Winter 2010

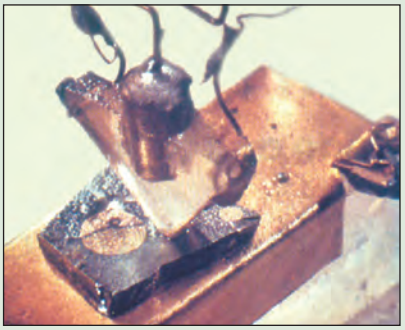
WIMS WORLD

Director's Message

When we look back on this period of history, we may find it referred to as the Great Reconnecting! It seems that with the introduction of the Internet and the plethora of information it makes available, that's what is happening. Perhaps it's just that we are searching for anchors in a sea of change that sometimes seems to be moving a bit too fast. As I approach retirement, I guess it's natural to reminisce more than I used to, looking back and wondering how I did with the time I had. Last month I was contacted by an old friend from high school whom I hadn't heard from in almost 50 years. It was nice to reconnect. I suspect everyone is having these experiences. Google a name and there they are. Now, I have to admit that I haven't quite figured out tweeting, twittering, blogging, or facebooking, yet, even though I'm sure they are very useful, but this reconnecting thing is happening on a broad scale. I've always had an interest in history and began resurrecting my family history as a teenager. Those efforts reconnected me with ancestral roots involving some reasonably important events and with people whose stories had long been forgotten. I used to think such forays were pretty uncommon, but I recently read that genealogy is now the number-one hobby in America. We're all trying to reconnect. Trying to find anchors.

Reconnecting applies to our professional roots as well. Too few of us feel much kinship with those who laid the foundation for what we do, but we stand on the shoulders of some real giants — Franklin, Maxwell, Edison, Bell, Marconi, Armstrong, and dozens of others. And benefitting from their work, the last fifty years have seen us change the world in ways they could scarcely have imagined. I've been reading *Crystal Fire*[1] lately, a book that details the events and people leading up to the birth of the transistor. It starts with the dawn of the twentieth century and the development of quantum physics, and then leads the reader into the mysterious world of semiconducting materials and our struggles to understand them. Most importantly, it gives us a glimpse of the people that grappled with things we take for granted today — electrons, holes, emitters, collectors, surface states, energy barriers, defects, doping, injection. They were pretty much like many of us, following one clue and then another, chasing a few dead ends, but slowly unraveling how things work. In the case of the transistor, Bell Telephone Laboratories provided the research environment that allowed theoreticians and experimentalists to mingle, to probe, and finally to understand. It was perhaps a unique environment, now sadly gone. I heard a rumor that the buildings at 600 Mountain Avenue may be demolished. If they ever are, I hope someone will put up a monument to all the things created there: negative feedback, noise theory, information theory, hearing aids, stereophonic sound, data networking, the transistor, cellular telephones, solar cells, the laser, digital communication/switching, communication satellites, digital signal processors, and much more.

Bell Labs was a national treasure, and I've always been grateful I started my career there. It was a very lucky series of events that took me to Murray Hill in 1963, and BTL enabled my graduate work at Stanford, where I had the privilege of getting to know some of the Bell Labs ex-patriots who had migrated west to work on the "farm." People like John Linvill, John Moll, Gerald Pearson, and (slightly) William Shockley. John Linvill was a great mentor and role model who inspired by own career in academia. I was always sorry that things didn't work out so I could work on his reading aid for the blind. It was my first glimpse of application-driven research in the biomedical area, research that gave birth to some of the first silicon visible imagers developed anywhere. And then there was Gerald Pearson, who had been a key member of the semiconductor group at Bell Labs and was co-inventor of the solar cell. He was justly proud of the fact that BTL allowed him to keep his identification card when he retired to the farm. (Mine is doubtless buried in a packing box somewhere if it hasn't already been incinerated.) I got to know him well, taking his laboratory course three times (two experiments per term). *Crystal Fire* has shown me, much more than I appreciated at the time, whom I was working with.



The first transistor, 1947, along with an AT&T publicity shot of Shockley, Bardeen, and Brattain. When John Bardeen got home on Tuesday evening, December 16, he parked his car and came in through the kitchen door. He found Jane there, peeling carrots at the sink. "We discovered something important today," he mumbled as he took off his hat and coat. "That's great," she replied, looking up for a moment. But he passed by her into the living room without mentioning anything more. Since John hardly ever discussed his work with her, however, she knew instinctively that he must have had a good day at the Labs. He had indeed. They had given birth to the Information Age. [1]

[1] M. Riordan and L. Hoddeson, *Crystal Fire: The Birth of the Information Age*, New York: W. W. Norton, 1997.

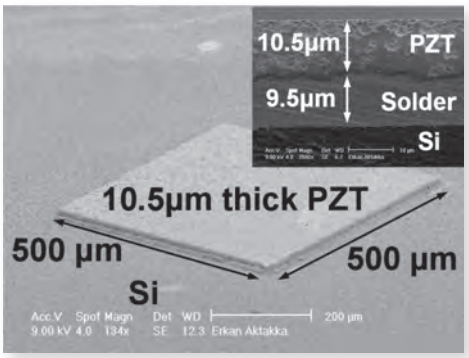
Continued on page 3

Research Highlights

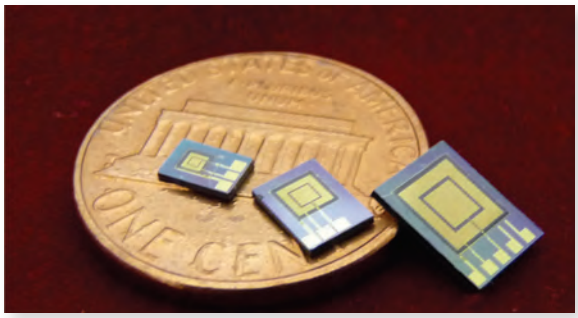
A New Process for High-Performance Piezoelectric MEMS

Erkan Aktakka and Khalil Najafi

Bulk piezoelectric ceramics provide greater electromechanical coupling, structural strength, and charge capacity compared to deposited piezoelectric thin films (e.g., sol-gel PZT or sputtered AlN). Such properties are highly desirable in many MEMS applications including high-force actuators and micropower scavengers. We have developed a new CMOS-compatible, wafer-level process to obtain thin films of bulk piezoelectric materials on silicon. The process relies on low-temperature, fluxless, patternable, and reliable solder or polymer bonding of PZT to silicon, followed by wafer-level mechanical thinning/polishing. Aligned, piece-wise bonding enables piezoelectric device fabrication on a silicon wafer with no chemical patterning of PZT. The PZT thinning process allows control over film thickness across a wide range from 5μm to 100μm, yielding highly flexible structures. The thinning technology can be applied at the wafer scale or to PZT pieces as small as 200μm × 200μm. Furthermore, the processed PZT samples do not require re-polarization, and bulk piezoelectric properties are fully conserved in the final thin film. Using this process, PZT out-of-plane actuators operating in the d_{31}-mode are fabricated in different sizes and shapes. A 20μm-thick diaphragm actuator with a diameter of 1mm driven at $20V_{PP}$ produces >12μm_{PP} deflection at 110.9kHz. This fabrication technique offers considerable performance advantages over previously introduced thin-film deposition techniques and it is transferrable to a wide variety of MEMS applications. ■



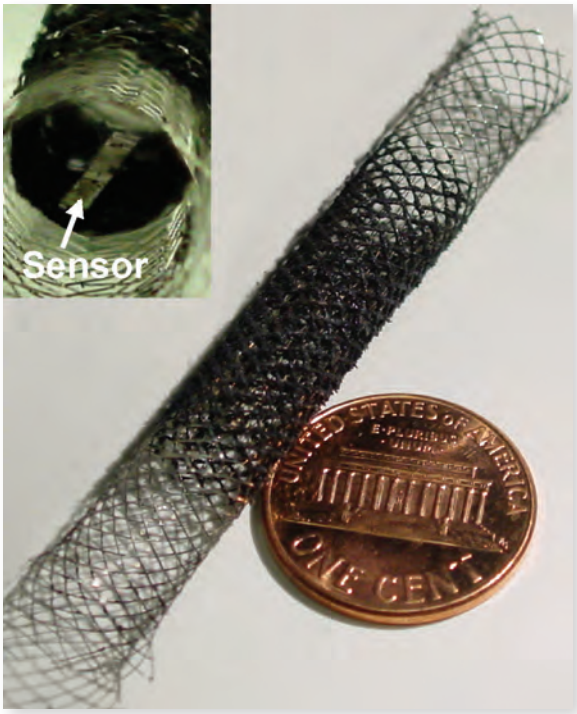
Bonded and thinned PZT film on silicon.



Thinned PZT diaphragm actuators.

Wireless Monitoring of Intraluminal Prostheses

Scott R. Green and Yogesh B. Gianchandani



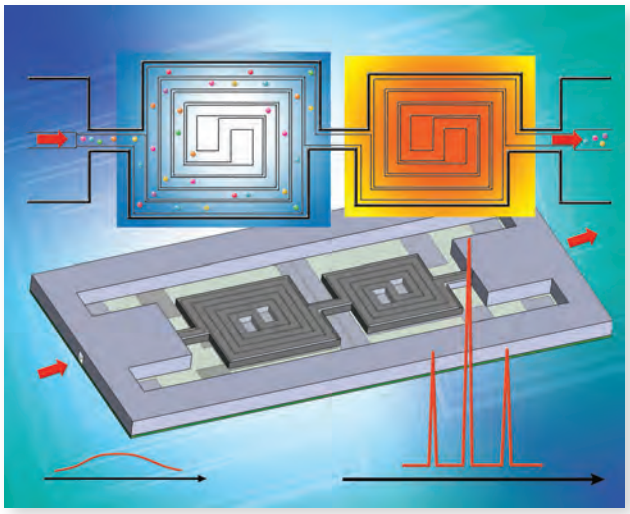
Resonant magnetoelastic sensors have been developed for wireless sensing of viscosity changes and sludge accumulation in biliary stents. The sensing element, located within the stent, is queried by a wireless radio-frequency signal. The stent has a conformal magnetic layer that biases the sensor. Both *in situ* and *ex vivo* evaluations have been performed. During *in situ* tests, the external interrogation module was able to acquire a signal from the sensor from a distance of at least 5cm while the sensor was implanted in a porcine carcass and loaded with biological fluids. *Ex vivo* testing used bile harvested from the porcine carcass. Batch-patterned sensor designs with tailored geometries have also shown increased sensitivity and the ability to determine the spatial distribution of sludge accumulation. The test results to date illustrate the fundamental usability of the system when the sensor is implanted, loaded by biological fluids, and integrated in a surgical setup. This project was supported in part by a National Science Foundation Graduate Fellowship. ■

Biliary stent with conformal magnetic layer and resonant magnetoelastic sensor.

A Microfabricated Thermal Modulator for Comprehensive Two-Dimensional WIMS μGC

Sung-Jin Kim and Katsuo Kurabayashi

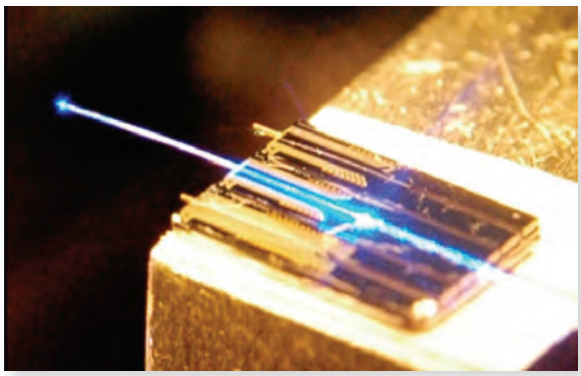
Comprehensive two-dimensional gas chromatography (GC×GC) is a powerful analytical technique to separate and detect the components of complex mixtures of volatile organic compounds. Focusing and re-injecting eluting mixture components, a thermal modulator placed between two separation columns in a GC×GC system plays a critical role in enhancing the resolution and the selectivity of analytes. As part of our efforts to develop a μGC×μGC prototype, we have designed, fabricated, and operated a two-stage, microfabricated thermal modulator (μTM) using MEMS technology. It contains two sequential serpentine Pyrex-on-Si microchannels (stages) that cryogenically trap analytes eluting from the first-dimension column and thermally inject them into the second-dimension column. The μTM is kept approximately at -50°C by a solid-state thermoelectric cooling unit placed a few tens of microns from the device, and for each rapid modulation cycle it is heated to 250°C at 2800°C s^{-1} by integrated resistive microheaters and then cooled back to -50°C at 250°C s^{-1}. Thermal crosstalk between the two stages is less than 9%. Preliminary tests of the μTM using conventional capillary columns and integrated microcolumns have demonstrated enhanced sensitivity and resolution in separating mixtures of alkanes and ketones. ■



Artists' drawing of the two-stage microfabricated thermal modulator, to appear on the cover of Lab on a Chip.

An Optical Stimulation Probe Monolithically Integrated With Polymer Waveguides

Il-Joo Cho, Fan Wu, and Euisik Yoon



Optical neural probe with a light guided to the stimulation site at the end of a probe tip.

We have monolithically integrated optical waveguides on the neural probe shanks for the first time in order to guide light to designated sites close to recording electrodes. This will harness additional capability to selectively stimulate the specific targeted neurons that are genetically modified to respond to light at a specific wavelength. (For example, when chanelrhodopsin-2 is expressed it will respond to a wavelength of 470nm.) We implemented the waveguide using an SU-8 core and an oxide cladding layer to guide light from an external optical source. A U-groove has been formed at the end of the waveguide for easy alignment with an optical fiber. The coupling loss between the optical fiber and waveguide has been measured below -3.7 dB with a waveguide propagation loss of -0.22dB/mm. The process is compatible with the existing Michigan probes and will provide optical stimulation capability as a modular option in addition to electrical recording and stimulation. The technology is being made available to the neuroscience community for *in vivo* experiments. ■

Director's Message

Continued from page 1

Well, now I'm reminiscing again, but I can't help being grateful for all the terrific experiences I've had in my career, and all the terrific people I've had the opportunity to work with. The WIMS ERC is jumping into the Great Reconnecting this summer as we complete the formation of a Microsystems Alumni Group that hopefully will allow our graduates to stay in better touch with their alma mater and with each other for many years to come. Go Blue! ■

Ken Wise

Director, Engineering Research Center
for Wireless Integrated MicroSystems

Faculty and Student Awards

Angelique Johnson

Angelique Johnson Awarded Marian Sarah Parker Prize

Each year, the University of Michigan's College of Engineering recognizes two deserving female students with Marian Sarah Parker Prizes. Marian Sarah Parker was the first woman to receive a Michigan degree in engineering, in 1895. With her hard-earned degree in civil engineering, Marian helped design such revolutionary steel skyscrapers as New York's Flat Iron Building and the Waldorf Astoria Hotel. The prizes in her name are presented to worthy women students (at either the senior or graduate level) who have demonstrated academic excellence, leadership qualities, and outstanding contributions to the University or the community, or both. This year, the Center's very own Angelique Johnson received one of the highly regarded Marian Sarah Parker Prizes. She accepted her award at the College's Honors Brunch for student leaders. Angelique received the award in recognition of her many outreach efforts, multiple leadership roles, and academic achievements.

While pursuing a Ph.D. in Electrical Engineering, Angelique has helped to organize over eight different outreach programs including the Grace Hopper Program, WISE Robot Camp, WIMS DAPCEP (see article, p. 6), and WIMS DAPCEP Innovative Technology Experiences for Students and Teachers. In addition to her outreach efforts, Angelique has served on the executive board of several graduate student organizations and is currently the President of both the WIMS SLC and its offshoot, the Nanotechnology and Integrated Microsystems Student Association (NIMSA). She also holds positions on the College's Diversity Outreach Council and the Lurie Nanofabrication Facilities User Committee (LNFC).

Angelique's thesis work is directed by Dr. Kensall Wise. Focusing on thin-film cochlear electrode arrays, she is making significant contributions to increasing the functionality and affordability of cochlear implants. Her research is in the process of being patented and has been featured on the cover of *Hearing Research*. ■

Robert Gordenker and Crew Awarded Rescue Medal

On August 1, 2009, while returning from Mackinac Island, WIMS Technical Director Robert Gordenker and two crew members, Dennis Maurer and Dee Adkins, plucked two sailors from the cold waters of Lake Huron. The rescue and life-saving actions of *Time Machine's* skipper and crew were recognized by the U.S. Sailing Association with the bestowal of the Arthur B. Hanson Rescue Medal. The medal is awarded to skippers and crews of boats who rescue people from the water. In addition to recognizing the significant accomplishment in seamanship that has saved a life, the award program facilitates collection of case studies of successful rescues for incorporation in U.S. Sailing Association educational programs.

Left to right – Vice Commodore Burgoyne, David and Jackie Warner, Robert Gordenker, and Dennis Maurer.

Indeed, as part of the North Cape Sailing School's spring seminar series, one of the sessions focused on cold-water rescues, where Robert presented a summary and analysis of the August 2009 rescue. This multi-media presentation included recorded audio of radio transmissions from *Time Machine* to the Canadian and U.S. Coast Guard. During the question-and-answer period, Robert was joined by David Warner, one of the victims, who eloquently described the desperation that he and his son Nathaniel felt as their sailboat sank beneath them. When asked what *Time Machine* looked like charging towards them at top speed, he answered, "beautiful… and huge!" Warner characterized the rescue as "calm, deliberate, focused, and professional." Following the session, North Cape Yacht Club Vice Commodore Burgoyne and Jackie Warner, David's wife, made a formal presentation of the Hanson Rescue Medal to Skipper Gordenker.

Time Machine is a J/35 racing sailboat that competes on the Great Lakes and in various one-design regattas at the national championship level. The *Time Machine* sailing team is an all-amateur group of friends who race in a class known for its consistently high level of competitiveness. As owner and captain of the vessel, Robert takes great pride in keeping *Time Machine* in racing condition and achieving excellence in sailing, while ever vigilant to help other sailors in need. A detailed write up of the rescue, including the audio, is at http://tmsailing.blogspot.com, and more information about the *Time Machine* is at http://www.eecs.umich.edu/~rgordenk. David and Jackie Warner live in Sanilac County, Michigan, and their son Nathaniel is training in North Dakota to be a helicopter pilot for the U.S. Army in an ROTC program. ■

Faculty and Student Awards

Ted Zellers Receives the 2010 Excellence in Teaching Award from the School of Public Health

Ted Zellers at the 2010 U-M School of Public Health Commencement Ceremony on April 29, in Hill Auditorium.

While the WIMS ERC knows Ted Zellers as its Environmental Thrust Leader, many throughout academia know Ted as a highly respected professor of environmental health sciences (and chemistry). Specifically, his primary teaching appointment is with U-M's School of Public Health (SPH), where he is on the faculty of the Department of Environmental Health Sciences (EHS). In this capacity, he was recently recognized with the 2010 SPH Excellence in Teaching Award on the basis of his distinguished record of performance and dedication to the teaching mission of the EHS Department. In conferring the award at the SPH commencement ceremony, Ted's teaching accomplishments were summarized as follows: "He is a highly effective instructor and mentor, a progenitor of curriculum reform within the department and nationally in the field of occupational health, and a staunch proponent of high academic standards and policies aimed at maintaining the reputation of the department for academic excellence. He has managed to excel in these areas while also directing a vibrant research program at the cutting edge of environmental science. Students and alumni appreciate Dr. Zellers for his thoroughness and high performance standards, and alumni credit him for their excellent preparation for careers beyond graduate school."

The award selection process relies to a large extent on student input and recommendations. In short, Ted's current and former students praise him profusely. The following excerpts come from just a few of the student endorsements that supported the award:

"What I most respect, and found to be his best attribute, was his dedication to his students and the vision of their potential. He continually challenges and encourages us to not just accept what is presented, but to take that information and apply it to real world problems. His teaching style is methodical and thought-provoking."

"Professor Zellers is an excellent professor. [His] course is very heavy with material, but he does a great job presenting it with enthusiasm and passion. I give him an A+ as a professor, probably one of the best professors I've ever had."

"Dr. Zellers was one of the first people to inspire me to pursue a Ph.D. and further my education. His encouragement and interest in my future was pivotal in my own academic career."

"'Passionate' is probably the strongest description I can use for him; his passion is contagious, leading students to go above and beyond."

The students have spoken, and the ERC agrees. Ted personifies the WIMS ERC at its best. ■

Personnel Focus

Professor Kensall Wise, Sister Mary Elizabeth, OP, her mother and father, Bernice and Daniel Merriam.

On April 21, 2010, the WIMS ERC proudly participated in a very unusual achievement, the Ph.D. degree was conferred on one of our WIMS graduate students who also happens to be a devoted nun, or sister, of the Dominican Sisters of Mary. **Sister Mary Elizabeth Merriam** successfully defended her doctoral dissertation in electrical engineering at the University of Michigan, to a lecture hall filled with her parents, fourteen other Dominican Sisters of Mary, and many of her professors and colleagues. Sister Mary Elizabeth, as convent members address her, began her graduate studies in electrical engineering prior to entering religious life, but after completing her Master's degree and her Ph.D. coursework, she heard the call to religious service. Consequently, she left her studies and entered the convent. After completing her education certification, Sister Mary Elizabeth was asked by the convent director, Mother Assumpta, if she would be interested in returning to the University to finish what she had begun. Three years later, she has done so.

Sister Mary Elizabeth's dissertation is entitled "A Three-Dimensional, Bidirectional Interface for Neural Mapping Studies." She was involved in creating a neural array to stimulate and record neural (brain) signals. Some of the potential, practical applications for this breakthrough work include treatments for a variety of afflictions, such as hearing loss, blindness, and Parkinson's disease. Her research advisor was Professor Kensall D. Wise, and she also worked quite closely with Professor Susan Shore (Otolaryngology). Other close collaborators included Professor A. John Hart (Mechanosynthesis), Professor Patrick A. Tresco, (Bioengineering, University of Utah), and Professor Euisik Yoon (Electrical Engineering and Computer Science).

While an electrical engineering program may not seem a likely place to find a devoted nun, Sister Mary Elizabeth manages to be "at home" in both realms. Indeed, she has excelled in all that she has attempted, whether spiritual or scientific. One of her convent sisters explained Sister Mary Elizabeth's dual achievement in this way: "Truth is to be found in many places." We at the Center feel fortunate to have had Sister Mary Elizabeth among our ranks for a few years as we explored engineering and technological solutions to today's pressing problems. The WIMS ERC proudly joins the Dominican Sisters of Mary in saying, "Congratulations, Sister!" ■

http://www.sistersofmary.org/index.php

Education Highlights

Center Continues Collaboration With Detroit-Area Schools

For the past nine years, the Center has maintained a strong relationship with the Detroit Area Pre-College Engineering Program (DAPCEP). During spring 2010, we once again hosted DAPCEP middle school students in the WIMS SuperStar Challenge Program, with financial support from the Electrical Engineering and Computer Science (EECS) Department at the University of Michigan. This year saw broader student composition than in the past, as DAPCEP began drawing students from a much wider range of pre-college schools, including private, religious, and charter schools, in addition to public schools.

Program assistant helps DAPCEP students work on their projects.

The Challenge Program offers a spectrum of engaging experiences for these motivated youngsters. For example, the students observe technology demonstrations, learn scientific principles, conduct experiments, build and program LEGO Mindstorm® robots, and rotate through interactive activities. Moreover, the Challenge Program uses team-based learning, complemented by individualized mentoring from WIMS graduate students. Throughout the program, the mentors emphasize the many biomedical and environmental applications for WIMS.

The Challenge Program takes place on consecutive Saturdays during the school year, so this demands a special "after-school" commitment from participants; in turn, the program rewards them with experiences they could not receive elsewhere, and not during regular school hours.

Two of the highlights of this year's program include the following: Our newest facility, the Lurie Nanofabrication Facility (LNF), served as the ideal location for hands-on learning in wafer design and nanotechnology. Also, the students combined lessons in logic programming and microprobe design to create a microprobe incorporating a two-to-four decoder, and they constructed and tested this also.

Building upon four years' experience as a program assistant and mentor, Michael Logue was this year's program coordinator. Michael is an EECS graduate student. He worked under the guidance of the SSCP faculty advisor, WIMS Education Director Leo McAfee. Special acknowledgement needs to be given to U-M's Biomedical Engineering Department, which contributed two mentors, specifically a post-doc and a graduate student. ■

Industrial Liaison's Report

We are in the midst of preparing for the final NSF Site Visit and our celebration as a graduating ERC. This offers an excellent opportunity to reflect on what we have accomplished during the past ten years. The ERC has created eleven startup companies. Two companies have been acquired and the remaining nine continue to prosper. This is quite an accomplishment at any time; however, during these particularly challenging times it is extraordinary. The ERC has provided a large infrastructure of equipment and process capability that has allowed our members to explore new systems faster and at a lower cost than they could have individually. We have assisted its member companies in developing new products and in exploring new avenues for products. The ERC also has had an impact on the State of Michigan estimated at over $400 Million. While it is useful to reflect on our past accomplishments, they are really only a launching platform for what we will accomplish as we move forward.

WIMS researchers will continue to combine micropower circuits, sensors, wireless interfaces, power sources, packaging, and nanostructures to critical national needs. The expanded Lurie Nanofabrication Facility ensures that the latest facilities will be available to WIMS faculty and member companies. WIMS will continue to drive advances in health care, environmental protection, national infrastructure, and other areas that will change the way we live and improve our quality of life. Our students will continue to provide the drive to create new companies that commercialize WIMS research. Member companies will continue to get an inside look at our intellectual property and an opportunity to interact with students. In our new form, we will continue to provide a forum for precompetitive engagement between diverse companies, and we will look for companies to provide us with performance targets, production requirements, and market insights. The ability to have a retrospective has made clear that the future is even brighter than the past. I invite you to join us as we move forward.

As always, please visit the Center when in the Ann Arbor area, so we can share our latest technical results and give you a tour of our Lurie Nanofabrication Facility.

If you, or one of your colleagues, is interested in giving a seminar, please contact me to schedule a date at (734) 615-3096 or giachino@eecs.umich.edu. ■

Joseph M. Giachino
Associate Director, Industry

Presentations and Publications

Conference Presentations/Papers

IEEE International Conference on Micro Electro Mechanical Systems (MEMS), Hong Kong, China, January 2010

A. T. Evans, S. Chiravuri, and Y. B. Gianchandani, "A Piezoelectric Valve Manifold With Embedded Sensors for Multi-Drug Delivery Protocols," pp. 1027–1030.

T. Galchev, E. Aktakka, H. Kim, and K. Najafi, "A Piezoelectric Frequency-Increased Power Generator for Scavenging Low-Frequency Ambient Vibration," pp. 1203–1206.

N. K. Gupta and Y. B. Gianchandani, "A High-Flow Knudsen Pump Using a Polymer Membrane: Performance At and Below Atmospheric Pressure," pp. 1095–1098.

A. C. Johnson and K. D. Wise, "A Robust Batch-Fabricated High-Density Cochlear Electrode Array," pp. 1007–1010.

S.-J. Kim, S. M. Reidy, B. P. Block, E. T. Zellers, K. D. Wise, and K. Kurabayashi, "A Miniaturized Robust High-Speed Thermal Modulator for Comprehensive 2-D Gas Chromatography," pp. 124–127.

T. Li and Y. B. Gianchandani, "A High-Speed Batch-Mode Ultrasonic Machining Technology for Multi-Level Quartz Crystal Microstructures," pp. 348–401.

M. Sadeghi, H. Kim, and K. Najafi, "Electrostatically Driven Micro-Hydraulic Actuator Arrays," pp. 15–18.

K. Visvanathan and Y. B. Gianchandani, "Biopsy Needle Tract Cauterization Using an Embedded Array of Piezoceramic Microheaters," pp. 987–1000.

SPIE Photonics West, MOEMS-MEMS Conference, San Francisco, CA, January 2010

Y. B. Gianchandani, "Emerging Challenges in Micro and Nano Systems: Opportunities and Challenges for Societal Impact," (invited plenary), paper no. 7593–201, pp. 1–8.

Midwinter Meeting of the Association for Research in Otolaryngology, Anaheim, CA, February 2010

S. Dehmel, Sr. M. E. Merriam, O. Srivannavit, S. Koehler, K. D. Wise, and S. E. Shore, "Exploring Multisensory Integration Using a Three-Dimensional Silicon Microelectrode Array for Simultaneous Ventral and Dorsal Cochlear Nucleus Recording and Stimulation."

Proc. SPIE Smart Structures and Materials Conference, San Diego, CA, March 2010

M. Kurata, J. P. Lynch, T. Galchev, M. P. Flynn, P. Hipley, V. Jacob, G. van der Linden, A. Mortazawi, K. Najafi, R. L. Peterson, L.-H. Sheng, D. Sylvester, and E. Thometz, "A Two-Tiered Self-Powered Wireless Monitoring System Architecture for Bridge Health Management," vol. 7649, p. 76490K.

Journal Articles

A. Basu and Y. B. Gianchandani, "Doublet Stirring of Aqueous Samples Using Microfabricated Thermal Probes," *Sensors and Actuators A: Physical*, 158(1), pp. 116–120, March 2010.

J. Cho and E. Yoon, "Design and Fabrication of a Single Membrane Push-Pull SPDT RF MEMS Switch Operated by Electromagnetic Actuation and Electrostatic Hold," *Journal of Micromechanics and Microengineering*, 20, p. 035028, March 2010.

A. T. Evans, S. Chiravuri, and Y. B. Gianchandani, "A Low Power Microvalve Regulated Architecture for Drug Delivery Systems," *Biomedical Microdevices, Springer*, 12(1), pp. 159–168, February 2010.

S. Green, R. Kwon, G. Elta, and Y. B. Gianchandani, "*In Situ* and *Ex Vivo* Evaluation of a Wireless Magnetoelastic Biliary Stent Monitoring System," *Biomedical Microdevices*, 12(3), pp. 477–484, online February 2010, DOI 10.1007/s10544-010-9404-7.

M. Richardson and Y. B. Gianchandani, "Wireless Monitoring of Workpiece Material Transitions and Debris Accumulation in Micro-Electro-Discharge Machining," *IEEE/ASME J. Microelectromechanical Systems*, 19(1), pp. 48–54, February 2010.

W. Zhu, M. J. White, G. F. Nellis, S. A. Klein, and Y. B. Gianchandani, "A Si/Glass Bulk Micromachined Cryogenic Heat Exchanger for High Heat Loads: Fabrication, Test and Application Results," *IEEE/ASME J. Microelectromechanical Systems*, 19(1), pp. 38–47, February 2010.

Doctoral Dissertations

Robert K. Franklin, "*In Vivo* Electrochemical Sensors"
University of Michigan, 2010
Postgraduate Position: Blackrock Microsystems, Salt Lake City, UT
Advisor: Professor Richard B. Brown

Sister Mary Elizabeth Merriam, "*A Three-Dimensional Bidirectional Interface for Neural Mapping Studies*"
University of Michigan, 2010
Postgraduate Position: Science Teacher, St. Dominic Savio Catholic High School, Austin, TX
Advisor: Professor Kensall D. Wise

Mikhail Pinelis, "A High-Throughput Method for *In Vitro* Generation and Studies of Oxygen Microgradients"
University of Michigan, 2010
Postgraduate Position: President and CEO, MEMS Investor Journal, Inc., Oak Park, MI
Co-Advisors: Professors Michel M. Maharbiz and Kensall D. Wise

Andrew T. Zimmerman, "802.15.4 MAC Layer Standards and Network Layer Implementation on Narada Boards"
University of Michigan, 2010
Postgraduate Position: Postdoctoral Research Fellow, Department of Civil and Environmental Engineering, University of Michigan, Ann Arbor, MI
President and CEO, Civionics, LLC, Ann Arbor, MI
Advisor: Professor Jerome P. Lynch

Daw Don Cheam, "Integration of Room Temperature Single Electron Transistor With CMOS Subsystem"
Michigan Technological University, 2009
Postgraduate Position: Research Assistant Professor, Michigan Technological University, Houghton, MI
Advisor: Professor Paul L. Bergstrom

Seminar Series

*** February 16, 2010**
Gregory Chen
Graduate Student, EECS, University of Michigan
"Millimeter-Scale Nearly Perpetual Sensor System With Stacked Battery and Solar Cells"

Razi ul-Haque
Graduate Student, EECS, University of Michigan
"An Implantable Microsystem for Intraocular Pressure Measurement"

*** February 23, 2010**
Eric Pop
Assistant Professor, Electrical and Computer Engineering, University of Illinois, Urbana-Champaign
"Carbon Nanoelectronics: Towards Energy-Efficient Computing"

*** March 3, 2010**
Paddy French
Professor, Electrical Engineering, Mathematics, and Computer Science, Delft University of Technology
"TU Delft: 40 Years of Sensor Development"

*** March 30, 2010**
Tim Denison, Ph.D.
Technical Fellow, Medtronic Corporation, Novi, MI
"Architecting Therapeutic Interface Circuits and Algorithms for the Nervous System"

*** April 7, 2010**
Rhonda R. Franklin
Associate Professor, University of Minnesota, Department of Electrical and Computer Engineering
"Ultrabroadband Integration Techniques for the Advancement of Complex Integrated System Design"

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