Summer 2008

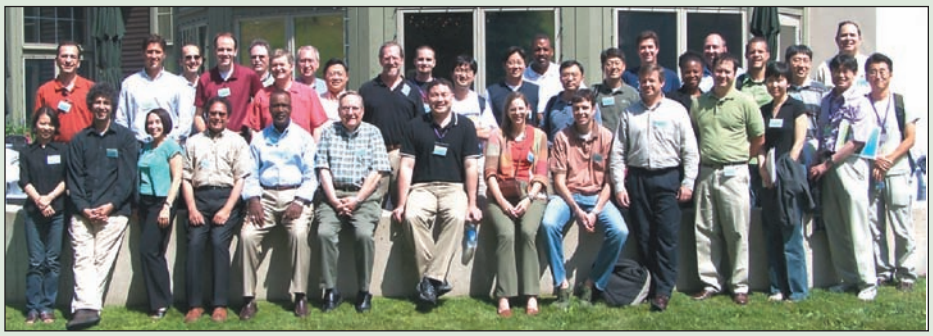
WIMS WORLD

Director's Message

Summer was a busy time here, and the single event that stands out the most was the WIMS Retreat ("Defining the Future") that was held in July. Now I confess I'm not sure why these things are called "retreats." Rather, we were trying to define how best to advance, taking the WIMS ERC to new heights after the cessation of National Science Foundation support in 2010. That funding started to taper off this September, putting a dent in our annual research budget that we clearly need to fill, but just filling it isn't adequate either. We need to find a way to go further, increasing our impact on the University and the nation.

In order to define how best to do that, we gathered together forty faculty and industrial personnel at the Crystal Mountain Resort up in northern Michigan for three days of talks, breakout sessions, and brainstorming. About half of the attendees had not previously been associated with WIMS and represented the University of Michigan's College of Engineering, School of Medicine, School of Public Health, and School of Literature, Science, and the Arts. They presented 14 of the 17 talks, exploring microsystem applications that ranged from smart farming and wearable/implantable health monitors to energy production and small low-power instruments for planetary probes. It was exciting to see the enthusiasm of these speakers for WIMS and learn more about their areas. There was strong support for continuing the WIMS ERC as an endowed institute, centered in the College of Engineering but spanning the University and beyond. Emerging applications and the organizational form such an institute should take were examined in five parallel breakout sessions focusing on materials and nanotechnology, opportunities in biomedicine, environmental applications, microsystems for energy production, and university-industry partnerships.

The industrial breakout group suggested an exciting new three-tiered partnership structure that is being explored further. There was strong support for continuing the present testbeds (neural interfaces and μGC-based environmental monitors), as well as for expanding into new areas. Many of the breakout groups, with participants representing the microsystem user community, stressed the need to field prototypes for use in addition to continuing to develop smaller, lower-power devices. Microsystems, even at their present stage, could revolutionize many areas, with prototype demonstrations leading to industrial products having impact on a global basis. While important breakthroughs can be expected in the continued development of microsystems, still others will be possible through their application. They also felt that the primary emphasis should remain at the micro level, using nanotechnology as it becomes available. One group suggested that "nano is useless without a micro connection, and micro needs to connect to macro," and while the former may not be true in all contexts, it does make an important point. Contributions ranging from carbon nanotubes to ultra-wideband communications, sensor networking, and adaptive decision making within complex systems will all play important roles in solving the difficult problems that confront us in health care, security, infrastructure, energy, and the environment. And one of the real attractions of microsystems is that its core technologies can be applied in all of these areas.



The participants in the WIMS Retreat "Defining the Future," July 2008.

The Retreat was very valuable in defining the appropriate role and form of a WIMS Institute. Such an Institute could play an important role in expanding collaborations in WIMS technology and its applications, but it will need endowed support from which to seed work in emerging areas and underpin the staff needed to continue outreach activities and work on system integration. Through such an Institute, we hope to energize groups extending far beyond the University to solve problems of national and global importance. ■

Ken D. Wise

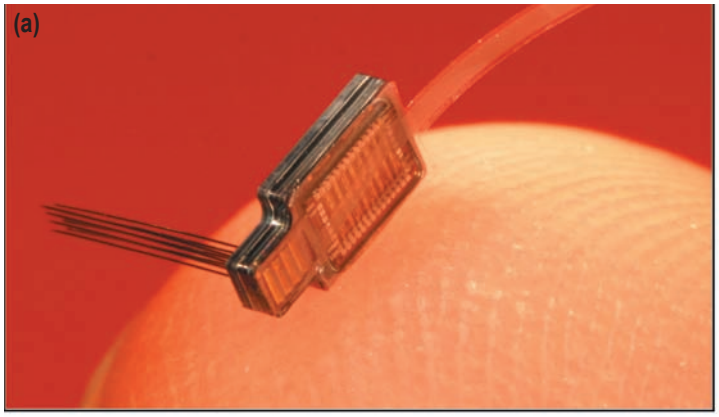
Director, Engineering Research Center for
Wireless Integrated MicroSystems

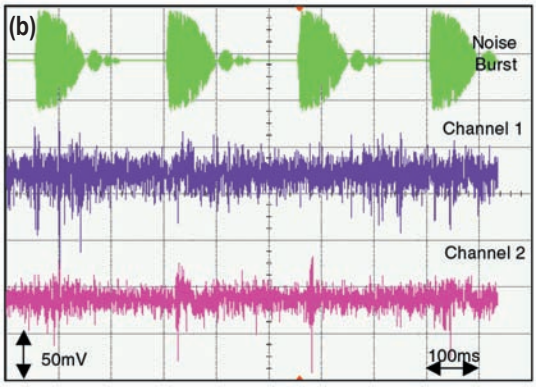
Research Highlights

Single-Unit Recording With a Low-Rise Active Microelectrode Array

Gayatri E. Perlin and Kensall D. Wise

A key challenge in realizing implantable multi-electrode microsystems for neural interface applications is the integration of the front-end electrodes with their interface circuitry. A low profile is important to allow the dura to be replaced over the implant, decoupling it from the skull and allowing it to move with the brain. A new approach to array formation uses a parylene overlay cable to connect a 3-D microelectrode array to a custom-designed signal conditioning chip and thence to the external world. Interconnect area is virtually eliminated, and the height of the array above the cortex is limited to one wafer thickness. A 64-site, 16-shank, 3-D array is shown (a), interfaced to a 16-amplifier circuit chip providing a per-channel gain of 1000 and a bandwidth from 100Hz to 9kHz. The chip was realized in 0.5μm CMOS. Neural activity recorded from a guinea pig inferior colliculus is also shown (b). The activity from two different sites is shown in response to an acoustic noise burst (an 80dB log up-sweep from 500Hz to 16kHz with a duration of 164msec). This is the most compact recording array ever reported and will be the basis for neural mapping studies underway in the WIMS ERC. ■





(a) New 64-site, 16-shank, 3-D electrode array on a fingertip. Sites are on 200μm centers. (b) Single-unit driven neural activity recorded in guinea pig inferior colliculus. Integrated amplifiers provide a band-limited gain of 1000x.

A Micro Thermoelectric Energy Scavenger for Microsystems

Niloufar Ghafouri, Hanseup Kim, Massood Z. Atashbar, and Khalil Najafi

The use of microsystems for many emerging wireless sensing applications has increased the demand for on-site, small-volume, and replacement-free energy sources as opposed to conventional batteries. On-site energy scavenging from various environmental sources including ambient heat, solar energy, and vibration has been introduced as efficient and promising approaches. This work focuses on the use of body heat generated by beetles as an energy source. The goal of this project is to develop a micro thermoelectric generator (TEG) with the area of approximately 1cm^2 that is capable of generating 20–50μW/cm^2/°C from a beetle's body heat. Flying insects can increase their body temperature by as much as 10°C during flight.

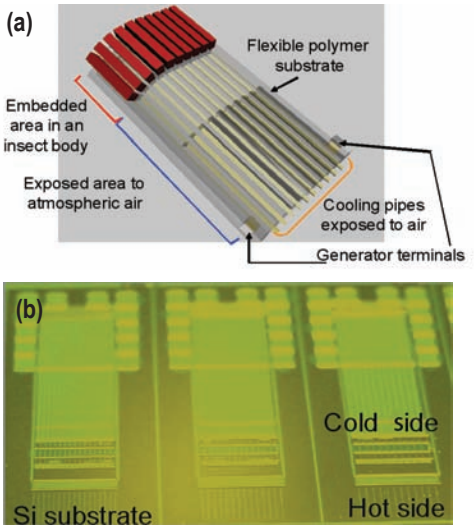


Figure 1 – (a) Illustration of an implantable micro-TEG. (b) Fabricated device on Si substrate.

Bulk bismuth telluride and antimony telluride have been chosen as thermoelectric materials due to their good thermoelectric properties. A micro-TEG composed of multiple thermocouples with an embedded area of 2 X 4mm^2 and exposed area of 6 X 4mm^2 is shown in Figure 1. After releasing the device from the support wafer (Figure 2), the exposed area, including heat pipes, integrated thermistors and terminal pads, is flexible. The micro-TEG has achieved generated power density of 10μW/cm^2 at 11°C temperature difference. This device has demonstrated power generation capability at the maximum temperature difference produced during the beetle's flight. ■

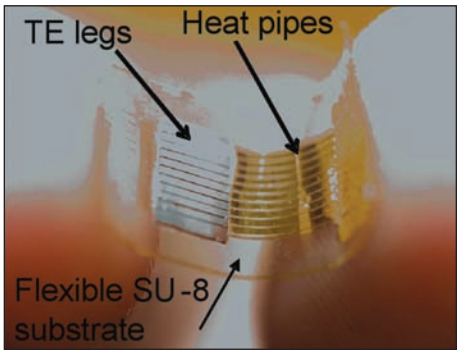


Figure 2 – Flexibility of the fabricated micro-TEG.

'Nano Nano': Exploiting Electron-Beam Lithography for Chemical Detection

Elizabeth Covington, Forest Bohrer, Çagliyan Kurdak, and Edward T. Zellers

Applying nano-scaled materials and technologies to microsystems has been a primary theme of the research conducted in the WIMS Center since its inception. Nowhere is this more clearly illustrated than in the chemiresistor (CR) arrays we have developed for the WIMS μGC detector. In the latest advancement, we have employed electron-beam lithography to create interdigital electrodes (IDE) with individual Au/Cr fingers and spaces measuring just 300nm in width (~8μm in length). Each IDE occupies 100μm^2, and an array of four such devices occupies only ~600μm^2 (see Figure 1). A set of thin films, each with a different chemical sensitivity, is required to achieve sensitive and selective vapor detection. The challenge was then to deposit the different chemically sensitive thiolate-monolayer protected gold nanoparticles (MPN) interface films, on each individual device. To solve this problem we turned again to electron-beam irradiation in order to crosslink the MPN films. By carefully controlling the radiation dose it was possible to render the films insoluble while still retaining their responsiveness to volatile organic compounds. Iterative deposition of an MPN film, irradiation of the region over one IDE, and rinsing the unexposed soluble residue produced a functional array with a different cross-linked MPN film on each device. Exposure to test atmospheres of toluene, n-propanol, and n-octane vapor gave unique sensitivity patterns (Figure 2) and verified the success of the technique. This is the smallest CR array ever produced. It is being incorporated into WIMS μGC prototypes intended for use as pocket-size microsystems for monitoring human exposures to air pollutants. ■

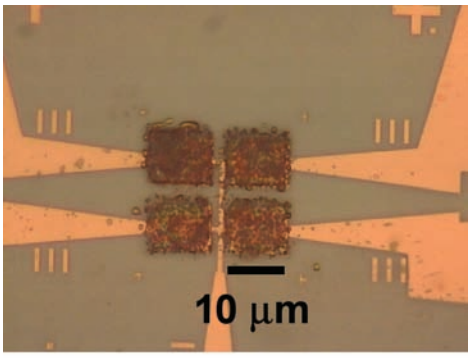


Figure 1 – SEM of crosslinked CR nanoarray.

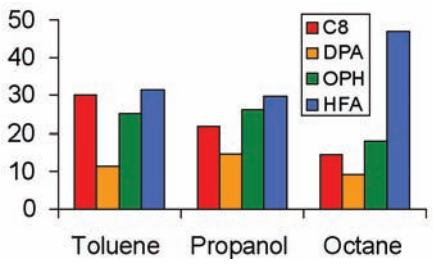


Figure 2 – Crosslinked nanoarray sensitivities.

Making Bridges "Smarter": Wireless Sensors Activated on Yeondae Bridge in Korea

Junhee Kim, Andrew Swartz, Andrew Zimmerman, and Jerome P. Lynch

The *Narada* wireless sensor platform has been under development at the WIMS Center since 2005. *Narada* is designed for field deployment in large-scale infrastructure systems where long communication range, power efficiency, and reliability are all necessities. This past summer, the platform was field tested on the Yeondae Bridge, located in Icheon, Korea (Figure 1). A dense network of 60 wireless sensors was installed on the bridge along with MEMS-based accelerometers. The sensors were installed on the bridge deck to measure its vertical acceleration upon traffic loading. One week of testing produced a substantial amount of high-quality data (Figure 2). In addition, data interrogation algorithms embedded within the computing cores of the *Narada* wireless sensors were tested. Specifically, embedded modal analysis software was executed to determine the vibration characteristics of the bridge. Accurate mode shapes and modal frequencies were autonomously identified by the wireless monitoring system. Future field testing is planned with the Korea Expressway Corporation, where the *Narada* wireless sensors will be placed permanently on several bridges in Korea. ■

Figure 1 – Yeondae Bridge in Korea.

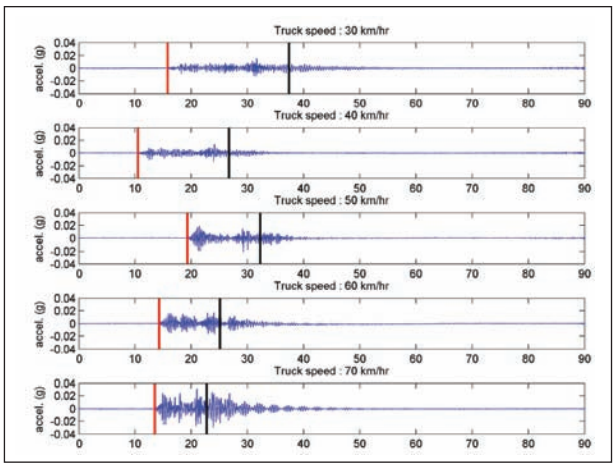


Figure 2 – Wireless sensor response data collected during a truck's passage over the bridge at five different speeds.

Multivariate Curve Resolution Enhances the Capabilities of the WIMS μGC

Chunguang Jin and Edward T. Zellers

The analysis of complex mixtures of volatile organic compounds (VOC) by a micro gas chromatograph (μGC) that uses a μ-sensor array detector can be greatly enhanced by the application of advanced chemometrics. For example, high-speed operation μGC having the design shown conceptually in Figure 1 can result in certain mixture components being only partially time-resolved by the μ-column. Composite peaks consisting of two or more components can appear as either a single, larger peak, or a "doublet" (see Figure 2, for example, which represents the output obtained from one sensor in the array). In such cases, multivariate curve resolution (MCR) methods are required to deconvolute the overlapping signals. In the first known application of MCR to μGC separations, we developed and implemented a novel hybrid algorithm that combines evolving factor analysis with alternating least squares regression (EFA-ALS). Using experimental data from a nano-particle-coated chemiresistor (CR) array detector, estimates of the number of components in composite peaks as well as the elution profiles and response patterns of those components were readily derived via EFA-ALS without any prior knowledge of the peak composition. The 4-sensor CR array employed in this study produces data matrices of relatively low dimension compared to conventional bench-scale spectrometric GC detectors. Yet, in simulations that probed performance as a function of several relevant variables (i.e., pattern similarity, chromatographic separation, signal-to-noise ratio, and relative composition), the results indicate this small array performs remarkably well. This bodes well for achieving highly accurate μGC determinations of VOC mixtures in applications such as environmental monitoring, homeland security, and biomarker detection. ■

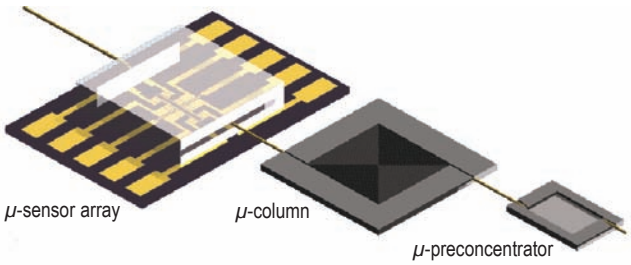


Figure 1 – Conceptual design of a high-speed μGC.

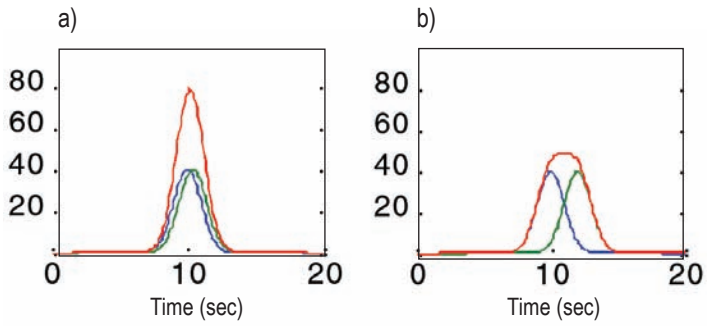


Figure 2 – Composite peaks of two components: a) Single, large peak and b) Double peak. Both can be resolved by multivariate curve resolution.

Recent Events

Detroit Area Precollege Students Experience WIMS Activities

Over recent years, the annual Detroit Area Precollege Engineering Program (DAPCEP) has become a favorite WIMS ERC tradition. DAPCEP is an educational program designed to raise interest in engineering, science, technology, and mathematics among middle-school students in the greater Detroit area. During the program, students visit the U-M campus on four or five Saturdays and participate in various learning activities, such as seminars and lectures provided by WIMS ERC faculty members. They also tour the Robert H. Lurie Nanofabrication Facility (LNF), and engage in interactive sessions mentored by WIMS ERC students. During the sessions, the students work with WIMS ERC mentors to solve various real-life engineering problems while employing software programming, mathematics, robotics, and team work. The relatively young DAPCEP program is already starting to pay off: some of the first-year graduates of DAPCEP returned this past year—as mentors! ■

WIMS ERC student Mahdi Sadeghi helps DAPCEP students design a programmable robot.

WIMS ERC Director Ken Wise lectures on MEMS technology.

Education Highlights

MSU Education and Outreach Programs: Creative, Challenging, and Continually Changing

Michigan State University (MSU) has developed and promotes a number of successful and expanding WIMS-based educational initiatives. As individual initiatives have been offered in successive years, participant enrollment has increased, and the specific programs and activities that compose each initiative have evolved as well. For example, this past summer, the LEGO Robotics to WIMS program attracted 32 participants, representing a 33% increase from the prior year. This program is aimed at the youngest children to be addressed by any of these outreach activities, primarily 9 and 14 year olds. High school students, nonetheless, have a place in this program also, as teaching assitants, thereby utilizing their continued enthusiasm. Thus, this program effectively embraces and excites two age groups. Similarly, graduates of the LEGO® Robotics to WIMS program are instrumental in

Motorola funded WIMS for Teens program at the Formula SAE team presentation.

teaching a new crop of students in a separate program, the NXT Robot. This innovative program was offered as an elective in conjunction with the comprehensive Grandparents University (GU), and it boasted 68 participants in its recent iteration, split over three sessions. The participants for this program is particularly noteworthy: school-age girls and their grandmothers, with nearly equal numbers of each. As just one of many electives that the intergenerational learning pairs can select while attending GU, the NXT Robot was the most popular of all the choices, and the local media concentrated its coverage on the NXT Robot program's two sub-components: building and programming.

Perhaps the flagship of all the initiatives, however, is MSU's WIMS for Teens residential program. With a recently awarded Motorola Foundation grant, this program has doubled its participation from last year—increasing enrollment to 50 students from 25—and has expanded from a 1-week affair to a full 2 weeks. This residential program has recruited talented middle school students in the past, and this past year was no exception, with 51% female, 65% from underrepresented groups, and 20% from out-of-state. Over 30 engineering faculty members contributed in some way to the program, which has been proven to enhance the participants' capabilities and interest in science, technology, engineering, and math (STEM). Student residents are taught with hands-on materials, and they produce professional-quality posters by the end of the summer session. Lastly, for slightly older students, the Women in Engineering (WIE) program helps steer females toward STEM as they prepare to apply for and attend college. In particular, the program incorporates one-on-one, pre-college planning with the WIMS ERC's Drew Kim. As with other MSU programs, the WIE program saw a big jump in participation recently, to 31 students, with 58% of participants from underrepresented groups. In sum, the MSU outreach-educational activities are continually improving; growing; and receiving praise, funding, and recognition from the community. ■

Personnel Focus

David Wentzloff received the B.S.E. degree in electrical engineering from the University of Michigan, Ann Arbor, in 1999, and the S.M. (2002) and Ph.D. (2007) degrees in electrical engineering from the Massachusetts Institute of Technology, Cambridge. In the summer of 2004, he worked for Intel's Portland Technology Development group in Hillsboro, Oregon. He joined the faculty at the University of Michigan in 2007, and he is currently an Assistant Professor in the Department of Electrical Engineering and Computer Science.

Professor Wentzloff recently joined the Center under the Micropower Circuits Thrust. His research group is working as a part of the WISP project in collaboration with Professors Sylvester and Blaauw. This is an on-going project to develop a 1mm^3 sensor node capable of energy storage, sensing, processing, and wireless communication. His group's focus is on the energy processing and wireless interface of the WISP sensor nodes. They are developing energy-efficient wireless links incorporating integrated antennas that conform to the strict volume requirements. The use of wireless communication among energy-constrained sensor nodes must be minimized to conserve energy; therefore, communication radios must be turned off most of the time. In order to synchronize communication among these nodes, Professor Wentzloff's group is also developing ultra-low-power wakeup radios that rely on existing wireless infrastructure to recover timing information. These wakeup radios will achieve synchronization by leveraging existing signals from prolific sources such as cellular phone base stations or WiFi hot spots.

Other research activities on-going in Professor Wentzloff's group include oscillator-based analog circuits synthesized from standard digital CMOS libraries, and wireless chip-chip communication through stacked die for system-in-package. Professor Wentzloff has taught a senior-level analog integrated circuits class and a graduate-level RF integrated circuits class. He is currently teaching a junior-level analog circuits class. He is also serving on the technical program committee for the International Conference on Ultra Wideband 2008–2009. ■

Faculty/Student Awards

Nayda Santiago Receives HENAAC Award 2008

For twenty years, the Hispanic Engineer National Achievement Awards Corporation (HENAAC) has recognized the achievements of America's best and brightest engineers and scientists within the Hispanic community. The 2008 Award Winners in Science, Technology, Engineering, and Mathematics were selected by the HENAAC Selection Committee comprising representatives from industry, government, military, and academic institutions. The Selection Committee convened in Houston, Texas, on July 18, 2008, and was chaired by Dr. Sallie Keller-McNulty, Dean of the George R. Brown School of Engineering at Rice University, HENAAC's 2008 Conference Academic Host. WIMS ERC Professor Nayda Santiago was one of the winners honored at the HENAAC Awards Show Gala on October 11, 2008, and throughout other events at the Hilton Americas Hotel in Houston, Texas, during the 20th Anniversary Career Conference & Awards Show, October 9–12, 2008. Professor Santiago is an Associate Professor in the Electrical and Computer Engineering Department, University of Puerto Rico at Mayagüez. ■

Nayda's acceptance speech.

Two WIMS Faculty Receive the Best Paper Awards at COMS 2008 Conference

COMS 2008 (Commercialization of Micro and Nano Systems Conference) is the world's most important meeting place for all those bringing emerging small technologies from concept to the marketplace. It addresses issues on an international front, gathering input from micro- and nano-technology leaders representing regions all over the globe. Dean Aslam received the Best Paper Award for innovations in education. Also, a paper on microsystems for energy scavenging and power generation from environmental sources was presented by a collaborative, inter-school group of students and faculty from the University of Michigan and Michigan Technological University. This paper won the Best Paper/Presentation Award. It is entitled "Micro Energy Scavengers," and the authors are E. Romero, M. Neuman, and R. Warrington from Michigan Tech; T. Galchev, E. Aktakka, N. Ghafouri, H. Kim, and K. Najafi from Michigan. COMS 2008 was held in Puerto Vallarta, Mexico, in September. ■

Industrial Liaison's Report

This summer, the WIMS ERC held a retreat to discuss how to continue moving forward in the coming years. Among the items addressed were broadening the application areas of our research making our technology transfer to industry even more efficient. These items are at the core of our mission to enable students, faculty, and industry to collaborate in solving challenging system problems. A key measure of our success is turning ERC research into successful products. Collaborative research provides an excellent way to apply the research, facilities, and expertise of the ERC to a company's specific needs. Collaborative research is also an excellent way to have our students understand a company and for a company to recruit graduates. The ERC has long recognized that technology transfer occurs with people, not through institutions. It is our goal to continue to foster interactions among our member companies' personnel, the ERC faculty, and the students. After all, the major contribution of the ERC to industry is the well-trained student.

In October of every year, the ERC makes available to our member companies the resumé of students seeking internships for the coming year, as well as those students who are seeking full-time employment. This allows member companies to attract people with exceptional technical backgrounds and common interests into difficult-to-fill positions. The Resident Engineer opportunity is another avenue where the ERC fosters collaboration. The Lurie Nanofabrication Facility permits the unique opportunity for industry and academia to work side-by-side and transfer technology in a very efficient manner.

At the retreat, which included industrial members as well as university personnel, we discussed ways to improve collaboration and technology transfer with members. The recommendations from the retreat were further discussed with our member companies at the Industrial Advisory Board meeting this fall. From these discussions we jointly developed a system that would allow both industry and the Center to move forward and continue to meet the goals of member companies, as well as the educational mission of the university.

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.

As always, please visit the Center when in the Ann Arbor area, so we can share our latest technical developments and have you tour our Lurie Nanofabrication Facility. ■

Joseph M. Giachino
Associate Director, Industry

Presentations and Publications

Conferences Presentations/Papers

IEEE International Symposium on Circuits and Systems (ISCAS), Seattle, WA, May 2008

Y. S. Lin, S. Hanson, F. Albano, C. Tokunaga, R. U. Haque, K. D. Wise, A. M. Sastry, D. Blaauw, and D. Sylvester, "Low-Voltage Circuit Design for Widespread Sensing Applications," pp. 2558–2561

D. Rairigh, A. Mason, M. P. Rowe, E. T. Zellers, "Baseline Resistance Cancellation Circuit for High Resolution Thiolate-Monolayer-Protected Gold Nanoparticle Vapor Sensor Arrays," pp. 2002–2005

ACM/IEEE International Symposium on Low Power Electronics and Design, Bangalore, India, August 2008

M. Seok, D. Sylvester, and D. Blaauw, "Optimal Technology Selection for Minimizing Energy and Variability in Low-Voltage Applications," pp. 9–14

Y-S. Lin and D. Sylvester, "Single Stage Level Shifter Design for Subthreshold to I/O Voltage Conversion," pp. 197–200

Proceedings IEEE International Conference of the Engineering in Medicine and Biology Society (EMBS), Vancouver, BC, August 2008

G. E. Perlin and K. D. Wise, "A Compact Architecture for Three-Dimensional Neural Microelectrode Arrays," pp. 5806–5809

G. E. Perlin, A. M. Sodagar, and K. D. Wise, "A Neural Amplifier With High Programmable Gain and Tunable Bandwidth," pp. 3154–3157

IEEE Custom Integrated Circuits Conference, San Jose, CA, September 2008

Y-S. Lin, D. Sylvester, and D. Blaauw, "An Ultra-Low Power 1V, 220nW Temperature Sensor for Passive Wireless Applications," pp. 507–510

M. Seok, S. Hanson, J-S. Seo, D. Sylvester, and D. Blaauw, "Robust Ultra-Low Voltage ROM Design," pp. 423–426

Quantitative Neuroscience Program, New Jersey Institute of Technology, Rutgers University, New Jersey Medical School, September 2008

K. D. Wise, "Toward Chronic Multi-Electrode Microsystems for Neuroscience and Advanced Neural Prostheses"

NSF/IMEC Workshop on Micro/Nanoelectronics: Devices and Technologies for Biomedical Applications, Leuven, Belgium, September 2008

K. D. Wise, "Wireless Implantable Microsystems: Toward Submillimeter Devices for Improved Health Care"

Proceedings, 22nd International Conference on Solid-State Sensors and Actuators, EUROSENSORS (EUROSENSORS 2008), Dresden, Germany, September 2008

D. Egert, H. Kim, and K. Najafi, "Characterization of Parylene Bonding for Vacuum Packaging"

IEEE European Solid-State Circuits Conference, Edinburgh, Scotland, September 2008

Y. Lee, M. Seok, S. Hanson, D. Blaauw, and D. Sylvester, "Standby Power Reduction Techniques for Ultra-Low Power Processors," pp. 186–189

Electronic Proceedings of the 2008 International Conference on Commercialization of Micro and Nano Systems (COMS 2008), Puerto Vallarta, Mexico, September 2008

D. M. Aslam, Z. Cao, and C. Rostamzadeh, "Hands-On Micro and Nano Learning Modules Using Programmable LEGO® Robotic Van de Graaf Generators and Their Commercialization," Best Paper Award

H-Y Chan, D. Aslam, S. Hatch, J. Wiler, and B. Casey, "*In-Vitro* and *In-Vivo* Neural Recordings Using Diamond Neural Probes"

E. Romero, T. Galchev, E. Aktakka, N. Ghafouri, H. Kim, M. Neuman, K. Najafi, and R.Warrington, "Micro Energy Scavengers," Best Paper/ Presentation Award

Global Management of Technology Conference 2008, Seoul, Korea, September 2008

Richard B. Brown, "Silicon Electrochemical Neurosensors," slides pp. 189–210

Korea Technology Industry Co., Technology Research Center, Seoul, Korea, September 2008

Richard B. Brown, "Silicon Electrochemical Neurosensors"

Journal Articles

S. Dehmel, Y. Cui, and S. E. Shore, "Cross-Modal Interactions of Auditory and Somatic Inputs in the Brainstem and Midbrain and Their Imbalance in Tinnitus and Deafness," *American Journal of Audiology*, In Press, 2008.

A. M. Kamboh, A. Mason, K. G. Oweiss, "Analysis of Lifting and B-Spline DWT Implementations for Implantable Neuroprosthetics," *Journal of Signal Processing Systems*, vol. 52, no. 3, pp. 249–261, September 2008.

M. D. Johnson, R. K. Franklin, M. D. Gibson, R. B. Brown, and D. R. Kipke, "Implantable Microelectrode Arrays for Simultaneous Electrophysiological and Neurochemical Recordings," *Journal of Neuroscience Methods*, vol. 174, pp. 62–70, September 2008.

B. Mitra, B. Levey, and Y. B. Gianchandani, "Hybrid Arc/Glow Microdischarges at Atmospheric Pressure and Their Use in Portable Systems for Liquid and Gas Sensing," *IEEE Transactions on Plasma Science*, vol. 34, (6), part 5, pp. 1913–1924, August 2008.

B. Mitra and Y. B. Gianchandani, "The Detection of Chemical Vapors in Air Using Optical Emission Spectroscopy of Pulsed Microdischarges From Two- and Three-Electrode Microstructures," *IEEE Sensors Journal*, vol. 8 (8), pp. 1445–1454, August 2008.

B. E. Pfingst, "Frontiers of Auditory Prosthesis Research: Implications for Clinical Practice," *Hearing Research*, vol. 242, pp. 1–208, August 2008.

J. Wang and K. D. Wise, "A Hybrid Electrode Array With Built-In Position Sensors for an Implantable MEMS-Based Cochlear Prosthesis," *IEEE/ASME Journal of Microelectromechanical Systems (JMEMS)*, vol. 17 (5), pp. 1187–1194, October 2008.

K. D. Wise, A. M. Sodagar, Y. Yao, M. N. Gulari, G. E. Perlin, and K. Najafi, "Microelectrodes, Microelectronics, and Implantable Neural Microsystems," *Proceedings of the IEEE, Special Issue on Implantable Biomimetic Microelectronic Systems*, vol. 96 (7), pp. 1184–1202, July 2008.

K. D. Wise, P. T. Bhatti, J. Wang, and C. R. Friedrich, "High-Density Cochlear Implants With Position Sensing and Control," (Invited), *Hearing Research, Special Issue on Auditory Prostheses*, vol. 242, (1–2), pp. 22–30, August 2008.

Doctoral Dissertations

Ruba Talal Borno, "Transpiration as a Mechanism for Mechanical and Electrical Energy Conversion"
University of Michigan, 2008
Postgraduate Position: Consultant, Boston Consulting Group (BCG), Detroit, Michigan
Advisor: Professor Michel M. Maharbiz

Chunguang Jin, "Chemometric Methods for the Determination of Volatile Organic Compounds With Microsensor Arrays"
University of Michigan, 2008
Advisor: Professor Edward T. Zellers

Yu-Shiang Lin, "Low Power Circuits for Miniature Sensor Systems"
University of Michigan, 2008
Postgraduate Position: Post Doctoral Engineer, IBM TJ Watson Research Center, New York
Advisor: Professor Dennis M. Sylvester

Gayatri Eadara Perlin, "A Fully-Implantable Integrated Front-End for Neural Recording Microsystems"
University of Michigan, 2008
Postgraduate Position: Postdoctoral Fellow, University of Michigan, Ann Arbor
Advisor: Professor Kensall D. Wise

Item of Interest

A special issue of the journal *Hearing Research* titled "Frontiers of Auditory Prosthesis Research: Implications for Clinical Practice," compiled and edited by Bryan E. Pfingst, was published in July 2008 (volume 242, issues 1–2). It features peer-reviewed articles about cutting-edge research on auditory prostheses including articles by WIMS ERC faculty Kensall D. Wise, David J. Anderson, Bryan E. Pfingst, and former graduate student, Dr. Hubert H. Lim, as well as several other articles featuring research using WIMS electrode arrays. Angelique Johnson, a current WIMS graduate student, helped to design the cover illustration, which features WIMS cochlear-implant electrode arrays shown on the background of a U.S. quarter depicting the image of Helen Keller. ■

Seminar Series

***September 16, 2008**
Joshua J. Whiting, Ph.D.
Senior Member of the Technical Staff, Sandia National Laboratories, Albuquerque, NM
"Recent Advances in Micro-Chem Lab Technology at Sandia National Laboratories"

***September 24, 2008**
Hongrui Jiang, Ph.D.
Assistant Professor, EECS Department, University of Wisconsin-Madison
"Controlled Microfluidic Interfaces for Microoptics and Microsensing"

**Available for viewing on Web site*

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