# WIMS WORLD

University of Michigan I Michigan State University I Michigan Technological University

## DIRECTOR'S MESSAGE

As I write this, I'm looking out at Lake Michigan, with its dark blue water highlighted against a bright blue sky. The white column of the Frankfort North Breakwater Light is staring at me, and the wonderful sand of the Eastern Shore is set off by occasional clumps of grasses that somehow manage to grow there. One fifth of the world's fresh water is in these lakes, and they are much the same now as they have been for many centuries. Let's hope that microsystems can help keep them that way.

WIMS faculty and students on the beach at the Hilton Head Workshop on Hilton Head Island.

The last three months have been busy—our annual "gauntlet" period. Early April is our National Science Foundation (NSF) Annual Report, followed by the end of the winter term, followed by our annual Site Visit, and this year followed by the Hilton Head Sensor/Microsystems meeting. Now, at last, it is time to catch up on other projects that have been put off, and they are many. But thanks to laptops and the Internet, some of the catching up can be done in wonderful surroundings.

Our Annual Report gives us an opportunity to take stock of our Center and where we are. In our fourth year of a ten-year run under NSF support, the WIMS ERC now has 132 active projects, covering micropower circuits, wireless interfaces, sensors, and packaging. It involves 39 faculty distributed across eight universities and includes 154 graduate students, 83 undergraduates, and 19 industrial partners. During the past year, we generated a total of 146 journal articles and conference presentations along with 27 patent disclosures. We are truly leading the way in microsystems that will soon tackle some of the most difficult challenges facing society, including increased food production, energy conservation, health care, security, and environmental protection. We are talking about preserving the quality of life for generations to come; these are not battles we can afford to lose.

The Hilton Head meeting this year was particularly enjoyable for me. The environment of that meeting is perhaps unlike any other. It combines a relaxed atmosphere with an excellent technical program and abundant opportunities to interact. And it is a great opportunity to see old friends. The sensor community has always been a congenial set of friendships, and I cannot imagine a better place to have spent a career. As I have seen other fields, I have been impressed that such competitive but mutually supportive settings may be more rare than they are common.

Michigan was especially well represented at Hilton Head this year, with a total of 35 present or former personnel in attendance, many with their families. We thus represented over ten percent of the meeting. One of our alums, Leland "Chip" Spangler, was elected technical program chair for the 2006 meeting, and we wish him the very best as he continues a strong tradition of leadership in the field. He and WIMS Deputy Director Khalil Najafi will also be working together on the *Transducers '09* conference, where Chip is doing local arrangements and Khalil will serve as general chair. It is good to see Michigan supplying leadership to these meetings, but again, this has been a field filled with many enduring friendships.

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A few years ago, I participated in a doctoral defense in chemical engineering at which the student was presented with his professional genealogy—a chart showing his advisor, his advisor's advisor, and so forth. I had never seen that before and didn't know it was possible. At Hilton Head, several pictures were taken this year that I value highly. One is of four "generations" of faculty members derived from the program here at Michigan. Somehow that's very nice to think about, and it underscores again the fact that people are our most important product. Maybe that's why I have enjoyed my career as much as I have. Here's wishing all of you a very enjoyable and productive summer!

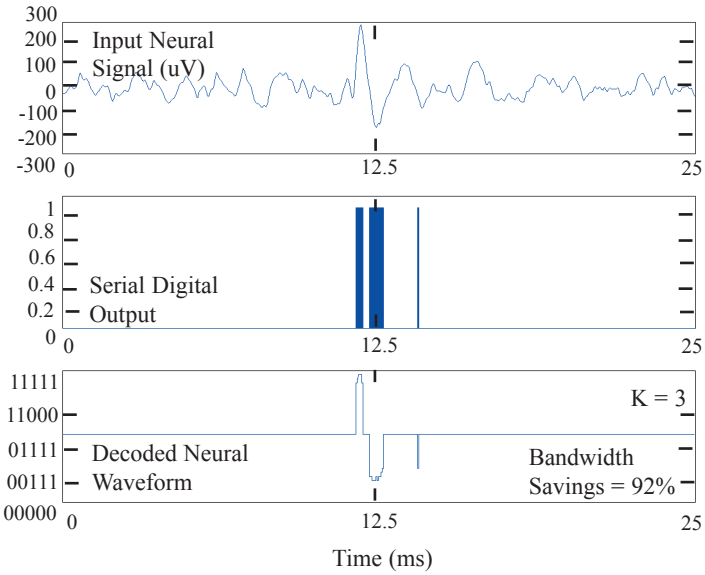
Four generations of faculty, from left to right: Kensall Wise, Khalil Najafi, Yogesh Gianchandani, and Chester Wilson at the beach on Hilton Head.

*Ken D. Wise*
Director, Engineering Research Center for Wireless Integrated MicroSystems

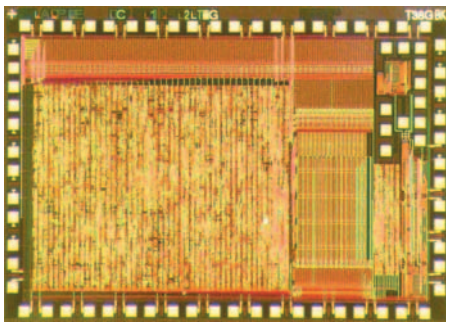
Our next Industrial Advisory Board meeting will be October 19–20, 2004 at the Crowne Plaza Ann Arbor. Please come join us. Contact Joe Giachino for more details—*giachino@eecs.umich.edu*.

## RESEARCH HIGHLIGHTS

### SPIKE-DETECTION INTEGRATED CIRCUIT CREATES SIGNIFICANT BANDWIDTH SAVINGS



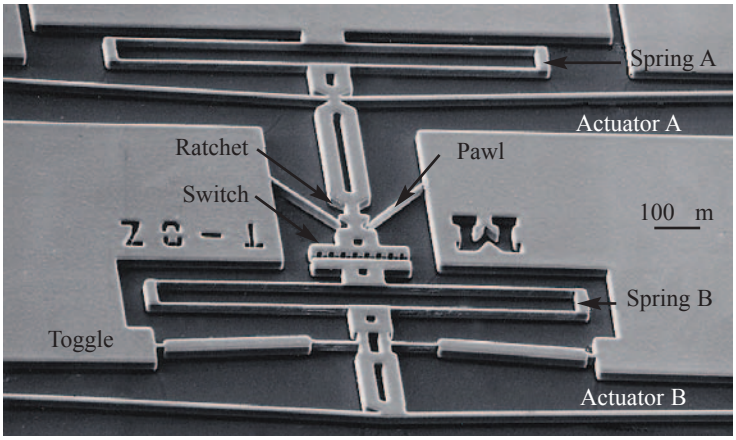

(Top) Neural signal recorded with an active probe from a rat hippocampus. (Middle) Compressed serial output of the spike detector. (Bottom) Reconstructed neural waveform.



A neural spike-detection application-specific integrated circuit.

A spike-detection application-specific integrated circuit (ASIC) has been developed to compress neural data in vivo, allowing hundreds of channels to be recorded simultaneously over a transcutaneous wireless interface. The spike detector successfully calculates neural-spike thresholds and detects neural spikes in the presence of neural and circuit noise, achieving an average bandwidth savings of 92%. While compressing the neural data, the spike detector preserves the key features of the waveshape necessary for spike discrimination, which is important in prosthetic applications. When a spike is detected, this ASIC serially shifts the 5-bit amplitude and 5-bit address of the spike off of the chip over a single data lead at 2.5Mbps. The spike-detection ASIC occupies 2mm x 3mm in 0.5mm features and consumes 2.6mW of power from a 3V supply. At a telemetry bandwidth of 2.5Mbps, the implantable spike-detection ASIC increases the total number of channels that can be transmitted transcutaneously at 5 bits of resolution and a sampling rate of 20kHz/channel from 25 to 312.

## MEMS-BASED VOLTAGE CONVERTER MEETS HIGH-VOLTAGE NEEDS FOR MICRO DEVICES

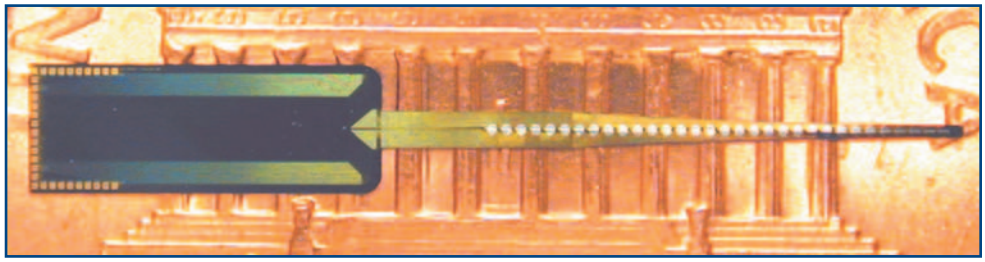



An SEM image of a self-oscillating relay fabricated by electroplating copper into lithographically patterned mold.

A variety of micromachined devices, ranging from electrostatic actuators to microfluidic electrokinetic pumps and microplasmas, all require relatively high voltages for operation. High-voltage generators that rely on electronic components are limited by the dielectric and junction breakdowns of CMOS technology. To solve these challenges, a voltage converter has been developed that generates voltages in excess of 500V with an instantaneous power of 1W from a 5V DC power source in a footprint of 4mm x 4mm. A critical component is a DC-powered self-oscillating micromechanical relay that operates without the aid of any electronic components. Although originally intended for use in a micromachined Geiger counter, this converter is suitable for use in a variety of other devices. The oscillator is fabricated using a low-temperature UV-LIGA process that can be appended to a CMOS process.

## PROFILE ANALYSIS MAXIMIZES RESOLVING POWER TO IMPROVE COCHLEAR IMPLANTS

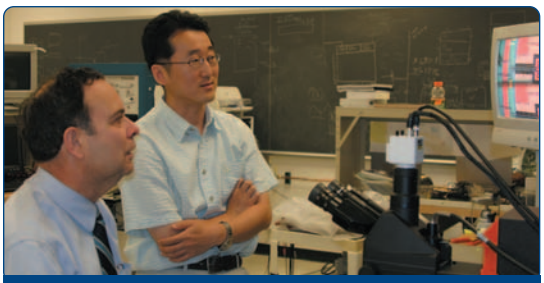
A technique known as "profile analysis" is being employed for the first time in cochlear implants at the Kresge Hearing Research Institute. As part of the WIMS cochlear implant testbed, profile analysis will be utilized first in the inferior colliculus (IC) implant, and then long-term in the thin-film cochlear implant. This will lay the groundwork for improving cochlear implants' effectiveness by maximizing spectral resolving power—the primary limiting factor in commercial implants.



Shown on a penny, this thin-film electrode array contains 32 high-density sites and is intended for use in the guinea pig cochlea. The iridium oxide sites are 180 m in diameter spaced on 250 m centers.

Originally developed by former University of Michigan faculty member David M. Green and his colleagues in the 1980s, profile analysis evaluates the minimum difference in the acoustic spectral shape that human listeners can hear. At the Kresge Hearing Research Institute, it was found that as the number of spectral channels of acoustical information was increased, the cochlear implant user's ability to hear a spectral change decreased, due to increased channel interaction. The different implant processing strategies being considered with the thin-film and IC implants might decrease the channel interaction, providing improved sound perception. Profile analysis will be used to measure the success of the innovative designs implanted in guinea pigs.

## PERSONNEL FOCUS



Ken Wise (left) with Sangwoo Lee in testing lab.

Joining WIMS ERC ranks in May, Sangwoo Lee, of Samsung Advanced Institute of Technology (SAIT) has become WIMS' newest resident engineer. Sangwoo Lee, his wife, and his 11-month-old son left Korea for the first time to participate in this one-year appointment. Here at the WIMS ERC, he will design mixed-mode application-specific integrated circuits (ASICs) for our prototype microsystems. While at Samsung, Lee focused on ASIC development and testing the performance of gyroscopes at SAIT, the primary research center of Samsung. He received his B.S., M.S., and Ph.D., all from Seoul National University in Korea, where he focused on the application of sacrificial bulk micromachining for fabricating the Samsung gyroscope.

## RECENT EVENTS

### RICHARD BROWN BECOMES DEAN AT THE UNIVERSITY OF UTAH

Richard Brown and his wife, Brenda, at their farewell reception in the Lurie Engineering Center.

Professor Richard B. Brown announced earlier this spring that he was leaving the University of Michigan (UM) after 19 years to become Dean of Engineering at the University of Utah. Professor Brown graduated from the University of Utah in 1985 with a Ph.D. in electrical engineering. His thesis dealt with solid-state chemical sensors. At UM, he quickly rose through the ranks from assistant to full professor, serving as associate chair of EECS for four years and then as interim chair for two more. He played a major role in developing a VLSI program at Michigan that is a model for the rest of the country and is scoring major advances in the development of sensors for water purity. Brown was one of the founding members of the WIMS ERC and served as thrust leader for Micropower Circuits. He will be much missed as an in-house colleague, but will remain involved in the Center as a number of his research programs continue here. We have no doubt Professor Brown will have a major impact on the College of Engineering at Utah and wish him and his wife much happiness as they return to their Salt Lake City roots.

### WIMS PROFESSOR HONORED BY NACME FOR SERVICE TO MINORITY STUDENTS

Michigan State University's Professor Percy Pierre was awarded the National Action Council for Minorities in Engineering (NACME) Founders award on May 4, 2004. The only individual to receive this award (Exxon-Mobile Corporation and the Alfred P. Sloan Foundation were also recipients), Pierre was honored for his years of dedicated service to NACME and involving minorities in engineering.

Pierre's contribution to NACME is deeply rooted. He founded two of the three organizations that comprise the NACME, and he was actively involved in the third. He also organized a symposium that produced the National Academy of Engineering's (NAE) NACME, and then he played a major role in developing the foundation for this organization. Thanks to Pierre, NAE's NACME became the focal point of a partnership between industry and government.

From his work with NACME, Pierre started a scholarship program that continues today. He has continued to work with a variety of organizations and schools to create more educational opportunities for minorities. Today, Pierre continues his work increasing minority engineering doctoral graduates at Michigan State University and facilitating WIMS minority programs.

*Based on NACME's Web site:* ***www.nacme.org/gala/honorees.html.***

### WIMS GRADUATE STUDENT TAKES THIRD AT DAC CONFERENCE

WIMS graduate student, Maysam Ghovanloo, placed third in the Operational Category at the 2004 41st Design Automation Conference. Ghovanloo was recognized for his modular 32-site wireless neural stimulation microsystem. This contest is held to encourage engineering students to excel in their designs and construction of electronic systems. The Operational Category is for students who have implemented and tested their systems as part of their graduate or undergraduate work.

*Based on the 41st DAC Student Design Contest Web site:* ***www.dac.com/41st/studcon.html.***

### WIMS GRADUATE STUDENT HONORED WITH AWARD AT RFIC SYMPOSIUM

At the IEEE Radio Frequency Integrated Circuits Symposium in June, WIMS graduate student, Fatih Kocer, was awarded second place in the best student paper competition. His paper was entitled "Wireless, Remotely Powered Telemetry in 0.25 m CMOS."

# EDUCATION HIGHLIGHTS

## WIMS CENTER HOSTS TWENTY UNDERGRADUATE STUDENTS DURING SUMMER PROGRAM

Summer researchers showing a wafer they created on a tour of the Solid-State Electronics Laboratory cleanroom as part of their program.

This year, the WIMS Center is hosting its largest and most diverse group of undergraduate summer researchers to date. Twenty undergraduate students have joined the WIMS Center for Summer 2004 from schools across the country. All three partner universities are represented. In this program, each student has a specific research project; must write a project description to explain the project goals, expected tasks, and the project scope within WIMS research thrusts and testbeds; and must give a final report and presentation. To facilitate their success, each student works closely with a WIMS graduate student or postdoc mentor. Usually, the undergraduate research projects are subprojects of the graduate student mentor's research, ensuring attentive mentoring.

One project deserves special note to highlight its center-wide attributes, geographically and educationally. A Michigan Technological University (MTU) undergraduate student is working in a University of Michigan (UM) research group, enhancing joint research collaborations between MTU and UM. The project's goal is to wirelessly link the Engineering Enterprise Tri-Corder with the WIMS Cube and its embedded microcontroller. The project results should quicken the transfer of WIMS Center research results to high school classrooms.

## SPRING DAPCEP PROGRAM EXTENDS CURRICULUM

During March and April, the WIMS Center and the Electrical Engineering and Computer Science (EECS) Department at the University of Michigan hosted twenty-two 7th and 8th grade DAPCEP (Detroit Area Pre-College Engineering Program) students. During five Saturdays, the students attended sessions where scientific principles were illustrated in a fun, hands-on manner. The pinnacle of the program for students is their opportunity to build LEGO robots. This year, in addition to constructing and programming the robots, students used the robots to visually illustrate science and math concepts such as distance, velocity, and acceleration. Also new to the program, students learned about microcontroller logic principles and components such as the binary number system, logic gates, memory, and arithmetic units. In addition, the physiology of the ear and the cochlea in relation to sound and audio principles (amplitude, frequency, timbre) was taught. Many EECS and WIMS Student Leadership Council graduate students served as mentors and teaching assistants, allowing a 2:1 student/mentor ratio.

DAPCEP students overseen by mentor, SLC student, Luciana da Silva.

## RESIDENTIAL DAPCEP PROGRAM AT MSU FOCUSES ON TEACHING MATH AND SCIENCE

DAPCEP students at ice rink during evening activities at MSU.

Michigan State University (MSU) College of Engineering's Diversity Programs Office welcomed 18 DAPCEP students to campus for four weeks of intense academics and college preparation from June 21 through July 16. Students participated in mathaphysics (an integration of math and physics), C++ programming, WIMS, and Unigraphics. They also learned about MSU admissions, resume writing, engineering professionalism, and research conducted by MSU/UM graduate students and faculty. New to the program this year, students interacted with Lyman Briggs School—a residential learning community devoted to studying natural sciences. Thirteen MSU graduate students taught, mentored, and tutored the students. During some evenings, students were immersed in activities such as ice skating, an adventure park, and a Lansing Lugnuts baseball game. Also unique to this year, MSU offered their top male and female student a $1,500 scholarship towards their first undergraduate year in engineering at MSU.

## STUDENT LEADERSHIP

### WIMS SLC FOCUSES ON ENGAGING TEENS IN WIMS THROUGH HANDS-ON METHODS

As part of a WIMS tour, Joe Potkay teaches aspiring graduate students about chips and how they work. Joe was one of several SLC students giving tours.

The WIMS Student Leadership Council (SLC) began the quarter by mentoring students every Saturday in the annual WIMS DAPCEP (Detroit Area Pre-College Engineering Program) program. Detroit-area teens, with the help of the WIMS mentors, built circuits and LEGO Mindstorm robots in order to learn about WIMS.

Michigan State University SLC students also taught teens scientific principles through a LEGO Robotics class. This program was offerred to several schools throughout June.

In May, WIMS students prepared for the Industrial Advisory Board (IAB) meeting and the National Science Foundation (NSF) Site Visit by preparing posters, slides, and talks. The SLC conducted an annual anonymous student analysis of the Center. Students were surveyed on the Center's strengths, weaknesses, and opportunities. This information was presented to the NSF Site Visit team, along with this year's SLC activities.

Throughout the quarter, the SLC continued to work towards an interactive Internet Web page on cochlear implants for the Ann Arbor Hands-On Museum. The Web page, which will be presented to the museum staff in the coming months, is the first step towards a floor exhibit in the museum.

In the coming quarter, the SLC is planning a camping trip in Northern Michigan and a barbeque for the entire WIMS Center, allowing faculty, staff, and students to become better acquainted and to have some fun.

## INDUSTRIAL LIAISON'S REPORT

May 2004 was the wettest May in Michigan history; however, our Industrial Advisory Board (IAB) meeting was held during the few dry days of the month. As before, our members were able to view posters detailing advances made in projects, talk with students involved in these projects, and see actual demonstrations.

To foster a continuing relationship between students and members, we invite members to establish a "dialogue" with any student whose project was of particular interest. This dialogue can be via email, phone, or personal visits. The purpose is for members to interact with the student in a manner convenient for them. We believe this will allow for a smoother and easier transfer of technology from the Center to industry.

Any member that could not attend the IAB meeting can contact a student by going to the Members Only section of our Web site, **http://wimserc.org**, and accessing the student's information in the resume section. Or, if it is easier, I can put the student directly in touch with you.

The emphasis within the Center, as always, is to transfer technology as rapidly and smoothly as possible. Accentuating early involvement with students is a component of technology transfer that should result in meaningful economic results (reduced cost, new products, faster production) for our members.

For those who attended the Solid-State Sensor, Actuator and Microsystems Workshop, it was a pleasure to have a chance to discuss both technical and nontechnical items. While we do not have sand and surf here in Ann Arbor, we do have a bucolic campus and would be delighted to continue those discussions here, or have you talk with our researchers about their advances.

*Joseph M. Giachino*
Associate Director Industry

## SEMINAR SERIES

### April 13, 2004

Professor Kensall D. Wise
University of Michigan
*WIMS Overview*

### April 20, 2004

Professor Noel Perkins
University of Michigan
*Application of MEMS Inertial Sensors to Sports Training Devices*

### May 25, 2004

Kabir Udeshi and Tao Li, graduate students
University of Michigan
*On-Chip High Voltage Generation Using Mechanical Oscillators/LEEDUS: A Micromachining Process for Die-Scale Pattern Transfer in Ceramics with High Resolution and Throughput*

### June 15, 2004

Professor Shuichi Takayama
University of Michigan
*Personal Microfluidics: Portable and Programmable Microfluidic Systems for Cell Engineering*

### June 22, 2004

Professor Jes Asmussen
Michigan State University
*Research Activities on Plasma Assisted PVD and CVD Process Machine Development and Advanced Carbon Material Processing at the MSU/ Fraunhofer Center for Coatings and Laser Applications*

## PRESENTATIONS/ PUBLICATIONS

**Hilton Head 2004: A Solid State Sensor, Actuator and Microsystems Workshop, Hilton Head Island, South Carolina, June 6–10, 2004**

A. DeHennis and K. Wise, "A Fully-Integrated Multi-Site Pressure Sensor for Wireless Arterial Flow Characterization"

A. Taylor and L. Thompson, "Integrated Micro Fuel Cell Power Supply"

A. Ucok, J. Giachino, K. Najafi, "The WIMS Cube: A Microsystem Package with Actuated Flexible Connections and Re-workable Assembly"

E. Zellers et al., "A MEMS Gas Chromatograph-Sorption Spectrometer ( GC-SS) for Environmental Monitoring" (Invited)

C. Wilson and Y. Gianchandani, "MicroGeiger: A Microfabricated Gas-Based Beta Radiation Detector"

H. Kim, A. Ucok, and K. Najafi, "Large-Deflection Stacked Multi-Electrode Electrostatic Actuator"

H. Yu, R. Olsson, K. Wise, and K. Najafi, "A Wireless Microsystem for Multichannel Neural Recording Microprobes"

K. Takahata and Y. Gianchandani, "A Micromachined Stainless Steel Cuff for Electromagnetic Measurement of Flow in Blood Vessels"

K. Udeshi and Y. Gianchandani, "A Transistorless Micromechanical High Voltage Generator Using a DC-Powered Self-Oscillating Relay"

M. Agah, J. Potkay, A. Guyon, G. Lambertus, R. Sacks, and K. Wise, "A High-Performance Temperature-Programmed Gas Chromatography Column"

S. Lee and C. Nguyen, "Phase Noise Amplitude Dependence in Self-Limiting Wine-Glass Disk Oscillators"

S. Martin, J. Ha, J. Kim, T. Strong, G. Cha, and R. Brown, "ISE Arrays with Improved Dynamic Response and Lifetime"

T. Li and Y. Gianchandani, "LEEDUS: A Micromachining Process for Die-Scale Pattern Transfer in Ceramics with High Resolution and Throughput"

**IEEE AP-S International Symposium and USNC/URSI National Radio Science Meeting, Monterey, CA, 2004**

N. Behdad and K. Sarabandi, "A Wideband Bi-Semicircular Slot Antenna"

N. Behdad and K. Sarabandi, "A Wideband Multiresonant Single-Element Slot Antenna"

N. Behdad and K. Sarabandi, "Dual Band Reconfigurable Slot Antennas Using Lumped Elements"

N. Behdad and K. Sarabandi, "Dual Resonant Slot Antennas for Wireless Applications"

**2004 IEEE International Symposium on Circuits and Systems (ISCAS), Vancouver, Canada, 2004**

F. Kocer, P. Walsh, and M. Flynn, "An RF Powered, Wireless Temperature Sensor in Quarter Micron CMOS"

S. Martin, F. Gebara, T. Strong, and R. Brown, "A Low-Voltage, Chemical Sensor Interface for Systems-on-Chip: The Fully Differential Potentiostat"

**ASEE 2004 Annual Conference & Exposition, Salt Lake City, Utah, 2004**

M. McCorquodale and R. Brown, "UMIPS: A Semiconductor IP Repository for IC Design Education and Research"

R. Brown, D. Sylvester, D. Blaauw, M. Flynn, G. Carichner, and C. June, "VLSI Design Curriculum"

**IEEE RFIC Symposium 2004, Fort Worth, TX, 2004**

F. Kocer, P. Walsh, and M. Flynn, "Wireless, Remotely Powered Telemetry in 0.25 m CMOS"

R. Gharpurey: Invited panel discussion: "Ultra-Wideband: An Academic Exercise or a Practical Path to Higher Data Rates?"

A. Basu, S. McNamara, and Y. Gianchandani, "Maskless Lithography by Patterned Heating of Photoresist Using Ultra-Compliant Thermal Probe Arrays," in *The 48th International Conference on Electron, Ion, and Photon Beam Technology & Nanofabrication,* San Diego, CA, 2004.

F. Gebara, S. Martin, K. Kraver, and R. Brown, "A Body-Driven Offset Cancellation Technique in PD-SOI," in *24th International Conference on Microelectronics (MIEL 2004).*

F. Kocer, P. Walsh, and M. Flynn, "An Injection Locked, RF Powered, Telemetry IC in 0.25 m CMOS," in *2004 Symposia on VLSI Technology and Circuits,* Honolulu, Hawaii, 2004.

W. Drennan and B. Pfingst, "Spectral Profile Discrimination Ability Using Cochlear Implants: Effects of Number of Active Electrodes and Pulse Rate," in *Acoustical Society of America Conference,* New York, New York, 2004.

B. Stark and K. Najafi, "A Low Temperature Thin Film Electroplated Metal Vacuum Package," in *IEEE Journal of Microelectromechanical Systems*, vol. 13, no. 2, 2004, pp. 147–157.

C. Zhang and K. Najafi, "Fabrication of Thick Silicon Dioxide Layers For Thermal Isolation," in *Journal of Micromechanics and Microengineering*, vol. 14, no. 6, 2004, pp. 769–774.

G. Lambertus, A. Elstro, K. Sensenig, J. Potkay, M. Agah, S. Scheureing, K. Wise, F. Dorman, and R. Sacks, "Design, Fabrication, and Evaluation of Microfabricated Columns for Gas Chromatography," in *Analytical Chemistry,* 2004, in press.

P. Mohseni and K. Najafi, "A Fully Integrated Neural Recording Amplifier with DC Input Stabilization," in *IEEE Transactions on Biomedical Engineering*, vol. 51, no. 5, 2004, pp. 832–837.

S. Nikles, R. Bradley, S. Bledsoe, and K. Najafi, "Design and Testing of Conductive Polysilicon Beam Leads for Use in a High-Density Biomedical Connector," in *Journal of Micromechanics and Microengineering*, vol. 14, no. 7, 2004, p. 957–968.

T. Lisby, S. Nikles, K. Najafi, O. Hansen, S. Bouwstra, and J. Branebjerg, "Mechanical Characterization and Design of Flexible Silicon Microstructures," in *IEEE Journal of Microelectro-mechanical Systems*, vol. 13, no. 3, 2004, pp. 452–464.

X. Zhu, D. Aslam, Y. Tang, B. Stark, and K. Najafi, "The Fabrication of All-Diamond Packaging Panels With Built-In Interconnects for Wireless Integrated Microsystems," in *IEEE Journal of Microelectro-mechanical Systems*, vol. 13, no. 3, 2004, pp. 396–405.

## DOCTORAL DISSERTATIONS

Reza Azadegan
"Highly Miniaturized Antennas and Filters for Wireless Applications"
University of Michigan, 2004

Current Position: Delphi Corp.
Advisor: Professor Kamal Sarabandi

Andrew DeHennis
"Remotely-Powered Wireless Monitoring Systems"
University of Michigan, 2004
Current Position: Engineer, Sensors for Medicine and Science, Germantown, MD
Advisor: Professor Kensall D. Wise

Keith Kraver
"Low-Voltage and Low-Power, Deep-Submicron Analog Circuits for Single-Chip, Mixed-Signal Microinstrumentation Systems"
University of Michigan, 2004
Current Position: Motorola, Inc.
Advisor: Professor Richard B. Brown

Michael McCorquodale
"Monolithic and Top-Down Clock Synthesis with Micro-machined Radio Frequency"
University of Michigan, 2004
Current Position: CEO, Mobius Microsystems, Inc., Ann Arbor, MI
Advisor: Professor Richard B. Brown

Gary O'Brien
"MEMS Angular Rate and Angular Acceleration Sensors With CMOS Switched Capacitor Signal Conditioning"
University of Michigan, 2004
Current Position: FreeScale Semiconductor, Phoenix, AZ
Advisor: Professor Khalil Najafi

Roy H. Olsson III
"Silicon Recording Arrays with Integrated Circuitry for In-Vivo Neural Data Compression"
University of Michigan, 2004
Current Position: Senior Member of Technical Staff, Sandia National Laboratories, Albuquerque, NM
Advisor: Professor Kensall D. Wise

## MEMBER COMPANIES

Ardesta, LLC
ChevronTexaco Corporation
Corning, Inc.
Delphi Corporation
Dexter Research Center
Discera, Inc.
EDF Ventures
EV Group, Inc.
Honeywell International
Intel Corporation
ISSYS, Inc.
MEDC
Mobius Microsystems
Motorola, Inc.
Samsung Electronics
Sensicore, Inc.
SUSS MicroTec, Inc.
Sandia National Labs
Texas Instruments, Inc.



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