Microsystems Technology Laboratories

The MIT Microsystems Technology Laboratories (MTL) is an interdepartmental laboratory whose mission is to foster research and education in semiconductor process and device technology and in integrated circuits and systems design. MTL provides micro- and nanofabrication and computer-aided design (CAD) infrastructure to the entire campus. MTL has 36 core faculty members who are engaged in diverse research related to electronic device fabrication, integrated circuits and systems, photonics, microelectromechanical systems (MEMS), and molecular and nanotechnologies. The most recent addition to MTL's core membership is senior research scientist Luis F. Velásquez-García.

In addition, 109 affiliate faculty and senior research staff benefit from the fabrication facilities and CAD infrastructure provided by MTL. This past year, more than 550 researchers, primarily graduate students, conducted research using MTL's advanced infrastructure. During FY2010, MTL recovered approximately 85 percent of operating expenses through charges to users and underwrote the balance through unrestricted funds (approximately $600,000 for FY2010). Sponsored programs administered directly through MTL have an annual research volume of approximately $15 million.

MTL's fabrication environment includes three clean rooms totaling 7,800 square feet: the class-10 Integrated Circuits Laboratory, 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.

MTL hosts a regular seminar series spanning diverse technical areas related to devices and circuits. A committee chaired by assistant professor Tomás Palacios organizes the seminar series, which is open to the public. MTL also hosts occasional distinguished seminars. Most recently, these seminars included Chang-gyu Hwang, former chief technology officer of Samsung Electronics, and Andrea Cuomo, executive vice president and general manager of STMicroelectronics. MTL holds a microsystems annual research conference (MARC) run by MTL graduate students in collaboration with a steering committee chaired by associate professor Joel Voldman. The conference is widely attended by industry, faculty, students, and staff; the 2010 event, held at the Cambridge Marriott hotel, attracted 186 attendees. MARC is a unique opportunity to learn about research in the diverse areas encompassed by MTL and helps encourage interaction among the MTL community. MTL also held the second Workshop on Next-Generation Medical Electronics, a two-day event at featured talks from leading experts and a lively poster session. In 2010, MTL will co-host a workshop with the MIT Energy Initiative, Next Generation μ-Energy Systems, with professor Anantha P. Chandrakasan as event chair.

MTL partners with industry through the Microsystems Industrial Group (MIG), a consortium that significantly subsidizes MTL research and operations. MIG donates major pieces of equipment to MTL, contributes directed fellowships, and provides access to state-of-the-art integrated circuit chip fabrication services. This year, Foxconn joined the MIG. Members of the MIG's Industrial Advisory Board (http://www-mtl.mit.edu/mig/iab.html) provide significant guidance in shaping the vision of MTL.

Research conducted at MTL can be broadly classified into circuits and systems, electronic devices, energy, materials, medical electronics, MEMS and BioMEMS, nanotechnology, and photonics. MTL has three affiliated research centers with focused themes: the Center for Integrated Circuits and Systems, MEMS@MIT, and the Center for Integrated Photonics Systems.

Administration, Management, and Operations

Professor Anantha Chandrakasan is the MTL director charged with overseeing daily administration and management. Three faculty associate directors—professor Jesus A. del Alamo, professor Judy Hoyt, and professor Hae-Seung "Harry" Lee—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, and industry liaison (Samuel Crooks). Ted Equi is technical liaison and assists in processing legal documents and license agreements (e.g., nondisclosure agreements).

MTL maintains several committees charged with policy development and implementation, including the policy board (A. Chandrakasan, chair), process technology committee (V. Diadiuk, chair), and computation committee (J. del Alamo, chair). MTL also has a social committee (Debroah Hodges-Pabon, chair), which builds a sense of community among MTL's many users, and a publications committee (Mara Karapetian, chair), which works on MTL's Annual Research Report (http://mtlweb.mit.edu/research/ar.html) and newsletter. MTL community members are also involved in other functional committees.

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 MTL's outreach programs. Similarly, the Fabrication Facilities Access Program enables local industries to use 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 of the 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 professional technical staff. All researchers planning to use the MTL fabrication facilities are required first to complete a safety and orientation course and to 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, group III–V semiconductors, organics, 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 includes students, faculty, and staff and meets weekly to review user process flows and protocols, requests for new materials, and fabrication operational issues.

Computation Facilities

MTL also maintains a comprehensive computation infrastructure that provides a broad array of services to the community. MTL supports the CAD tools required for circuit and system design. Users of MTL's fabrication facilities interface with the fabrication tools through MTL's common object representation for advanced laboratories (CORAL), which is seamlessly connected to the computation infrastructure. The user log is coupled to a charging algorithm that calculates user fees on a monthly basis. CORAL was developed in collaboration with Stanford University and continues to evolve as is needed by MIT's microfabrication community.

Over the period covered by this report (July 1, 2009, to June 30, 2010), MTL supported 774 registered users. Of those users, 26 were faculty and 45 were technical, research, and administrative staff. The remaining 703 were active users of MTL's microfabrication, computational, and CAD service facilities.

Research Highlights

Modeling Spatial Variations in MEMS Embossing Processes: H. Taylor and D. Boning

To achieve effective MEMS manufacturing, better spatial control of fabricated features is needed, including large-area spatial uniformity across an entire chip or wafer for products fabricated using hot embossing and other imprint processes. We have developed a computationally efficient approach to simulating the embossing of micrometer-scale, feature-rich patterns on thermoplastic polymeric layers. The method employs a linear viscoelastic model for the embossed layer and computes the distribution of contact pressure between the polymeric layer and a rigid embossing stamp that is consistent with the progression of the polymer deformation. An impulse loading function enables computation of resulting displacement distribution by simple spatial convolution (Figure 1a). Although the computation is valid only for the loading phase of the process, this is sufficient to assess whether features will be fully formed under the applied conditions. An approximation to the embossed topography of the polymeric layer is generated as a function of the material being embossed, the stamp design, and temperature, duration, and applied load of the embossing process (Figure 1b). For a stamp design described with an 800 × 800 matrix of topographical heights, simulation can be completed within 30–100 s, sufficiently fast to employ iteratively when designing a pattern to be embossed or selecting processing parameters. The viscoelastic properties of three polymeric materials—polymethyl methacrylate, polycarbonate, and Zeonor 1060R, a cyclic olefin polymer—have been experimentally calibrated. For a test pattern having features with diameters of 5 μm to 90 μm, simulated and experimental topographies agree with rms errors of less than 2 μm across all processing conditions tested, with absolute topographical heights ranging up to 30 μm. Extensions of the model have been developed to model variation in nanoimprint lithography of very thin 200 nm resist films, to accelerate simulation speed using a hierarchical spatial representation, and to study the effects of air trapped in features during embossing.

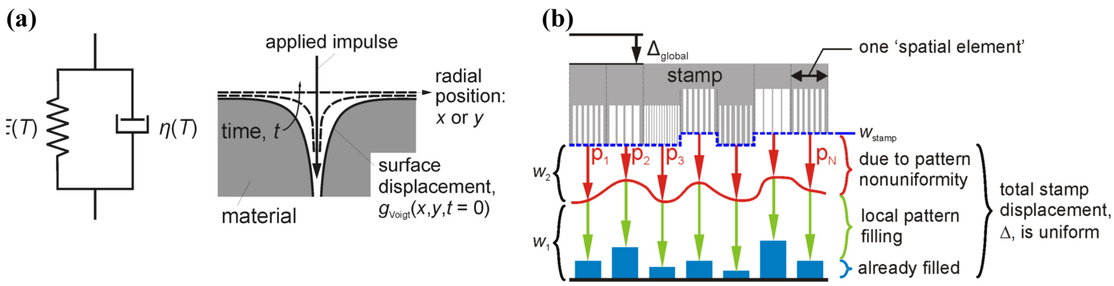

Figure 1. (a) Mechanical impulse-displacement model for embossing using a Kelvin-Voigt viscoelastic model for the polymer. (b) Application of the model showing variations in the tool (stamp) pattern or design, pressure distribution and the resulting feature filling.

A Batteryless Thermoelectric Energy Harvesting Interface Circuit for Body-worn Applications: Y.K. Ramadass and A.P. Chandrakasan

Exploiting thermal energy as a source of power for biomedical applications has become the subject of a great deal of research in recent years. The heat energy expelled by the human body can be used to supply power to body-worn sensors with the help of thermoelectric generators (TEGs). The TEGs used for body-wearable applications typically output a voltage of 50mV for the temperature differences of 1–2°K that are usually found between the body and ambient temperatures. To use this heat energy for practical electronic purposes, interface circuits that can start up and efficiently extract electrical energy from these ultra-low voltages are essential. Through our research, a batteryless thermoelectric energy harvesting interface circuit using a mechanically assisted startup circuit to operate from voltages as low as 35mV was developed. With the help of efficient control circuits and maximum power point tracking, the circuit was able to transform 58% of the available electrical power into actual use. Overall, the circuit was able to provide 100μW of usable electrical power for a temperature difference of 2°K between a human body and its surroundings.

Y.K. Ramadass and A.P. Chandrakasan. 2010. A batteryless thermoelectric energy-harvesting interface circuit with 35mV startup voltage. IEEE ISSCC Dig. Tech. Papers, Feb., 486–487.

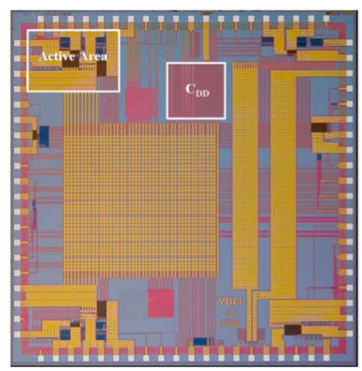

Figure 2. Die photo of the thermal energy harvesting interface circuit implemented in a 0.35μm CMOS process.

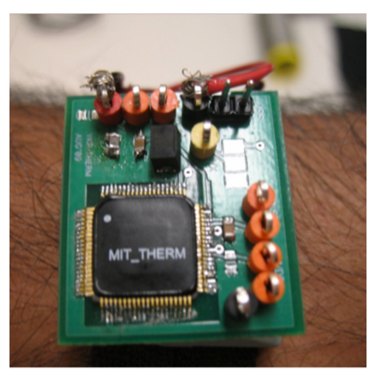

Figure 3. The thermal energy harvesting interface circuit worn on the arm of a person.

A New Architecture for Radio Transmitters: J.L. Dawson (in collaboration with D.J. Perreault)

Professor Joel Dawson's group currently focuses on two areas: new architectures for wireless transceivers and improved electronics for biomedical electronics. In 2009, we reported an exciting new transceiver architecture (Figure 4) used in an asymmetric multilevel outphasing (AMO) transmitter. The most important attribute of this new architecture is that it allows a wireless transmitter to be both highly efficient and highly linear at the same time. Failure to reach this goal is the reason, for example, that a cellular phone cannot stream live video without running down the battery in a matter of minutes.

In the past year, we have reached a number of milestones in the research and development of this new idea. We published the first experimental results in the International Microwave Symposium and tested the first microchip realization of this concept in the cellular band. Significantly, with the aid of the Deshpande Center for Technological Innovation (which is funding this effort), we have established that a strong market exists for transmitters of this type in cellular telephone base stations. In May, we (myself, David Perreault, and Sloan Fellow alumnus Mattias Astrom) formally incorporated Eta Devices, Inc., a startup company whose purpose is to develop highly efficient, highly linear cellular transmitters for 4G wireless networks.

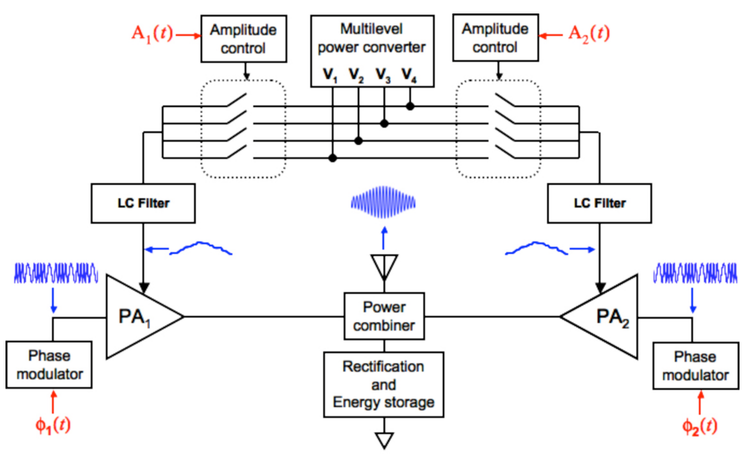

Figure 4. Simplified diagram of the new transmitter architecture.

Seawater Desalination Device: J. Han

Because of an explosive growth in population and of industrial and agricultural activities, the shortage of fresh water has become an acute global challenge. Converting abundant seawater into fresh water could solve a substantial portion of this worldwide water crisis. Much research has gone into energy-efficient desalination techniques—reverse osmosis, electrodialysis, and thermal distillation, for example—in the past few decades. However, current desalination methods require high power consumption and large-scale infrastructure, which do not make them appropriate choices for resource-limited settings such as underdeveloped countries or disaster-stricken areas.

Professor Jongyoon Han's research group recently published a groundbreaking paper (Kim, S.J., et al. *Nature Nanotechnology*, 2010) that elucidates a novel process to convert seawater to fresh water by utilizing an electrokinetic phenomenon called ion concentration polarization. A continuous stream of seawater is divided into desalted and concentrated streams that then flow into different microchannels. The key feature of this scheme is that both salts and larger particles (cells, viruses, and microorganisms) are pushed away from the membrane in a continuous, steady flow, significantly reducing the problems of membrane fouling and salt accumulation that plague reverse osmosis and other membrane filtration methods. Using a simple microfluidic unit device, we have demonstrated a continuous desalination of seawater (~99% salt rejection at 50+ percent recovery rates) at power consumption of less than 3.5Wh/L, which is comparable with state-of-the-art reverse osmosis desalination systems. We are working on building a small, portable water desalination and purification system that can supply enough potable water for a family. Battery-powered operation of such a small plant is possible. When the necessary engineering advances have been made, we believe, this technology will function as a high-efficiency alternative to current seawater desalination methods.

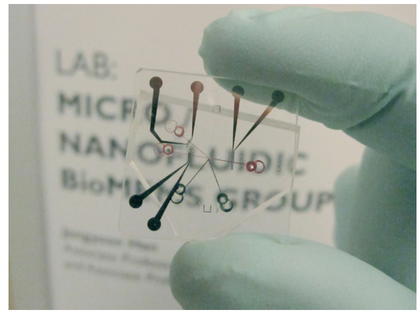

Figure 5. A demonstrated unit microfluidic device for seawater desalination (courtesy of Dr. Sung Jae Kim, RLE / MIT).

Gate-All-Around Strained-Si Nanowire MOSFETs for Low-Power CMOS: P. Hashemi, L. Gomez, and J.L. Hoyt

"Gate-all-around" metal-oxide semiconductor field-effect transistors (MOSFETs) are attractive for deeply scaled low-power complementary metal-oxide semiconductors (CMOSs) because their geometry improves the ability of the gate to turn the transistor on and off. This improved gate control relative to conventional planar transistors enables the transistor to be scaled down to a very small size. Despite these attractive features, nanowire transistors often suffer from reduced current carrying capability in a given chip area, compared with conventional planar transistors, because of the small nanowire diameter and reduced carrier mobility associated with many nanowire fabrication methods. We have been addressing these two issues by developing novel methods to incorporate strain and new materials into nanowire MOSFETs. A method to incorporate uniaxial tensile strain in silicon nanowire MOSFETs has been demonstrated, and roughly 2X strain-induced electron mobility improvement has been measured in such devices. More recently, the ability to stack up to five levels of such strained nanowires in a single device

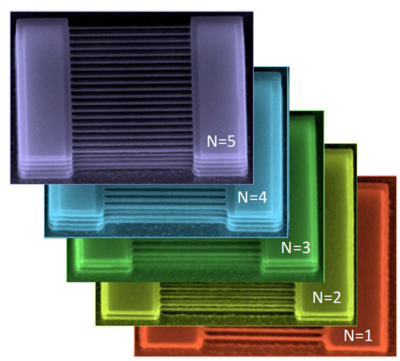

Figure 6. Colorized scanning electron microscope images of vertically stacked, suspended strained Si nanowires with the number of levels of nanowires increasing from N=1 to N=5. The length of the nanowires is 1.4 microns and their diameter is roughly 25 nm.

structure, while retaining the strain, has been demonstrated (Figure 6). These results are promising for adoption of nonplanar device geometries in future CMOS generations.

Ultra-Wide-Bandwidth MEMS-scale Piezoelectric Energy Harvester: S.-G. Kim

At the present time, most piezoelectric energy-harvesting devices have been designed to have high-Q linear cantilever beams that resonate at small environmental vibrations and result in sizable bending strain on the piezoelectric layer to generate electrical charge. There is, however, an inherent problem associated with this resonant beam design: power will decay sharply if the input vibration frequency is off by more than 1 percent to 2 percent from the natural frequency of the beam structure. The higher the Q-factor, the less robust the system becomes. A simple broadband harvester has been sought to make energy-harvesting devices compact, efficient, and practically deployable. Professor Sang-Gook Kim's group recently demonstrated a very wide bandwidth energy harvester that achieved a bandwidth at least two orders of magnitude wider than that of most reported devices (Figure 7). The key idea is to utilize the stretching strain in thin, doubly anchored beams instead of the bending strain in cantilever structures. The resulting nonlinear stiffness provides passive feedback and consequently results in wide-band resonance. The power spectrum simulation shows a more than 100-times-wider bandwidth than that achieved by a linear resonant system in a similar configuration. The novelty of the design is a device structure that ensures the dominance of the stretching mode of the beams and subsequently the effective conversion to electric energy via the piezoelectric effect. This is believed to be a crucial invention to make commercially valuable energy harvesting products from this technology.

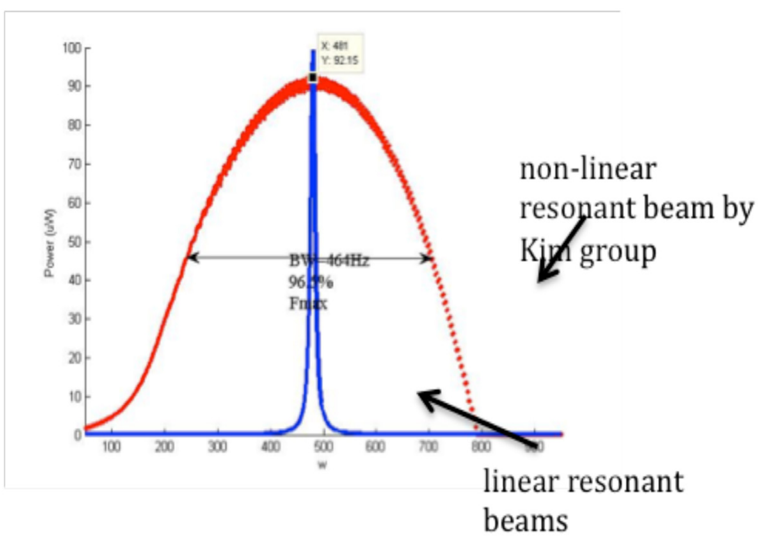

Figure 7. Nonlinear resonant beam energy harvester shows bandwidth that is at least two orders of magnitude wider than the linear resonant beam's bandwidth.

Gallium Nitride Transistors for Efficient Power Conversion: B. Lu, D. Piedra, and T. Palacios

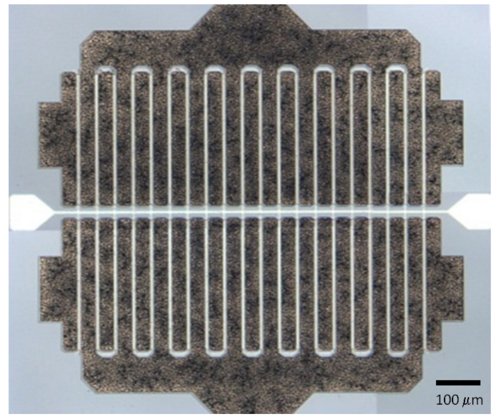

Figure 8. Optical micrograph of a multifinger GaN power transistor optimized for solid-state lighting applications. (Photo: Daniel Piedra.)

Virtually all the electricity used in the world flows through power electronic circuits, which transform its voltage to the values required by specific applications. The efficiency of power electronics therefore has a tremendous impact on global energy consumption and on the ultimate performance of many electronic systems, such as computer data centers, photovoltaic panels, and hybrid vehicles. It has been estimated that more extensive utilization of high-efficiency power electronics could lead to a reduction of roughly 15–20 percent of electricity consumption in the United States. Our group is developing a new generation of power electronics based on gallium nitride (GaN) semiconductors (Figure 8). The combination of the outstanding transport properties of this new material with advanced device concepts offers the potential of reducing the size of power electronic systems tenfold while providing much lower power losses and unprecedented integration capability. Our research focuses on three important components of GaN power electronics: maximizing the efficiency of power transistors by reducing their on-resistance and frequency capability; developing new technologies to fabricate normally off transistors, that is, switches that do not let the current flow unless a voltage is applied to the gate electrode; and increasing the breakdown voltage of GaN transistors beyond 1,200 V so that they can be used in applications such as hybrid cars and grid electronics.

A Wireless, Wearable Cardiac Monitor: E.S. Winokur, C.G. Sodini

Given the escalating costs of hospital visits, clinicians are opting to use at-home monitoring devices to diagnose and follow patients. Current ECG Holter monitoring devices typically have memory and battery capacities of 24–48 hours. With many patients experiencing intermittent heart problems, occurring perhaps once a week or once a month, the Holter monitor is not a good solution and an event recorder or loop recorder is required. However, each of these recorders can save only up to a few minutes of ECG recordings. This constraint leads to the loss of most of the data, which could be very important in alerting the user to the onset of future episodes. Therefore, we have developed a Holter monitor prototype with the goal of extending battery and memory capacities to two weeks. Figure 9 shows a block diagram of the system.

We based the long-term monitor prototype on a Texas Instruments MSP430 low-power microcontroller that enables high computing power with very low power consumption. The prototype monitor is mounted on standard 3M 2560 Red Dot electrodes and fabricated on a flexible PCB substrate. Mounting the PCB directly on the electrodes improves the signal-to-noise ratio by an estimated 40 dB compared with using wired leads. The monitor is L-shaped with rounded corners and is placed on the patient's chest (Figure 10). The L shape means that several different ECG vectors can be recorded, depending on what the cardiologist wants to observe. The monitor has 1 GB of FLASH memory, which is enough to store two weeks of data sampled at 250 Hz continuously with Huffman encoding. Total power consumption of the system is approximately 2 mW.

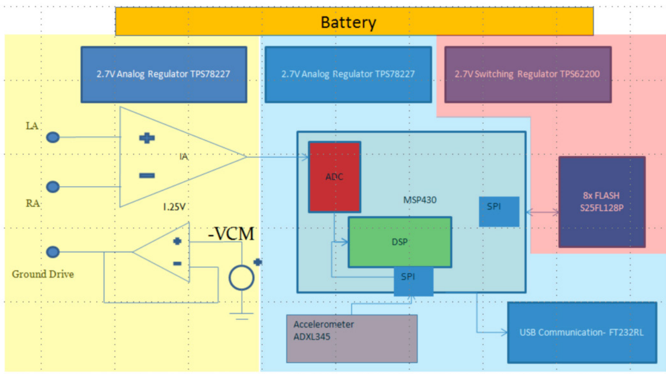

Figure 9. Block diagram of the ECG long-term Holter monitor system. The front end uses TI OPA333 and INA333 amplifiers and has a bandwidth from 0.5 Hz to 125 Hz. The 3-axis ADI accelerometer data samples at 2Hz to help correlate activity level with the ECG recordings. The battery is a 3.7V 600 mAh Li-Pol cell from Cameron-Sino.

Figure 10. A photo of the wearable, wireless cardiac monitor. The monitor is coated in Parylene C to protect it from water and sweat that may come in contact with the circuits.

Micro- and Nano-Enabled High-Performance Multiplexed Electrospray Sources: L.F. Velásquez-García (in collaboration with A.I. Akinwande and M. Martínez-Sánchez)

Electrospray refers to the technique that uses high electrostatic fields to ionize electrically conductive liquids. Electrospray ionization (ESI) can be used to produce micro- and nano-scaled particles such as droplets, solvated ions, and fibers with very low morphological variation. These particles can be used in many applications useful in such areas as healthcare (mass spectrometry of biomarkers), the environment (in situ water quality monitoring), manufacturing (high-performance structures using nano-reinforced composites, ultra-precise printing, etching, and coating, production of quantum dots) and space exploration (mass-efficient and energy-efficient nanosatellite propulsion).

We are interested in developing massively multiplexed ESI sources because the throughput of a single electrospray emitter is quite small, which severely limits the range of applications that can be satisfied with the technology; also, multiplexed ESI sources can visibly increase the specific charge of the emitted plume for a fixed flow rate. Massive multiplexing of ESI sources is challenging because it requires individual electrical/hydraulic flow control of each emitter; otherwise, the emission of the array is very nonuniform. Moreover, flow regulation is required to set the electrospray emitter to work in steady-state, or to produce a particular kind of particle from a given liquid. In addition, multiplexed ESI sources require proximal gates and scaled-down emitters to achieve high emitter density, low-voltage operation, and low power consumption.

We recently reported the design, fabrication, and experimental characterization of a fully microfabricated planar array of externally fed electrospray emitters that produces heavy molecular ions from the ionic liquids EMI-BF_4 and EMI-Im. The device is the first reported fully microfabricated ESI source with integrated extractor that is shown to operate in the pure ionic emission regime. An exploded view of the device is shown in Figure 11. The multiplexed MEMS ESI source has as many as 502 emitters in 1.13 cm^2 that are monolithically batch-fabricated on a silicon substrate using plasma microfabrication technology. The emitters are coated with black silicon, a nanostructured porous material that transports the liquid to the emitter tips. This device could readily be used as a very efficient source of thrust for nanosatellites, generating thrust at specific impulse values as high as 10,000 s (10,000 V bias) with propulsive efficiency of better than 85 percent.

B. Gassend, L. F. Velásquez-García, A. I. Akinwande, and M. Martínez-Sánchez. 2009. A Microfabricated Planar Electrospray Array Ionic Liquid Ion Source with Integrated Extractor, Journal of Microelectromechanical Systems, Vol. 18, No. 3, 679–694.

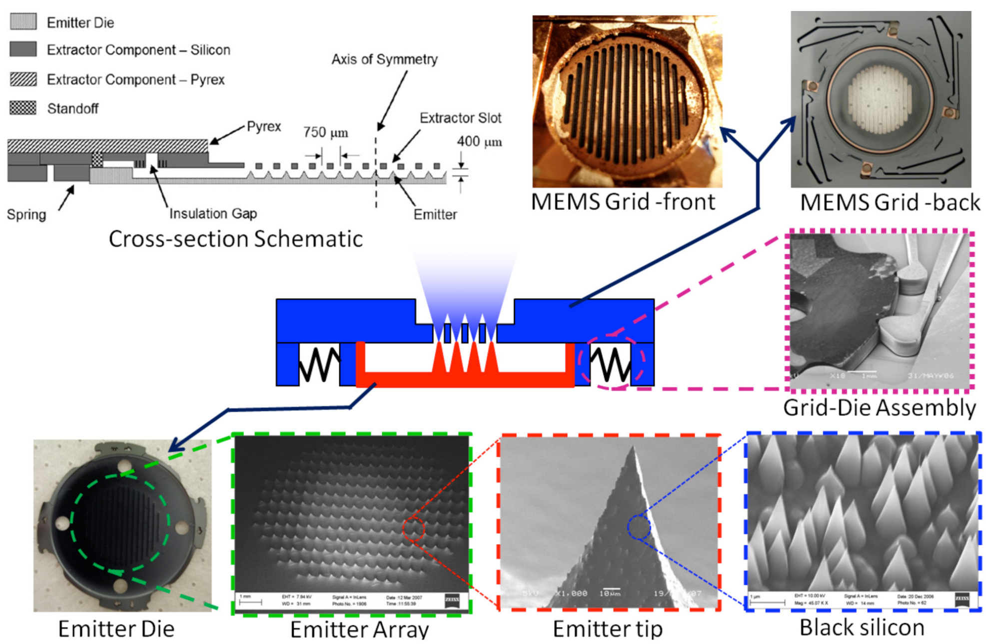

Figure 11. Exploded view of a fully microfabricated, massively multiplexed MEMS ESI source with integrated extractor. The emitters are organized in rows and are coated with black silicon. The electrodes are made from a three-wafer stack where the electrical insulation is provided by the vacuum gaps and the Pyrex substrate. The extractor and the emitting substrate are assembled using a set of DRIE-patterned deflection springs.

Indium Arsenide Quantum-Well Field-Effect Transistor with World Record Frequency Response: D.-H. Kim and J.A. del Alamo

Professor del Alamo's group is investigating a new generation of quantum-well transistors that are capable of extending Moore's law for several more generations. The group's transistor designs are attempting to exploit the extraordinary electron transport properties of indium gallium arsenide (InGaAs), indium arsenide (InAs), and other group III–V compound semiconductors.

In the past year, Dae-Hyu Kim, until recently a postdoctoral associate in Professor del Alamo's group, has achieved 30 nm gate length InAs high electron mobility transistors (HEMT) that display a world-record frequency response. For the first time, a transistor has been fabricated that exhibits a current-gain cutoff frequency and a power-gain cutoff frequency that are both over 640 GHz. Both are measured at the same bias point. These two figures of merit are widely used in the community to evaluate the suitability of transistors for high-frequency and high-speed operation. The values reported by the del Alamo group are the highest combination ever on any transistor type on any material system. This bodes well for the suitability of InAs-based quantum-well transistors for ultra-high-speed logic and terahertz applications.

D.-H. Kim and J.A. del Alamo 30 nm InAs PHEMTs with f_T=644 GHz and f_{max}=681 GHz. *IEEE Electron Device Letters*, in press.

Awards and Honors for Core MTL Faculty

President emeritus Paul E. Gray has been named the recipient of the 2010 Institute of Electrical and Electronics Engineers (IEEE) Founders Medal in recognition of his "exemplary career of leadership in education, research and public policy." The IEEE is the world's largest technical professional association.

Professor Chandrakasan received the Semiconductor Industry Association (SIA) University Researcher Award for his work in micro-power design, wireless microsensor arrays, and ultra-wideband radios. The SIA University Researcher Award was established in 1995 to recognize lifetime research contributions to the US semiconductor industry by university faculty.

Hayden Taylor and Duane Boning's embossing/imprinting simulation work received the 2009 Software in Design Innovation Award from the Institution of Engineering and Technology (IET). The IET Innovation Awards span 15 categories and attracted more than 300 entries from around the world.

Tomás Palacios won the 2010 Young Scientist Award of the International Symposium on Compound Semiconductors. He is cited for contributions to the development of mm-wave GaN high electron mobility transistors and their integration with silicon electronics.

Dana Weinstein received the 2010 Young Faculty Award from the Defense Advanced Research Projects Agency.

Sefa Demirtas, a doctoral student working with Professor del Alamo, received the Best Student Paper Award, Lifetime Estimation of Intrinsic Silicon Nitride MIM Capacitors in a GaN MMIC Process, Compound Semiconductor Manufacturing Technology Conference, 2009.

Junwoo Joh received the Department of Electrical Engineering and Computer Science's Jin-Au Kong Outstanding Doctoral Thesis Prize, Honorable Mention, 2010, for Physics of Electrical Degradation in GaN High Electron Mobility Transistors.

Denis C. Daly received the 2009 International Solid State Circuits Conference (ISSCC) Jack Kilby Award for Outstanding Student Paper for A Pulsed UWB Receiver SoC for Insect Motion Control. The award was presented at the 2010 IEEE International Solid-State Circuits Conference.

Principal research scientist Luis F. Velásquez-García received the Best Oral Paper Award at the 2009 International Workshop on Micro and Nanotechnology for Power Generation and Energy Conversion Applications (PowerMEMS) for the paper Design, Fabrication, and Demonstration of a MEMS Steam Generator for Ejector Pump Applications, by F. Eid, L.F. Velásquez-García, and C. Livermore.

Affirmative Action

MTL supports the affirmative action goals of the Institute.

Anantha P. Chandrakasan
Director
Professor of Electrical Engineering and Computer Science

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