WIMS WORLD

University of Michigan • Michigan State University • Michigan Technological University

DIRECTOR'S MESSAGE

Last quarter we entered our fourth year as an Engineering Research Center (ERC), and somehow the ten-year life of the ERC looks shorter now than it did three years ago. The challenge then was to set up an organization and get it moving toward goals that frankly looked a long way off. While we expect the Center to continue well beyond its "graduation" as an active ERC, time is certainly flying, and we need to focus on accomplishing things of lasting value. In research, our goals are relatively clear, even if how to achieve them is sometimes not. In education, we need to focus on a few things that will have a positive impact on national needs. One thing is for sure—those needs are great.

In early November, the annual meeting of all ERCs was held in Washington, D.C. It was a great opportunity to meet with other centers. A major theme of the meeting was diversity, an increasingly important topic at the National Science Foundation and for us as a Center. We are indeed fortunate to be able to bring together so many talented individuals from so many different backgrounds. Our 44 faculty come from over 22 different departments across 7 universities, representing over a dozen different countries of birth. Our students, now more than 200 strong, come from over 20 different countries. Indeed, the WIMS ERC represents the world's best and brightest at all levels. We are working hard to attract more women and underrepresented minorities into the Center and have recently begun collaborations with a number of additional universities to further broaden an already very diverse population.

Microsystems, merging low-power microelectronics, wireless interfaces, MEMS, and advanced packaging are an increasingly central theme in microelectronics. Personal digital assistants (PDAs), cell phones, and similar products are already calculator-size and seem poised to become wristwatch-size within a few years. The WIMS ERC is playing a central role in this evolution, and the associated challenges are going to make for some exciting careers. But we don't do a good enough job publicizing the importance and excitement of what engineers do. The recent success of the Spirit Mars landing is a great example, and so are the neural prostheses and environmental monitors being developed here. We need to make it clear to our young people that there are many of these "grand challenges" and that they are the keys to solving many of the important problems confronting the twenty-first century.

We in the United States have maintained technological leadership during the past fifty years because we have had an outstanding university system that has attracted the best and brightest young people that the world has to offer. Most of these students have stayed here, enhancing our competitiveness and enriching our society. But they have also allowed us to ignore the alarmingly low participation of domestic students in engineering careers. As more and more attractive opportunities are found elsewhere, it is increasingly important that we make engineering more attractive to our youth. We must make better use of the tremendous diversity we have as a nation. The projects underway in the WIMS ERC are great examples to use in doing that, and if we can make an impact in this area through our initiatives in education, they are certain to be among our most important contributions.

WIMS for TEENS 2003—the engineers of tomorrow—on a field trip at the 4-H Children's Garden.

Ken D. Wise

Director, Engineering Research Center for
Wireless Integrated MicroSystems

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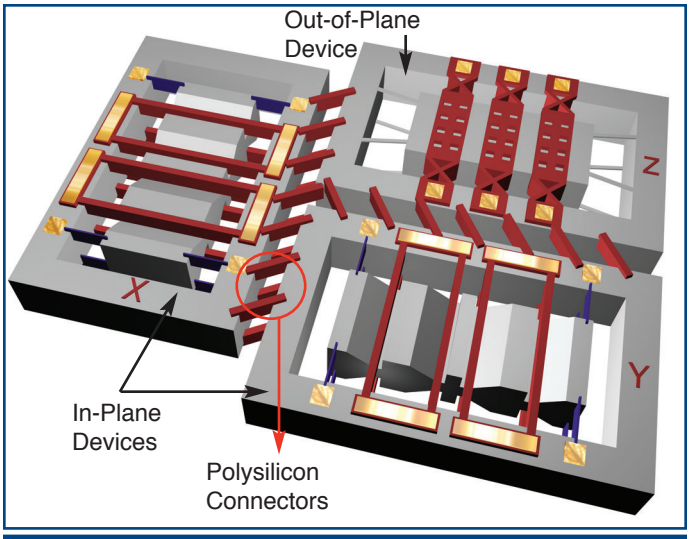
THREE-AXIS CAPACITIVE ACCELEROMETER PROVIDES TRUE MICRO-G PERFORMANCE

University of Michigan researchers have reported creating a monolithic three-axis capacitive accelerometer with a hybrid low-noise CMOS readout circuit providing true micro-g noise performance for all three axes. This mechanism was devised to meet the needs of many consumer applications, such as seismology, position sensing, and inertial navigation and guidance. Past high-performance capacitive accelerometers have achieved micro-g resolution, but only for a single-axis accelerometer. Many applications require a three-axis precision accelerometer system.

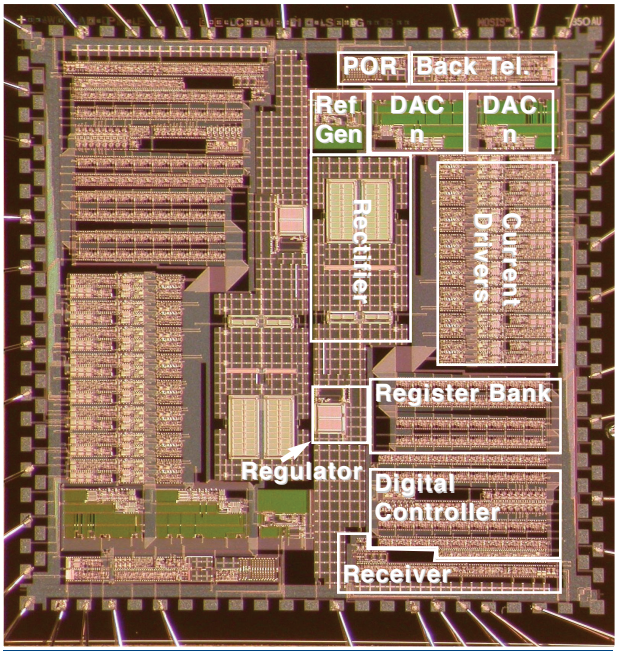
In-plane and out-of-plane capacitive silicon accelerometers with micro-g resolution both utilize combined surface- and bulk-micromachining technology and have an almost identical fabrication process. Thus, one out-of-plane and two in-plane accelerometers can be integrated on a single substrate, making a three-axis single chip silicon capacitive accelerometer with micro-g resolution.

The individual axes are mechanically connected by polysilicon connectors, which electrically isolate the three accelerometers to ensure crosstalk-free operation and microscale alignment accuracy. Because this three-axis chip utilizes combined surface- and bulk-micromachining technology, it has a large structural mass (a full wafer thick) and large-area electrodes with a small sensing gap, which produces high-sensitivity, low-noise accelerometers.

The size of the chip is 7 x 9mm^2, with greater than 5pF/g measured sensitivity and a sub-μg/√Hz mechanical noise floor for all three axes. The total measured noise floor of the accelerometer hybrid assembled with CMOS interface circuit is 1.60μg/√Hz for in-plane and 1.08μg/√Hz for out-of-plane devices.



A monolithic three-axis accelerometer consisting of three individual single-axis accelerometers. The three devices have full-wafer-thick proof-mass, large-area polysilicon sense/drive electrodes, and a small sensing gap formed by a sacrificial oxide layer.

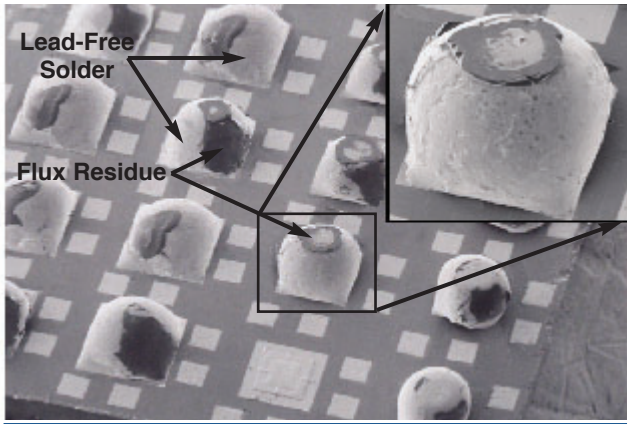


Interestim-2B: A modular 64-site wireless microstimulating ASIC, which receives power and stimulation data at 2/5Mbps using a 5/10MHz FSK carrier and generates up to 250mA stimulation pulses at 65.8kHz.

NEURAL STIMULATION MICROSYSTEM DEVELOPED FOR IMPLANTABLE PROSTHESES

A modular 64-site wireless interface chip has been developed for neural prosthesis applications. Implanted just below the skull, along with a high-density intracortical electrode array, the chip enables leadless operation of the resulting microsystem, accepting power and data from the outside world and inserting information into the nervous system in the form of stimulating currents. Such microsystems are the key to prostheses designed to alleviate disorders such as blindness, deafness, and severe epilepsy.

The chip receives inductive power and data at 2.5Mb/sec from a radio-frequency carrier that is frequency-shift keyed between 5 and 10MHz. Up to 32 such chips can be connected in parallel to drive multiprobe arrays of up to 2,048 sites. The 4mm x 4mm chip, fabricated in a 5V 1.5μm 2M/2P CMOS process, can generate up to 65.8K pulses per second. The only off-chip component required is the receiver inductive-capacitive (LC) tank. Implant size could be reduced further by using an integrated coil. Each chip contains 16 current sources, generating stimulus levels up to 250μA with 5b resolution and a dynamic range that extends to within 150mV of the 5V supply rail. The first implants with these chips are now underway.



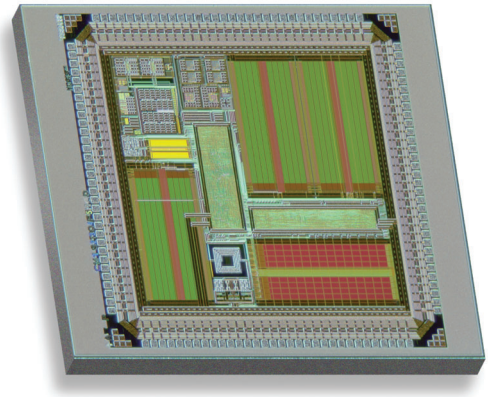
Nickel packages sealed with transferred solder balls. One package is left intentionally unsealed for comparison. The residual flux can be removed after transfer.

NEW TRANSFER METHOD OVERCOMES TRADITIONAL LIMITATIONS IN SEALING MEMS

A low-cost method for sealing MEMS/electronics packages has been developed at the University of Michigan. This technique allows solders capable of being vacuum sealed and MEMS to be fabricated on the same die. A reusable bulk-micromachined silicon wafer (mold wafer) is utilized for premolding lead-free solder balls and removing flux before transferring the solder to a host wafer. By defluxing the solder prior to transfer, the device can be integrated with vacuum-seal-capable, lead-free solders. The mold wafer controls the solder volume, minimizing waste and lowering cost. By using solder to seal MEMS devices, the package simultaneously forms an electrical interconnect structure. To test the effectiveness of the seal, Pirani gauges were enclosed in the solder balls. The packages maintained hermeticity during long term tests and also during accelerated thermal cycling and autoclave tests.

LATEST PROTOTYPE MAKING SIGNIFICANT STRIDES

In the process of developing a low-power microcontroller, the latest WIMS module has been produced with, after a year's work, a more intricate and functional digital core. Also different from previous versions, this chip contains clock frequency selection, which allows software to dynamically switch between frequencies ranging from 2kHz up to 66MHz, generated from a 132MHz reference supplied by the on-chip clock generator block. This clock has been tested on a separate die and has proven to be fully functional. A similar prototype has been deployed on the microcontroller and is functional as the sole clock for the system. The microcontroller contains a three-stage digital pipeline, a variety of input/output interfaces, and 64KB of low-power, on-chip SRAM for sensor data storage. A small, ultra-low power loop cache is managed by the WIMS compiler to reduce the power of commonly executed program loops. Notable analog peripheral blocks are a 14-bit, 900mV analog front end; a monolithic, on-chip CMOS-MEMS clock generator; and a differential potentiostat.



The latest prototype of the WIMS microcontroller containing a more intricate digital core.

PERSONNEL FOCUS

Michel M. Maharbiz, a new professor in the Electrical Engineering and Computer Science Department at the University of Michigan, has recently joined the WIMS ERC. He received his BS degree from Cornell University, Ithaca, NY, in 1997. Immediately following, he joined Professor Roger Howe's group in the Electrical Engineering and Computer Science Department at the University of California–Berkeley. He moved to Professor Jay Keasling's lab in the Chemical Engineering Department in 1999. From 1997 to 2000, Professor Maharbiz was an Intel Masters Fellow. He received the PhD degree in electrical engineering from the University of California–Berkeley in May 2003. His research interests include parallel assembly processes, microsystems for cell culture and biology, and bio-derived processing and fabrication. He is a member of the Institute of Electrical and Electronic Engineers and the American Chemical Society.

Also a new professor in the Electrical Engineering and Computer Science Department at the University of Michigan, **Ranjit Gharpurey** joined the WIMS team this fall. Professor Gharpurey received his bachelor of technology degree from the Indian Institute of Technology, located in Kharagpur, India, in 1990. In 1995 he received his PhD from the University of California–Berkeley in electrical engineering, where he studied modeling and analysis of substrate coupling for mixed-signal and radio-frequency (RF) integrated circuits. Until this last August, Gharpurey was a senior member of technical staff at Texas Instruments, Inc. His current research interests include RF and high-frequency analog design for wireless applications and studying spurious coupling mechanisms through substrates and packages that adversely impact the performance of highly integrated mixed-signal and RF circuits. He has published several journal and conference papers and co-authored a book in the area of substrate coupling analysis.

RECENT EVENTS

MICHIGAN'S COLLABORATION TEAM BEATS STIFF COMPETITION FOR NSF-FUNDED AWARD

Previously unprecedented, a 13 university team will create an integrated, nationwide, user-facility system allowing collaborations in nanoscience, engineering, and technology. WIMS Deputy Director Khalil Najafi will be heading the University of Michigan's contribution to this prestigous team. Michigan's efforts were heavily recuited for this position because of the quality of the Solid-State Electronics Laboratory. This collaboration will continue to enhance the quality of the laboratory, as well as expand its base of users. Many academic teams competed for the task of forming the National Nanotechnology Infrastructure Network (NNIN), funded by the National Science Foundation. University of Michigan's team, led by Cornell University, was the team selected. This collaborative infrastructure begins its five-year stint in January 2004, where it will provide nationwide access to leading-edge tools and instruments in nanotechnology, as well as develop a workforce competent in nanotechnology and the latest laboratory techniques. Sandip Tiwari, director of the NNIN, commented that "we have created the world's largest, most comprehensive and accessible nanotechnology laboratory."

~ based on NSF Press Release, December 22, 2003

WIMS GRADUATE STUDENTS PRESENTED AT WORKSHOP FACILITATING CHIP DESIGN

At a workshop intended to help students design and submit properly functioning chips to MOSIS for fabrication, WIMS graduate students, Michael McCorquodale and Robert Senger, presented on analog, radio-frequency, and digital design. Hosted by University of Michigan's Electrical Engineering and Computer Science Department on October 17, various presenters discussed the practical aspects of integrated-circuit design transfer and fabrication, including topics such as adequate verification, design back annotation and simulation, metal fill, antenna rules, and design transfer.

This workshop also provided an overview and history of MOSIS, its technologies, services offered, educational program, and customer base. MOSIS will continue to present this seminar at other universities using the slides developed by WIMS students to increase the likelihood of success for individuals who intend to submit designs to any foundry.

WIMS SHORT COURSE HIGHLIGHTED AT MICHIGAN STATE UNIVERSITY'S SET DAY

The Michigan State University (MSU) Diversity Programs Office presented the nation's first precollege WIMS short-course demonstration at their Science, Engineering, and Technology (SET) Day on October 18, 2003. The WIMS precollege education project lab was also opened for exhibits and demonstrations showcasing robots created by the WIMS summer program students as their final projects. This included a karaoke machine, drag racing cars, a plotter, and radio- and remote-controlled soccer robots. The WIMS short course is designed to provide experience in cutting-edge technologies, lectures, laboratory experiments, projects, and seminars by internationally renowned WIMS experts. MSU's SET Day is an annual event designed to teach precollege age students about science, engineering, and technology career opportunities available to them. This year it welcomed approximately 300 participants.

NEW PARTNERSHIPS BEING ESTABLISHED

The WIMS ERC formed collaborations with a number of additional universities during the last quarter. These partnerships are bringing new faculty and students into the Center, adding expertise in several important areas. Professor Dale Joachim at Tulane University will be working to add sound localization capability to our environmental monitor. Requiring both sensors and signal processing electronics, this is especially challenging when overall system dimensions approach 1cm. Professor Nayda Santiago of the University of Puerto Rico at Mayaguez will be adding her expertise in the area of low-power signal processing architectures, automated sensor calibration, and power management. These functions are key to achieving long life in microsystems such as the environmental monitor. Professor Gary Harris and postdoc Juan White of Howard University are adding materials expertise to the ERC, exploring wireless sensors for high-temperature applications using silicon carbide. Lastly, Professor Pamela Obiomon of Prairie View A&M University will be working on ultra-low-power devices and circuits for sensor readout in microsystems. Additional partnerships in other areas needed by the Center are also being explored.


Dale Joachim


Nayda Santiago


Gary Harris


Juan White


Pam Obiomon

EDUCATION HIGHLIGHTS

LEGO ROBOTICS TEAM ADVANCES TO STATE FINALS IN REGIONAL COMPETITION

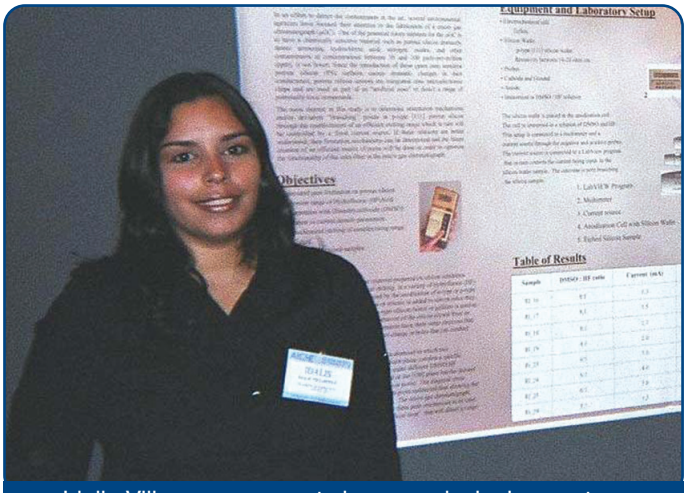
Group shot of both Lansing area LEGO robotics teams, the Spartan Explorers and the Techno Spartans, along with Michigan State University (MSU) student coaches and Drew Kim (front right), the head of MSU's College of Engineering Diversity Programs Office.

Jointly sponsored by the WIMS ERC, General Motors, and Michigan State University's College of Engineering Diversity Programs Office, Lansing area LEGO robotics teams competed against twenty other teams at the Saginaw Regional Tournament on November 21, in order to advance to the state finals. The Spartan Explorers placed in the top five, which earned them the right to advance, and the Techno Spartans won the award for the best hypothesis research presentation. Teams were judged in four categories: robot performance, hypothesis research presentation, technical interview, and teamwork. The Spartan Explorers competed in the state competition at the Novi Expo Center on December 6, where they won the Young Mentors' Award.

These teams have had a remarkable season. They enjoyed perfect attendance even though four out of fourteen team members traveled at least an hour and a half each way to participate. Close to fifty parents and students traveled to Saginaw to support the teams at the regional tournament.

Michigan State engineering students worked as volunteer coaches for both Spartan teams. They deserve special thanks for dedicating their time the entire season. These coaches met four hours a week for the past thirteen weeks. Volunteer coaches were Nathan Usher, Matt Mets, Theresa Sands, Guy Pustusza, Leidy Ramirez, and George Bibbs.

Thank you again for your support and encouragement!



Idalis Villanueva presents her award-winning poster.

REU STUDENT IS ONLY PUERTO RICAN TO WIN AWARD AT AICHE COMPETITION

The Research Experience for Undergraduate (REU) program is giving undergraduate students even more opportunities to excel. Idalis Villanueva recently won second place at the American Institute of Chemical Engineers (AIChE) Undergraduate Student Poster Competition in the Materials Science and Engineering category. She was the only Puerto Rican participant to receive this award. Her award-winning poster explained her research from this summer when she worked as an REU student for Paul Bergstrom at Michigan Technological University. Idalis' research focused on finding pore deviations in porous silicon in order to optimize the filtering system of the micro gas chromatograph.

STUDENT LEADERSHIP COUNCIL CONTRIBUTES TO MANY SERVICE-ORIENTED PROJECTS

Woodcreek Elementary School third graders programming and controlling their robots.

To kick off their fall semester, a student/faculty mixer was held at Michigan State University (MSU). The activity started with an overview of the WIMS ERC, given by WIMS Associate Director for MSU Dean Aslam. Following Dean Aslam, presentations were given by WIMS faculty and students. At the conclusion, students and faculty participated in a ping-pong game challenge.

Also under the direction of Dean Aslam, MSU Student Leadership Council (SLC) students taught robot programming sessions at Woodcreek Elementary School in Lansing as part of the K–PhD program. At the end of the semester, the children had built their own robots. Due to the program's success, an after school session will be added.

In a recent meeting with the Hands-On Museum, Helena Chan presented an interactive audio matching game that simulated cochlear implant processing. This game, developed by University of Michigan graduate student Chun Kok, is intended to teach people with full hearing what those with limited hearing experience. Contact Peggy Henderson at **peggyh@eecs.umich.edu** if you are interested in becoming involved.

SLC students mingle with Ohio State at the Blood Battle while competing to donate the most blood.

The SLC sponsored a blood drive on November 18 as part of the University of Michigan vs. Ohio State University Blood Battle—a two week round of drives to see which university could collect more pints! Our drive contributed to the overall total of 1,860 units of blood collected at the University of Michigan. Thanks to our WIMS volunteers—Helena Chan, T.J. Harpster, Joe Potkay, Nelson Supelveda-Alancastro (MSU)—and many WIMS donors for making this activity a success.

Also in November, several SLC officers attended an SLC retreat at the NSF Engineering Research Center Annual Meeting in Washington, D.C. They met to collaborate with other SLCs, present the WIMS SLC's work, and learn how to further improve their work based on other's experiences.

At the end of fall semester, MSU SLC Chairperson Nelson Sepulveda-Alancastro met with Professor Raul Torres from the University of Puerto Rico at Mayaguez and presented a PowerPoint presentation about the WIMS ERC. Professor Torres was extremely interested and several possibilities for involvement were discussed.

Lastly, the SLC hosted a meeting to elect new SLC officers for the 2004 term. Joe Potkay is the new president, with Neil Welch as vice president, Helena Chan as industrial chair, Luciana DaSilva as educational chair, and Jay Mitchel as social chair. Serving on the SLC is an excellent way to lead interesting new projects, meet and work closely with new students, and develop leadership skills.

Michigan State University students barbecuing at the MSU faculty/student mixer held this last semester.

INDUSTRIAL LIAISON'S REPORT

It became apparent during the last National Science Foundation Annual Meeting in Washington, D.C., that we needed to increase industry's awareness of our Engineering Research Center's (ERC) unique capabilities. An ERC emphasizes system engineering, creating an environment for individual research projects to focus on a collective capstone project: a testbed. Researchers collaborate and ensure that their individual projects meet testbed objectives. This requires that all researchers take a system approach to their research, understanding their individual area and how it fits into the whole. We believe that this team approach trains students to more quickly adapt to an industrial environment and contribute to the corporation. The WIMS ERC is a prime example, with approximately 100 research projects directed at the totally implantable neural prosthesis testbed and the integrated environmental monitoring system testbed.

The Center is continuing to schedule visits for students and faculty to our member companies. This is an excellent opportunity for members, students, and faculty to discuss research projects in detail. In particular, it allows our students to become more familiar with your company. Please contact me if you are interested in arranging a visit to one of your facilities.

As always, please stop at the Center whenever you are in Ann Arbor.

Joseph M. Giachino
Associate Director Industry

SEMINAR SERIES

October 7, 2003
Professor Nick McGruer
Northeastern University
Boston, MA
Reliability Physics of Contact-Type MEMS Switches

October 21, 2003
Philippe Salamitou, PhD; Oliver Vancauwenberghe, PhD; and Larry Schwartz
Schlumberger Doll Research
Richfield, CT
Sensors Development for Oilfield Applications

October 28, 2003
Professor Albert Pisano
University of California, Berkeley
MEMS Rotary Engine Power System: Project Overview and Recent Research Results

November 4, 2003
Professor Suman Das
University of Michigan
Advances in Design and Rapid Prototyping for Heterogeneous Multifunctional Devices

November 11, 2003
Randall Kubena, PhD
Hughes Research Laboratories
Malibu, CA
MEMS-based Quartz Resonators

November 12, 2003
Thomas Stieglitz, PhD
Fraunhofer Institute for Biomedical Engineering
Saint Ingbert, Germany
Microsystem-based Neural Prosthesis

November 18, 2003
Professor Alexander Arts
University of Michigan
Prosthetic Stimulation of the Auditory System with Intraneural Electrodes

November 25, 2003
Ruby Ghosh, PhD
Michigan State University
Silicon Carbide Interfaces for High-Temperature Electronics and Sensing Applications

December 2, 2003
Hossein Mosallaei, PhD
University of Michigan
Engineered Meta-Substrates for Radio-Frequency/Wireless Systems

PRESENTATIONS/ PUBLICATIONS

2003 ASME International Mechanical Engineering Congress & Exposition, Washington, DC, 2003

A. Ucok, J. Giachino, and K. Najafi, "A High-Density Flexible Connector Array for Multi-Substrate Packages"

P. Mohseni and K. Najafi, "A Fully-Integrated Neural Recording Amplifier with DC Input Stabilization," IEEE Transactions on Biomedical Engineering, in press.

Z. Zhang, K. Najafi, L. Bernal, and P. Washabaugh, "Mechanical and Thermal Design of a Combustion-based Thermionic Micro-Power Generator"

IEEE International SOI Conference, Newport Beach, CA, 2003

A. Drake, N. Zamdmer, K. Nowka, and R. Brown, "Analysis of the Impact of Gate-Body Signal Phase on DTMOS Inverters in 0.13mm PD-SOI"

J. Sivagnaname and R. Brown, "Standby Currents in PD-SOI Pseudo-nMos Circuits"

K. Das, R. Joshi, C. Chuang, and R. Brown, "Noise Consideration and Detailed Comparison of Low Standby Gate/Sub-Threshold Leakage Digital Circuits in Nano-Scale SOI Technology"

7th International Conference on Miniaturized Chemical and BioChemical Analysis Systems, Squaw Valley, CA

Y. Li, M. Gulari, and K. Wise, "High-Yield Buried Microchannel Formation for Drug Delivery at the Cellular Level"

C. Lu, W. Tian, W. Steinecker, A. Guyon, M. Agah, C. Oborny, R. Sacks, K. Wise, S. Pang, and E. Zellers, "Functionally Integrated MEMS Micro Gas Chromatograph Subsystem"

25th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, Cancun, Mexico, 2003

M. Ghovanloo and K. Najafi, "A Small-Size Large-Voltage Compliance Programmable Current Source for Biomedical Implantable Microstimulators"

S. Nikles, D. Pellinen, J. Kitagawa, D. Kipke, R. Bradley, and K. Najafi, "Long Term In Vitro Monitoring of Polyimide Microprobe Electrical Properties"

IBM Austin Research Laboratory, Austin, TX, 2003, R. Brown, "Low-Power Mixed-Signal Microcontrollers for Solid-State Sensor Applications"

IEEE International Robotics and Systems Conference, Las Vegas, NV, 2003, K. Najafi, J. Chae, H.

Kulah, and G. He, "Micromachined Silicon Accelerometers and Gyroscopes," (Invited Paper, IROS)

IFIP VLSI-SoC International Conference, PhD Forum, Darmstadt, Germany, 2003, M. McCorquodale and R. Brown, "Monolithic and Top-Down Clock Synthesis with Micromachined RF Reference"

IFIP VLSI-SoC International Conference, Darmstadt, Germany, 2003, A. Drake, K. Nowka, and R. Brown, "Evaluation of Dynamic-Threshold Logic for Low-Power VLSI Design in 0.13mm PD-SOI"

International Conference on Computer Aided Design, San Jose, CA, 2003, R. Rao, F. Liu, J. Burns, and R. Brown, "A Heuristic to Determine Low Leakage Sleep State Vectors for CMOS Combinational Circuits"

International Symposium on Micro-Mechanical Engineering, Tsukuba, Japan, 2003, M. Kaviany and L. DaSilva, "Micro Thermoelectric Cooler: Interfacial Effects, Optimization and Fabrication"

International Conference on Compilers, Architecture, and Synthesis for Embedded Systems (CASES), San Jose, CA, 2003, R. Ravindran, R. Senger, E. Marsman, G. Dasika, M. Guthaus, S. Mahlke, and R. Brown, "Increasing the Number of Effective Registers in a Low-Power Processor Using a Windowed Register File"

The 46th IEEE Midwest Symposium on Circuits and Systems, Cairo, Egypt, 2003, J. Sivagnaname and R. Brown, "Effect of Scaling on Stand-by Current in PD-SOI Pseudo-nMOS Circuits"

The University of Texas at Austin VLSI Seminar Series, Austin, TX, 2003, R. Brown, "Digital, Analog, MEMS Systems-on-Chips"

DOCTORAL DISSERTATIONS

Koushik K. Das
"Robust Low-Power Digital Circuit Design in Silicon-on-Insulator (SOI) CMOS Technology"
University of Michigan, 2003
Current Position: Research Staff Member, IBM T.J. Watson Research Center
Yorktown Heights, NY
Advisor: Professor Richard Brown

MEMBER COMPANIES

Ardesta, LLC
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Cochlear Americas
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Motorola, Inc.
Samsung Electronics
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MEDC

 Schedules of upcoming seminars as well as a listing of publications are available at www.wimserc.org.

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