARC) run by MTL graduate students in collaboration with a steering committee. In 2013, MARC was co-chaired by students Katherine Song (from professor Vladimir Bulović's group) and Kailiang Chan (from professor Charles Sodini's and professor Anantha Chandrakasan's group) and assisted by professor Jing Kong as faculty liaison. Every year MARC is widely attended by members of industry, faculty, students, and staff, as it provides a unique opportunity to learn about research in the diverse areas encompassed by MTL while fostering interaction among the MTL community. The 2013 event was held on January 29 at the Cambridge Marriott, attracting more than 300 attendees. In May 2013, MTL also held the fourth Workshop on Next-Generation Medical Electronics, a two-day event held on campus, featuring talks from leading experts on the topic as well as a lively poster session.

MTL partners with industry through the Microsystems Industrial Group (MIG). The MIG consortium members support MTL research and operations through membership fees and by providing access to state-of-the-art tools and processes. MIG members donate major pieces of equipment to MTL and provide access to their integrated circuit chip fabrication services. Members of the MIG Industrial Advisory Board provide significant guidance in shaping the vision of MTL. MTL's affiliated research centers—the Center for Integrated Circuits and Systems, the Center for Graphene Devices and Systems, and the Center for Excitonics—provide direct support for focused research initiatives.

Recent examples of interactions with MTL's industry partners include:

- In January 2013, MIT president Rafael Reif and MTL director Vladimir Bulović visited Qualcomm, followed by an engaging meeting at MTL in April 2013 with Qualcomm's founder, Irwin Jacobs.
- On February 21, 2013, a delegation from MTL visited Maxim Integrated in San Jose, CA, for a day of executive- and student-led talks, a tour led by MIT alumni, and a closing reception. Student presentations were given by Eric Winokur, Dina Reda El-Damak, Kailiang Chen, and Sabino Pietrangelo.
- Intel and Foxconn Technology Group delegations visited in February 2013 and exposed MTL students to technical opportunities at these partner companies.
- On May 31, 2013, an MTL delegation of 10 students and three faculty members attended MTL Day at Texas Instruments' Kilby Labs in Dallas, TX, and presented talks focused on power management design and gallium nitride (GaN) technology.

- A number of conversations with Ray Stata, cofounder of Analog Devices, provided great insights into technologies that will redefine the 21st century.
- In May 2013, Rob Gilmore, MTL's Qualcomm liaison, introduced us to Greg Wright, director of IT acceleration at the Houston Technology Center, who presented an excellent seminar on energy and power in the mobile computing world. Rob Gilmore, joined by Serafin Diaz and Mahesh Makhijani, returned to MTL on June 25, 26, and 27 for an extensive round of meetings with core faculty as well as faculty at the Computer Science and Artificial Intelligence Laboratory and the Media Lab. The visit was organized through the office of the MTL director.
- In May 2013, Marco De Fazio, the STMicroelectronics MIG liaison to MTL, arranged a visit from Bruno Murari, who shared wisdom accrued over the decades in "From More Moore to More than Moore."
- Vladimir Bulović visited Lam Research Corporation in Freemont, CA, on June 17, 2013, following the February 2013 visit to their tool fabrication facility.

Administration, Management, and Operations

Professor Bulović is the MTL director with oversight for daily administration and management of the laboratory. Four faculty associate directors—professor Jesús del Alamo, professor Judy Hoyt, professor Karl Berggren, and professor Jeffrey Lang—assist the director in managing the computational and fabrication infrastructure as well as communications and sponsor relations. Two staff associate directors provide direct support for the fabrication facilities (Vicky Diadiuk) and administrative services, compliance, legal matters, and license agreements (nondiscosure agreements, etc.) and industry liaison (Samuel Crooks).

MTL maintains several committees charged with policy development and implementation, including the policy board (Vladimir Bulović, chair), process technology committee (Vicky Diadiuk, chair), and computation committee (Jesús del Alamo, chair). MTL also has a social committee (Debroah Hodges-Pabon, chair) that builds community spirit among its many users, and a communications committee (Mara Karapetian, chair). The communications committee works on MTL's *Annual Research Report*, on restructuring the MTL website, and on a triannual newsletter, From the Labs, among other publications. MTL community members are also involved in other functional committees. In January 2013, Mara Karapetian, media specialist, was promoted to manager of media and design.

Shared Service Facilities

MTL's microfabrication, testing, and computational facilities are open to the entire MIT community as well as to researchers from other universities and government laboratories through the MTL outreach programs. Similarly, the Fabrication Facilities Access Program offers local industries access to the clean room facilities.
MTL has committed significant resources to the acquisition and maintenance of capital equipment. These capital improvements, upgrades, and purchases allow MTL to serve an increasingly diverse user base. Many MIG member companies donate capital equipment that is used in the fabrication and computation facilities.

Fabrication Facilities

MTL's fabrication resources are managed and operated by a group of professional technical staff. All researchers planning to use MTL fabrication facilities are required to complete a safety and orientation course beforehand and must receive training from a research specialist for each piece of laboratory equipment they plan to operate. The facilities support research on projects involving a range of substrates, including silicon, germanium, III–V semiconductors, and 2-D materials such as graphene, organic thin films, and glass; they include capabilities for deposition of a wide range of materials, such as dielectrics, plastics, semiconductors, metals, carbon nanotubes, and graphene. The process technology committee—which includes students, faculty, and staff—meets weekly to review user process flows in addition to requests for new materials, protocols, and fabrication operational issues.

This past year was the first full operational year of the electron beam lithography (EBL) facility in a purpose-built, temperature-controlled room in 24-041. The EBL houses the recently installed ELS-F125 electron-beam lithography tool made by Elionix. The EBL facility is jointly run by the Research Laboratory of Electronics and MTL, and provides students and researchers from across MIT and neighboring institutions with access to patterning at the smallest sizes available anywhere (capable of patterning features smaller than five nanometers). Electrons are accelerated to an energy of 125 kilovolts and then swept across resist-coated substrates, such as silicon wafers, to form arbitrary patterns that can later be transferred into underlying or deposited materials. Large areas can be patterned across substrates ranging from 5-mm-square chips to 200-mm-diameter wafers.

Computation Facilities

MTL also maintains a comprehensive systems and software infrastructure that provides a broad array of services to the community. MTL supports a large number of research workstations and computer servers and offers various computing services to the MTL community. In addition, MTL offers to the general MIT community a wide variety of commercial CAD tools used for circuit and system design research. MTL has also developed a suite of software tools to help manage three core pieces of the laboratory's operations — user management (MUMMS), equipment use management (CORAL), and billing (Cost Recovery). Although CORAL was developed in collaboration with Stanford University, MUMMS and Cost Recovery were developed at MTL. All three tools have also been deployed at MIT's Center for Materials Science and Engineering.

Research Highlights

Molybdenum Disulfide Used to Make Electronic Devices

Published in *Nano Letters*
Professors: Tomás Palacios (EECS) and Jing Kong (EECS)
Postdoctoral researcher: Yi-Hsien (EECS)
Graduate students and affiliates: Han Wang (EECS), Lili Yu (EECS), Allen Hsu, and Yumeng Shi

Funded by: US Office of Naval Research, the Microelectronics Advanced Research Corporation Focus Center for Materials, the National Science Foundation (NSF), and the Army Research Laboratory

Molybdenum disulfide has been used for many years in a number of industrial applications, such as high-temperature lubricants. Building on work first carried out in Switzerland, MIT researchers and collaborators have developed methods of depositing two-dimensional films of molybdenum disulfide over large areas and constructing and testing electronic devices, such as Negated AND or NOT AND (NAND) gates, inverters, and ring oscillators. Molybdenum disulfide has many of the potential advantages of graphene; for example, it is transparent in single layers. Unlike graphene, it has a well-defined bandgap and has proven far easier to turn into active electronic devices. The researchers envision numerous applications, such as large-area displays and active window coatings.

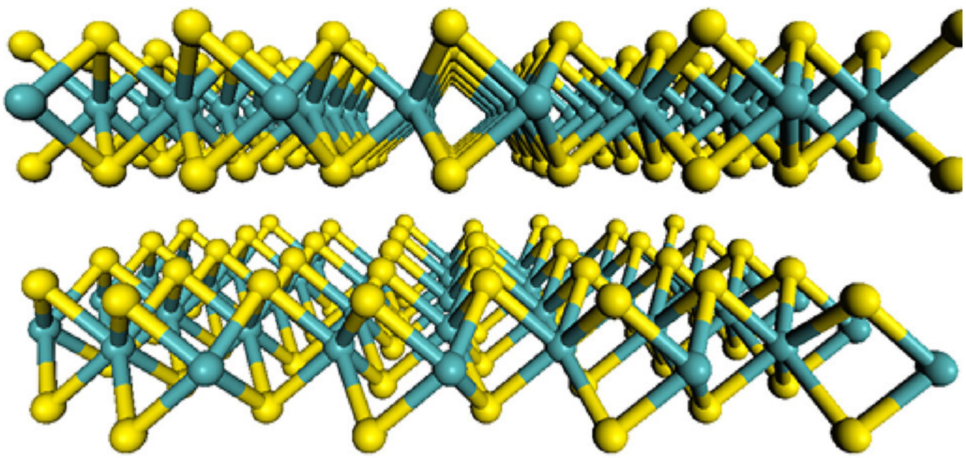
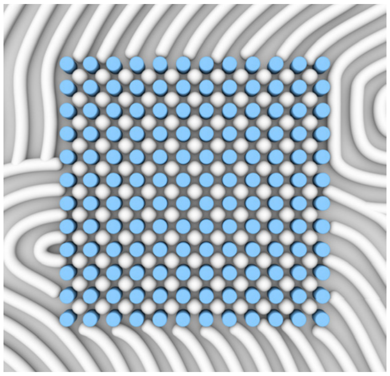


Diagram shows the flat-sheet structure of the material used by the MIT team, molybdenum disulfide. Molybdenum atoms are shown in teal and sulfur atoms in yellow. Image courtesy of Wang et al.

Self-assembling Polymers Used to Create Densely Packed Electronic Wiring

Published in *Advanced Materials*
Professors: Caroline Ross (DMSE), Karl Berggren (EECS), and Alfredo Alexander-Katz (DMSE)
Graduate students: Adam Hannon (DMSE), Kevin Gotrik (DMSE), and Amir Tavakkoli (visiting from National University of Singapore)
Funded by: Semiconductor Research Corporation, the Center on Functional Engineered Nano Architectonics, the National Resources Institute, the Singapore–MIT Alliance, NSF, Taiwan Semiconductor Manufacturing Company, and Tokyo Electron

MIT researchers have developed a method of using self-assembling polymers to create closely packed electronic wiring with very small dimensions. The key discovery was that by introducing small posts on the surface, fabricated using e-beam lithography, the polymers could be triggered to assemble in a variety of controlled shapes. Potential applications include, in addition to on-chip wiring, high-density magnetic media for storage applications.

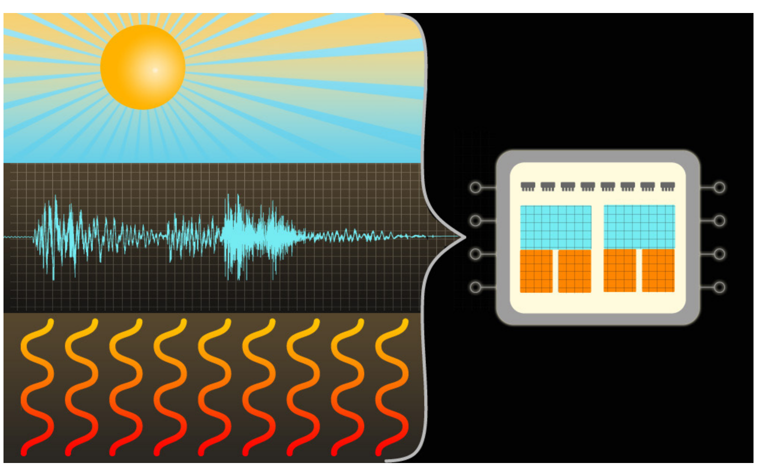


An artist's representation of the structures produced by this self-assembly method shows a top-down view, with the posts produced by electron-beam lithography shown in blue and the resulting self-assembled shapes shown in white. Image: Yan Liang

Computer Chip Developed to Harvest Power from Ambient Light, Heat, and Vibration Sources

Published in *IEEE Journal of Solid-State Circuits*
Professor: Anantha Chandrakasan (EECS)
Graduate student: Saurav Bandyopadhyay (EECS)
Funded by: Interconnect Focus Center, a combined program of the US Defense Advanced Research Projects Agency (DARPA) and companies in the defense and semiconductor industries

Building on their previous work in the development of extremely low-power computer chips and sensors, researchers in Anantha Chandrakasan's lab have developed a chip that can harvest energy from three ambient sources simultaneously: light, heat, and vibration. The key development was to combine the energy inputs from these three sources, which come with very different voltage levels. The sensor itself can be powered in real time from the ambient sources or from energy stored onboard from these sources. The numerous potential applications include wireless sensor nodes.

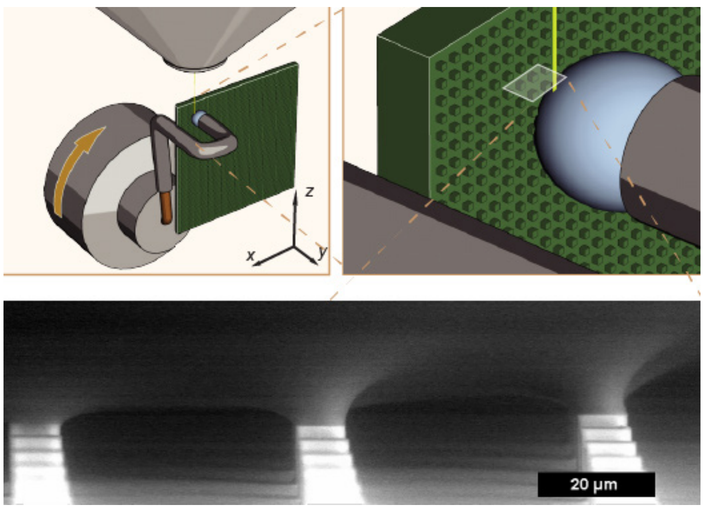


Cartoon of the energy-harvesting chip collecting energy from light, heat and vibration. Graphic by Christine Daniloff, MIT News Office

A New Class of Highly Robust Hydrophobic Ceramics Developed

Published in *Nature Materials*
Professor: Kripa Varanasi (Department of Mechanical Engineering)
Postdoctoral researchers: Gisele Azimi and Rajeev Dhiman
Graduate students: Hyuk-Min Kwon and Adam Paxson
Funded by: NSF, the Dupont–MIT Alliance, the MIT Energy Initiative, and DARPA

Hydrophobic surfaces have a wide range of applications in industry, for example as condensers for power and desalination plants. Existing hydrophobic materials are typically polymer based and are easily damaged by heat or mechanical abrasion. Professor Varanasi and his colleagues have developed a new class of hydrophobic materials that are based on rare-earth oxide ceramics. These materials are inherently robust because the hydrophobic properties are intrinsic to the material and not dependent on a surface coating. Resistance to both high temperatures and mechanical abrasion has been demonstrated.

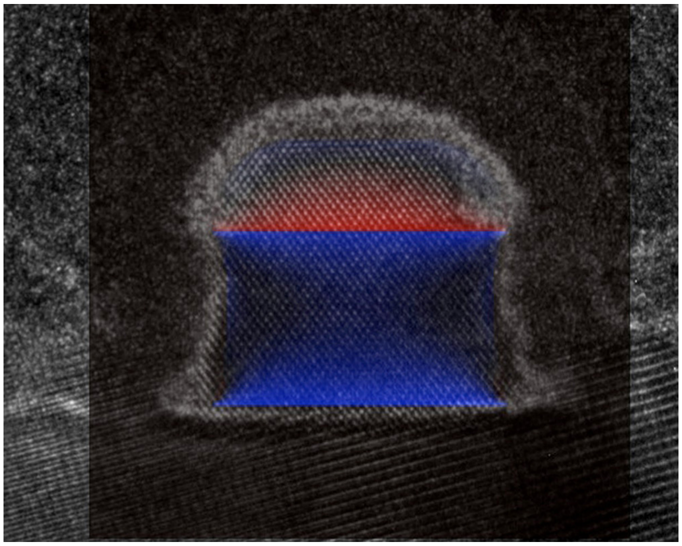


An illustration of the setup that MIT researchers used to image the tiny "necks" that form where a droplet contacts a surface. The image at the bottom shows the base of an actual water droplet moving across the surface and was taken using a special scanning electron microscope. Image courtesy of Kripa Varanasi and Adam Paxson

High Carrier Mobility P-type Transistor Developed

Presented at the International Electron Devices Meeting (IEDM), December 2012.
Professors: Judy Hoyt (EECS) and Dimitri Antoniadis (EECS)
Postdoctoral researcher: Pouya Hashemi (now at IBM)
Graduate students: Winston Chern (EECS) and James T. Teherani (EECS)
Funded by: DARPA and the Semiconductor Research Corporation

MIT researchers have demonstrated the highest mobility p-type transistor. The record hole mobility is obtained through both a highly strained germanium layer and a trigate design. The germanium layer helps to increase the drive current and the trigate design helps to reduce the leakage in the off state. The combination of the two gives a device that has great future potential.

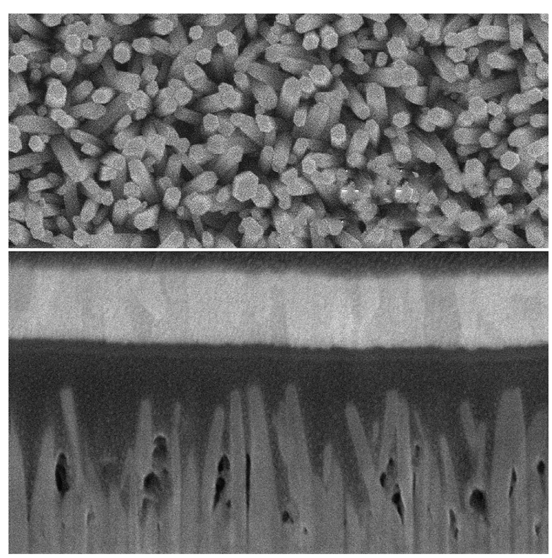


In this micrograph of an experimental transistor, blue highlighting indicates areas of "strain," where germanium atoms have been forced closer together than they find comfortable. One of the reasons for the transistor's record-setting performance is that the strain has been relaxed in the lateral direction. Image: Winston Chern, Pouya Hashemi, and James Teherani

Photovoltaic Cell Based on Graphene and Nanowires

Published in *Nano Letters*
Professors: Silvija Gradečak (DMSE), Moungi Bawendi (Department of Chemistry), Mildred Dresselhaus (Office of the Institute Professors), Vladimir Bulović (MTL), and Jing Kong (EECS)
Postdoctoral researchers: Hyesung Park (DMSE and EECS), Sehoon Chang (DMSE), Paulo Araujo, and Mingsheng Wang (affiliate)
Funded by: The Eni–MIT Alliance Solar Frontiers Program and facilities funded by NSF

A novel photovoltaic cell design has been developed using several new technologies. The base material is graphene. Subsequent layers are a polymer, zinc-oxide nanowires, and a layer to extract energy from sunlight, which could be quantum dots or P3HT polymer. The overall approach could lead to low-cost, transparent solar cells for installations such as windows and roofs. The graphene provides a low-cost alternative to indium tin oxide for the transparent conductive layer. The polymer allows the nanowire and light-absorbing layers to be applied, without degrading the properties of the graphene. The graphene is deposited by chemical vapor deposition. The zinc-oxide nanowires are deposited by a solution process at low temperature, making the process both scalable and low in cost.

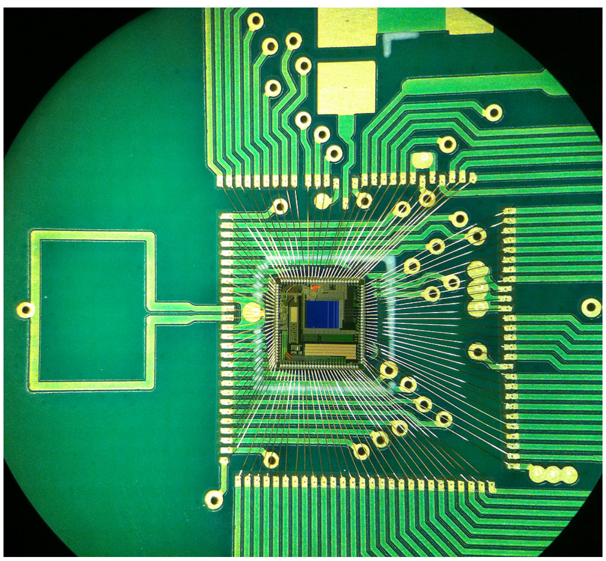


Scanning electron microscope images show an array of zinc-oxide nanowires (top) and a cross-section of a photovoltaic cell made from the nanowires, interspersed with quantum dots made of lead sulfide (dark areas). A layer of gold at the top (light band) and a layer of indium tin oxide at the bottom (lighter area) form the two electrodes of the solar cell. Images courtesy of Jean, et al. (Advanced Materials)

Self-powered Electronic Device for Inner Ear Implantation

Published in *Nature Biotechnology*
Professor: Anantha Chandrakasan (EECS)
Graduate students: Andrew Lysaght (Harvard–MIT Division of Health Sciences and Technology), Patrick Mercier (now at the University of California, San Diego), Saurav Bandyopadhyay (EECS)
Funded by: Focus Center Research Program, the National Institute on Deafness and Other Communication Disorders, and the Bertarelli Foundation

The inner ear contains a natural battery comprising a membrane separating potassium and sodium ions. The membrane has specialized cells that can pump ions across it, creating an electrical potential. The MIT researchers created a very-low-power chip equipped with a radio transmitter, with on-board power conditioning circuitry that continuously collects the very low power available from the inner ear and periodically sends out a radio signal. Applications of such bio-powered devices include both implanted hearing aids and implanted diagnostics. Successful surgical studies have been carried out on guinea pigs.

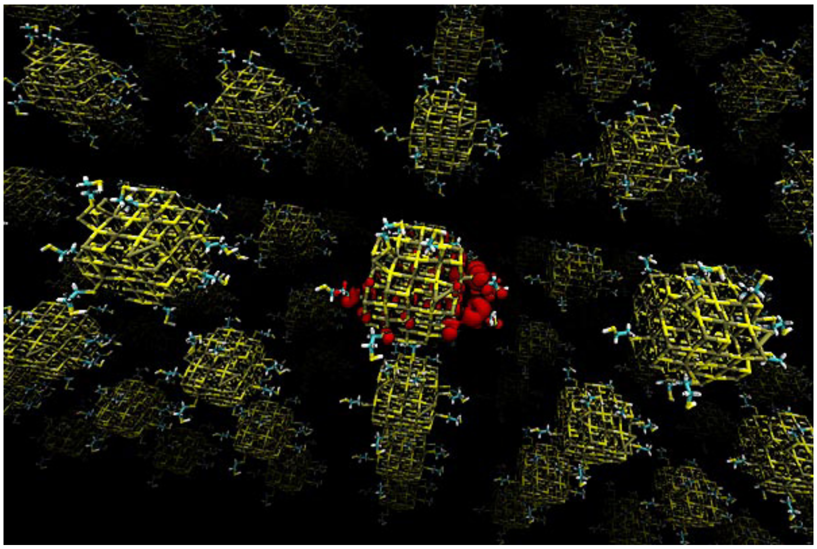


A close-up of the new chip, equipped with a radio transmitter, powered by a natural battery found deep in the mammalian ear.
Image: Patrick P. Mercier

Advances in Quantum Dot Solar Cells

Published in *Physical Review Letters*
Professors: Jeffrey Grossman (DMSE), Vladimir Bulović (MTL), and Moungi Bawendi (Chemistry)
Postdoctoral researcher: Joo-Hyoung Lee (now at the Gwangju Institute of Science and Technology in South Korea)
Graduate student: Donghun Kim
Funded by: Samsung Advanced Institute of Technology

Lead sulfide quantum-dot-based solar cells trap charge in a manner not theoretically predicted, thus limiting their effectiveness. Through numerical simulation, the MIT team has found that, at the nanometer scale, small imbalances in the passivating material can cause the lead–sulfur stoichiometry to vary from its optimal 1:1 ratio. This variance strongly affects the available energy level structure and, hence, charge and exciton transport.



This illustration shows a lead sulfide quantum dot array. Each quantum dot (colored clusters) is "passivated" by molecules that bind to its surface. Dots that are made up of unequal amounts of lead and sulfur tend to cause electrons (shown in red) to become highly localized, which can substantially lower the electrical transport of the device.
Image: Donghun Kim and Jeffrey C. Grossman

Advances in Fundamental Understanding of LED Operation

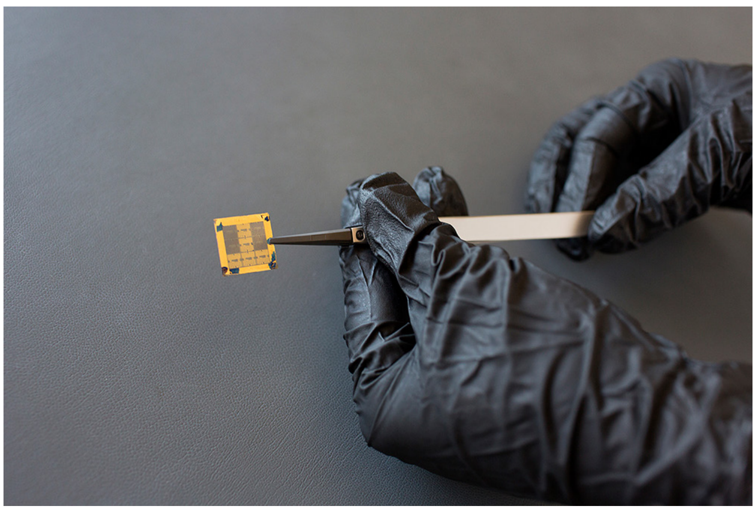
Published in *Applied Physics Letters*
Professor: Silvija Gradečak (DMSE)
Postdoctoral researcher: Kamal Baloch (Research Laboratory of Electronics)
Funded by: MIT Center for Excitonics (funded by the US Department of Energy)

Despite successful commercialization of light-emitting diodes (LEDs), until recent work carried out at MIT there was still significant uncertainty in the scientific community about the precise mechanisms leading to light emission from indium gallium nitride LEDs. The mystery was centered on why the LED output is as good as it is, given the high level of defects in the material as grown. With the use of newly developed imaging techniques based on scanning transmission electron microscopy, Professor Gradečak's group determined that indium-rich clusters are not the primary source.

High-performance Filters for Improved Wireless Spectrum Usage

Presented at the International Conference on Solid-State Sensors, Actuators and Microsystems
Professor: Dana Weinstein (EECS)
Graduate student: Laura Popa (Physics)

MIT researchers have developed a method of fabricating filters that will allow more efficient utilization of the wireless spectrum. They converted the radio signal to a physical vibration, performed the filtering, and then converted the vibration back to an electrical signal. Previously, the challenge with implementing acoustic resonators has been in fitting many of them into a small area; this was difficult because of coupling between resonator structures and the need to have a switch on each resonator. Use of a gallium nitride transistor provided a solution to both problems and suggests a straightforward path to commercial adoption.



Weinstein and Popa's experimental chip, which they manufactured at MIT's Microsystems Technology Laboratory, is divided into nine identical regions, each of which contains 65 resonators and additional circuitry required to test them. Photo: M. Scott Brauer

Potential for Dramatically Improved Photovoltaic Cell Efficiency Demonstrated

Published in *Science*
Professors: Marc Baldo (EECS) and Troy Van Voorhis (Chemistry)
Graduate students: Daniel Congreve, Nicholas Thompson, Eric Hontz, Shane Yost, and Jiye Lee '12
Funded by: the Excitonics Center, funded by the US Department of Energy

The Shockley-Queisser efficiency limit has long been accepted as limiting the solar conversion efficiency of a single semiconductor junction to 34%. MIT researchers have demonstrated singlet exciton fission with visible light, in which each photon generates two free electrons rather than the one that is usually created. The solar cell in the demonstration used an organic compound, pentacene. Although the overall efficiency was still only 2 percent, the work creates the possibility of developing low-cost organic solar cells with efficiencies exceeding that of silicon cells.

A New High-fficiency Video Coding Chip

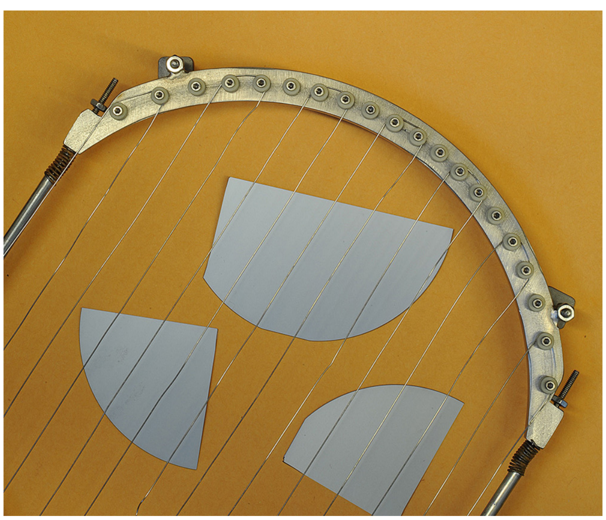
Presented at the International Solid-State Circuits Conference
Professors: Anantha Chandrakasan (EECS)
Postdoctoral researcher: Chao-Tsung Huang (formerly of EECS)
Graduate students: Mehul Tikekar (EECS), Chiraag Juvekar (EECS), Vivienne Sze (now at Texas Instruments)
Funded by: Texas Instruments

MIT researchers have developed a new HEVC chip that can be used to study algorithms and how video data interacts with hardware. They have investigated different algorithms for pipelining and storing data. The researchers are also studying how to reduce power consumption by reducing the computational demands on the circuitry.

A New Passivation Process for Silicon Solar Cells

Published in *Advanced Materials*
Professors: Karen Gleason (Chemical Engineering) and Tonio Buonassisi (Mechanical Engineering)
Graduate student: Rong Yang (Chemical Engineering)
Funded by: Research supported by the Italian energy company Eni S.p.A. under the Eni–MIT Alliance Solar Frontiers Program

Passivation processes are common for all silicon-based devices. However, for solar cell applications, the passivation process typically used today involves the deposition of silicon nitride at 400° C, which is a costly step that consumes a great deal of energy. The MIT team has developed an alternative passivation method that uses organic vapors decomposed by hot wires and then deposited onto room-temperature solar wafers. The process is potentially less expensive to implement and is scalable to large substrates.



Pieces of a silicon wafer (in gray), used for solar cells or computer chips, can be coated or "passivated" using a vapor deposition process, in which the wires shown here are heated to vaporize polymer materials which then are deposited to coat the surface. Photo: Felice Frankel

Investigation of Compressed Sensing Algorithms

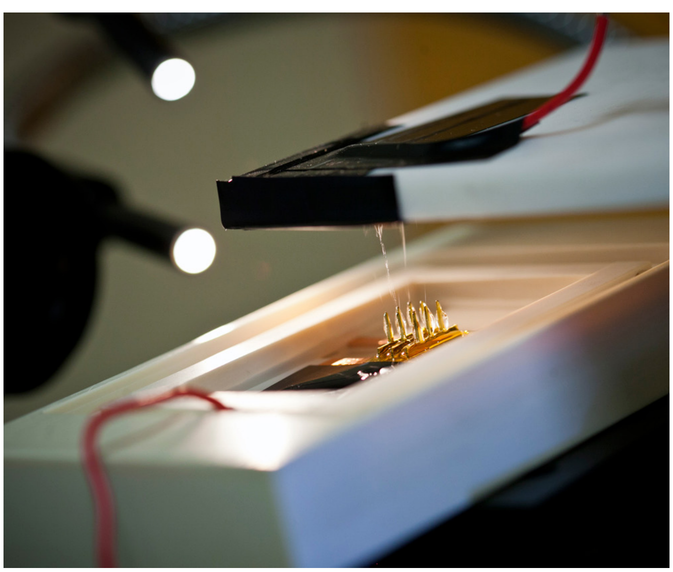
Published in *IEEE Transactions on Circuits and Systems*
Professor: Vladimir Stojanović (EECS)
Postdoctoral researcher: Fabian Lim (EECS)
Graduate student: Omid Abari (EECS)

Compressed sensing extracts more information from the signal than it appears to contain. Although compressed sensing offers the possibility of large reductions in cost and power consumption across a range of applications, it has not been yet been widely adopted. The reason is uncertainty as to how well the algorithms work in real-world situations. The MIT researchers have developed a mathematical framework for evaluating compressed sensing implementations with respect to real-world performance of hardware. In one example, looking at spectrum sensing, they found that the compressed sensing technique did not work well; but with wireless sensors such as EKG monitors very large reductions in power consumption are possible.

A New System for Spinning Nanofibers

Presented at the International Workshop on Micro and Nanotechnology for Power Generation and Energy Conversion Applications
Research scientist: Luis Velásquez-García
Postdoctoral researcher: Frances Hill
Graduate student: Philip Ponce de Leon
Funded by: DARPA

Nanofibers have many potential applications. However, to date their utility has been limited due to the expense and complexity of producing them. To address these issues, MIT researchers fabricated an array of cones on a silicon substrate. When the cones are immersed in liquid plastic and a voltage is applied to the tips, the nanofibers are produced via electrospinning. Potential applications include passive electronic components, fuel cells, filters, and catalysts.



A tiny array of silicon tips sandwiched between electrodes spins out nanofibers of plastic that could be useful for a host of applications.

Awards, Honors, Promotions

Karl Berggren, Jongyoon Han, Tomás Palacios, Li-Shiuan Peh, and Joel Voldman all received tenure in the Department of Electrical Engineering and Computer Science. Dana Weinstein was appointed associate professor without tenure.

Han Wang (Palacios group): Best Paper Award, International Electron Device Meeting (2012)

Tomás Palacios: IEEE Electron Devices Society George Smith Award (2012)

Pablo Jarillo-Herrero: Presidential Early Career Awards for Scientists and Engineers (July 2012)

Dana Weinstein: Intel Early Career Faculty Honor (September 2012)

Jesús del Alamo: Semiconductor Research Corporation (SRC) Technical Excellence Award (September 2012)

Kailiang Chen (Sodini group): Best Design Award, A-SSCC 2012 Student Design Contest, "Ultrasonic Imaging Front-end Design for CMUT: A 3-level 30Vpp Pulse-shaping Pulser with Improved Efficiency and a Noise-optimized Receiver," IEEE Asian Solid-State Circuits Conference (November 2012)

Jesús del Alamo: 2012 Electron Devices Society Education Award (January 2013)

Vladimir Bulović: Fariborz Maseeh professorship in emerging technology (January 2013)

David Perreault: IEEE Fellow status (Janaury 2013)

Dirk Englund: Department of Electrical Engineering and Computer Science Jamieson career development professorship (February 2013)

Polina Anikeeva: NSF Career Award (February 2013)

Anantha Chandrakasan: IEEE Donald O. Pederson Award in Solid-State Circuits (February 2013)

Michael Christiansen (Anikeeva group): NSF Fellowship and National Defense Science and Engineering Fellowship (March 2013)

Pablo Jarillo-Herrero: Office of Naval Research Young Investigator (April 2013)

Duane Boning: appointment to Skolkovo Foundation professor (April 2013)

Yogesh Ramadass (Chandrakasan group): Innovator of the Year in the Annual Creativity in Electronics Awards (April 2013)

William Tisdale: Early Career Award of the Office of Science of the US Department of Energy (May 2013)

Marc Baldo: Society for Information Display Jan Rajchman Prize (June 2013)

Nicholas Fang: American Society of Mechanical Engineers Chao and Trigger Young Manufacturing Engineer Award (2013)

Colleen Loynachan (Anikeeva group): MIT School of Engineering Barry M. Goldwater Scholarship and Excellence in Education Program (2013)

Kripa Varanasi: Outstanding Young Manufacturing Engineer Award, given by the Society of Manufacturing Engineers (2013)

Vladimir Bulović
Director
Fariborz Maseeh (1990) Professor of Emerging Technology and Electrical Engineering