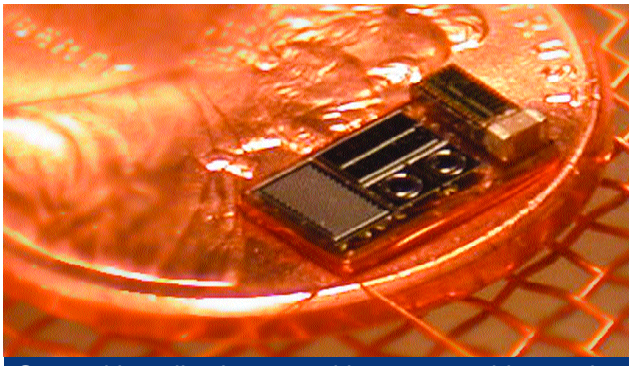
WIMS WORLD

University of Michigan • Michigan State University • Michigan Technological University

DIRECTOR'S MESSAGE

During the past few months, the main focus of the WIMS ERC was on our third-year Annual Report and the subsequent Site Visit, just recently completed. Both represented heroic efforts, especially on the part of our staff, who worked long evenings and weekends to put documents together that we could all be proud of. They were real evidence of the commitment and dedication of everyone in the Center. The ERC is now completing its third year, with no less than 114 projects involving 145 graduate students, 57 undergraduates, and over 40 faculty members. Nineteen companies are participating along with organizations such as Sandia National Laboratories. In the Annual Report and at the Site Visit, two distinguishing features of Engineering Research Centers were much in evidence–interdisciplinary research and engineered systems. I'd like to spend a few minutes here reflecting on these features and the system integration activities that bind them together.



Our multi-application capacitive sensor chip can be configured as shown for biomedical implants or used for environmental monitoring of pressure, temperature, and humidity.

I have always enjoyed working on sensors because they are naturally interdisciplinary. I am constantly put in a position where I get to learn something new. I am convinced that the most important future advances in engineering will come from its intersections with other disciplines, e.g., bridging from electrical engineering to medicine, chemistry, or biology. Interdisciplinary research is relatively easy to do in academia and is one of the reasons why sensors research has always flourished here. WIMS are more interdisciplinary still, merging sensors with efforts in embedded computing and wireless communications. This makes the ERC exciting and critically important for society. Our two testbeds are good examples. The first is a generic neural prosthesis–an electronic interface to the brain with which we hope to show the feasibility of treating disorders such as deafness, blindness, paralysis, epilepsy, and Parkinson's disease. A tall order, to be sure, but we have good reason to hope that real miracles will be possible in this area. This optimism is fueled by the miracles that have already occurred using cochlear implants for the deaf and deep brain stimulation for the relief of Parkinson's tremor. Our neural testbed is already extending our understanding of the nervous system in important areas.

The second testbed is a wristwatch-sized environmental monitor. Such devices will have applications ranging from food processing to pollution and global warming to homeland security. The micro gas chromatograph that is the heart of this microsystem is producing results that are nothing short of amazing, and we have barely scratched the surface of possibilities. This testbed too is interdisciplinary, and it is exciting.

A second defining feature of an ERC is its focus on engineered systems. In some Centers this may have to be forced a bit, but in ours engineered microsystems are the theme. They are what we do. The goal of the Center is to create a generic platform that will work, across the board, for microsystems that are implanted, worn, installed, stand-alone, or remote. From the beginning, sensors have tended to be low-volume, individually calibrated, and expensive; for the most part, they still are. But the generic platform we are developing could change all that by allowing such systems to be rapidly customized for a given application, changing only the front-end sensors and the associated control code in the embedded processor. Generic means that volumes will go up, performance will go up, and costs will go down. Can this be done? We think so, and we think it is not far off.

The system integration that makes engineered systems a reality is not a natural fit in academia. University research has typically focused on individual, not team, accomplishments. So ERCs face significant challenges in developing effective system integration efforts in an academic setting. This is a fight worth fighting, for in the end it means that we all benefit as we see our work used to solve real problems. System integration teaches teamwork like nothing else can, better preparing our students for industry and academia alike. We have been committed to making system integration a pervasive part of the WIMS ERC, and the microsystems that are now emerging are a result. Some of these are shown in this newsletter. I hope you find them as exciting as we do!

Ken D. Wise

Director
Engineering Research Center for
Wireless Integrated MicroSystems

INSIDE

MICROCONTROLLER TAKES THE CAKE AT INTERNATIONAL CONFERENCE

First place in the conceptual category of the Design Automation Conference/International Solid-State Circuits Conference Student Design Contest went to EECS graduate students Robert Senger, Eric Marsman, Fadi Gebara, Keith Kraver, Matthew Guthaus, Michael McCorquodale, and their advisor, Prof. Richard B. Brown. Their project, the WIMS Microcontroller, is a 16-bit mixed-signal microsystem with integrated CMOS-MEMS clock reference.

The conceptual category recognizes excellence in classroom or research projects that have been designed and simulated but not tested at the time of submission. The microcontroller has since been fabricated, and its digital core has been tested and shown to be fully functional. Test results were presented at the conference. Project details can be found in "A 16-Bit Mixed-Signal Microsystem with Integrated CMOS-MEMS Clock Reference," published in the *40th DAC Proceedings*. Currently a new version of the microcontroller is being designed to consume less power than its predecessor yet provide additional functionality.

Prof. Alan Mantooth, DAC/ISSCC Student Design Contest Co-Chair, presents the conceptual category awards. **Top:** First place to team representatives Robert Senger, Eric Marsman, Michael McCorquodale, and Prof. Richard Brown.
Bottom: Second place to Masoud Agah, Yang Li, and Robert Senger.

ERC members were fortunate to receive an additional award at the conference, again in the conceptual category. Second place went to Masoud Agah, Yang Li, Robert Senger, and Prof. Ken D. Wise for designing an integrated thermally based microflow sensor.

~Catharine June

VISIONARY STUDENT HAULS IN TWO AWARDS

Michael McCorquodale, a WIMS graduate student, received the 2003 Harry B. Benford Award, which recognizes a UM College of Engineering undergraduate or graduate student who has made the most of the resources available at the College while exhibiting entrepreneurial flair and leadership ability.

McCorquodale was also the winner of the University of Michigan Business School's Pryor-Hale Business Plan Competition, one of the oldest contests of its kind. Pryor-Hale competitors must submit proposals that focus on a consumer or industrial product or service, or on a detailed acquisition or turn-around situation treated as a new venture.

Partnering with Jeff Wilkins, a Business School graduate student, McCorquodale proposed the framework for Mobius, a company that will sell patented intellectual property to microchip makers. Specifically, Mobius will sell technology that permits manufacturers to integrate clock mechanisms directly onto microprocessors.

McCorquodale's research interests lie in microsystems technology with a focus on the convergence of commercial complementary metal oxide semiconductor and micromachining technologies for system-on-chip applications.

~Jack Fishstrom

STUDENTS STAND OUT AT SUBCONTINENT CONFERENCE

Jay Sivagnaname and Rahul Rao, WIMS graduate students, took a first prize at the 16th IEEE International Conference on VLSI Design, held in New Delhi, India. Advised by Prof. Richard B. Brown, they submitted an entry titled "Dual Issue PowerPC FXU Processor."

This contest intends "to encourage education and research in state-of-the-art VLSI design and its realization at universities and educational organizations." The contest comprises three categories: (1) Designed and actually implemented on chips in universities or other educational organizations during the last two years, (2) Designed and accompanied by actual measurements from implementations, and (3) Designed as an innovative prototype.

~Catharine June

INTELLECTUAL PROPERTY WEBSITE LAUNCHED

Founded by five EECS doctoral students with the help of Prof. Richard B. Brown, a new website seeks to foster collaboration between designers by sharing intellectual property (IP) to reduce the overall design time for research projects. Our "Fab Five" students are Michael McCorquodale, Robert Senger, Eric Marsman, Fadi Gebara, and Matthew Guthaus, and their website is the University of Michigan Intellectual Property Source (UMIPS). The website describes the IP submission guidelines and showcases IP that is currently available for download. Response from the research community has been tremendous. Several IP submissions have already been processed from both American and international researchers, and the site has been visited frequently. This underscores the need for design reuse, which is especially important when undertaking large research projects where much of the design time is wasted "reinventing the wheel" by designing blocks that have already been built by other researchers. This repository is open to the international community so that researchers from around the world can obtain quality IP for free.

If you would like to access this resource, point your browser to www.eecs.umich.edu/umips.

~Catharine June

ERC REORGANIZES THRUSTS

Because of the unprecedented expansion of projects, the ERC instituted a significant structural change. With the intention of making the Center run more efficiently, Ken D. Wise made the following announcement:

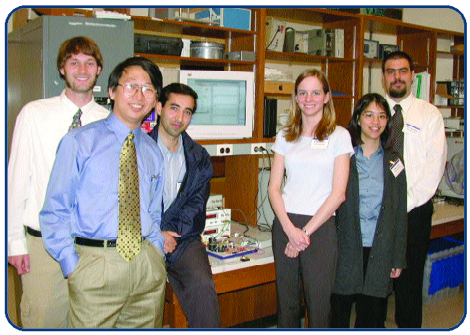
> For some time it has been evident that the Sensors and Microinstruments Thrust is very large and rather difficult to manage. It worked because Ted Zellers and I managed it jointly. . . . With the approval of the WIMS Executive Committee, and the NSF, we are dividing the Sensors and Microinstruments Thrust in two:
>
> ◆ Biomedical Sensors and Subsystems
>
> ◆ Environmental Sensors and Subsystems
>
> Daryl Kipke has agreed to serve as the leader for the Biomedical Sensors and Subsystems Thrust; Ted Zellers has agreed to serve as leader of the Environmental Sensors and Subsystems Thrust, and Yogesh Gianchandani has agreed to serve as leader of the Micropackaging Thrust.
>
> We commend the new thrust leaders for stepping up to the challenge.

STUDENT LEADERSHIP

The Student Leadership Council met with NSF representatives again this year during the Site Visit/Industrial Advisory Board meeting. We discussed strengths, weaknesses, and opportunities for the Center. Also students sat down and talked with the IAB members during informal, lunchtime "meet and greets," which proved to be beneficial for both parties.

A new setup was arranged for the poster session this year as well. Addressing some of the issues raised by students and IAB members about the lack of time and opportunity to talk about and present posters, the Center tried out a new–and by all accounts more successful–approach based on thrusts. If you missed the new and improved poster session in May, make sure to come out and see us in October!

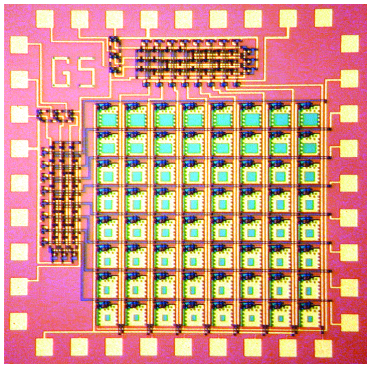
As we reported in past issues, the SLC continues to work with the Hands-On Museum–a nationally recognized children's museum located in downtown Ann Arbor–to create an interactive auditory prosthetic exhibit. The prosthetic device driving the exhibit is a working, first-generation cochlear synthesizer. As next-generation algorithms progress, they will be integrated with computing hardware and a customized display to enhance the exhibit's "hands-on" functionality.

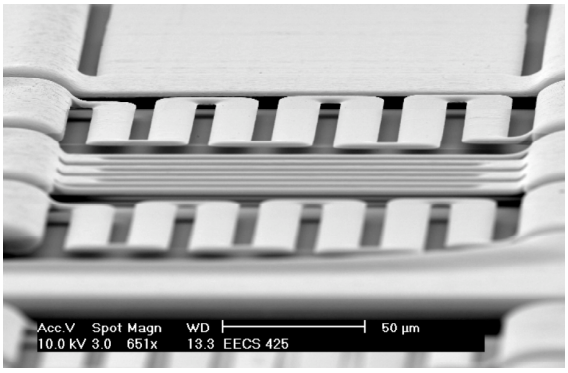


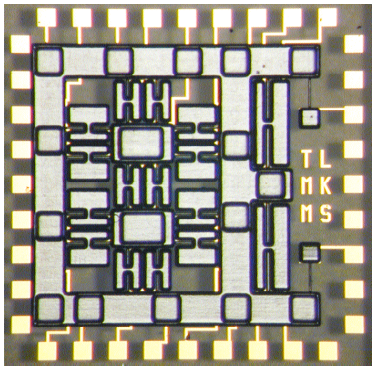
~T.J. Harpster

Highlights from the Combined NSF Site Visit/IAB Meeting in May

EDUCATION HIGHLIGHTS







INTEGRATED MICROSYSTEMS LABORATORY, 2003

Working in four-person teams, students last term developed thermal- and pressure-based flow microsystems, microvalves, and micropumps; visible and tactile imagers; microphones; digital micromirror displays; and a vibration spectrometer. For the first time, the course involved scholars from all three WIMS ERC universities. Course enrollment has increased from 13 to 48 students in three years.

INFLUENCING YOUNG MINDS

From January through April of this year, the eleventh grade class of Dr. Mary Brake at Mercy High School in Farmington Hills, Michigan, helped to pilot a pre-college course segment in WIMS. Hoping to especially motivate young women, Dr. Brake sought activities to demonstrate that engineering and science can be fun, while contributing beneficially to society.

The course segment featured Lego Mindstorm robotic units and digital gates. Mimicking human movement was emphasized during the building and programming phases of the segment. Digital activities included connecting NAND gates to confirm and understand both NAND functional operation and bistable RS flip-flop memory functional operation, demonstrating basic components of the robot controller. Al Tessmer, WIMS Program Associate, directed several workshops and arranged for other presentations by Student Leadership Council members. In one presentation, for example, Danielle Merriam introduced WIMS cochlear implant concepts. Another course highlight involved a class trip to the UM campus, where the students heard a talk by Prof. Ken D. Wise and afterwards engaged in a discussion with him about the human benefit of WIMS applications.

FIVE CORE COURSES ON THE BOOKS

EECS 514 Advanced MEMS Devices and Technology, a continuation of EECS 414, was taught for the first time by Prof. Khalil Najafi this past winter term. EECS 515 Advanced Integrated Microsystems is slated for fall 2003 as well. Both courses are offered to MSU and MTU students, via the distance education program UM has setup with the aid of the Center for Professional Development (CPD).

The introduction of EECS 514, along with the upcoming 515, rounds out the core set of five courses (EECS 414 Introduction to MEMS, EECS 425 Integrated Microsystems Laboratory, and EECS 830 Societal Impact Seminar) developed within the last year to provide new educational opportunities for students at all three partnering universities. Notably, EECS 425 is being used to provide projects and mentoring for high school students, linking university and pre-college educational efforts.

PERSONNEL FOCUS

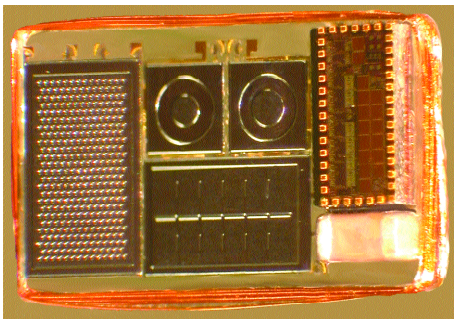
Professor Richard B. Brown, Micropower Circuits Thrust Leader, received the University of Utah's Electrical and Computer Engineering Department's Distinguished Young Alumnus Award. The award honors ECE students who have made significant contributions to their profession within 15 years of graduation. In bestowing the award on Prof. Brown, the University recognized some of his special accomplishments: starting the Integrated Circuit Design program at UM, organizing a student VLSI design contest that has turned into an international competition with awards presented at a major conference, and serving as interim chair for the EECS department at UM.

Professor Ernest "Charlie" Hasselbrink Jr. recently joined UM's Mechanical Engineering Department and quickly was brought into the WIMS ERC because of our common research interests. He specializes in microscale electrokinetic transport, flow control, and biochemical analysis. He is a *summa cum laude* graduate of the University of Houston and holds M.S. and Ph.D. degrees from Stanford. Previously he worked at Sandia National Labs, helping to create a self-contained, hand-held biotoxin sensor. With several patents to his name, he has spoken at conferences worldwide and served industry as a consultant. Prof. Hasselbrink brings a wealth of experience to the Center, and we welcome him as a close associate.

RESEARCH HIGHLIGHTS

EMERGING MICROSYSTEMS

In the system shown below, monolithic pressure-temperature-humidity sensors and a CMOS circuit chip realize a wireless RF-powered sensing module in a space of about 0.15 cubic centimeter. Intended primarily for implant applications, the sensing module also is going to be incorporated into both the ERC's environmental monitor and the microcomputer-controlled data logging system (shown at right). Combining a commercial microprocessor and flash memory with custom sensors and interface electronics, this system is realized on a silicon platform in a volume of less than 0.5cc (including the battery). It operates with an average power dissipation in the processor-memory core of only 16 µwatts from 3 volts at a data rate of 80 bits/second.



Sensing Module

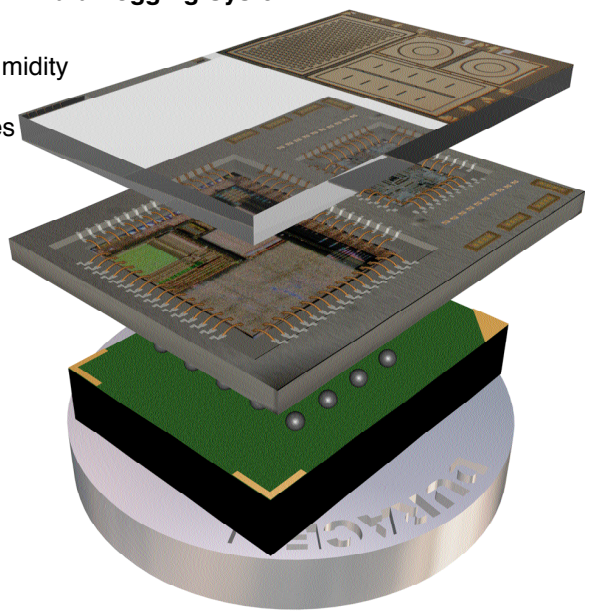
Sensor Suite
Pressure, Temperature, Humidity
X-Y Accelerometer
Off-board Neural Electrodes

Silicon Platform
Microconnections
Through-wafer Vias
Fully Recessed Chips

Electronics
On-board Microcontroller
Flash Memory (16Mbit)
Sensor Interface Chip

Power
3V Lithium Cell
Power Management
Low-power Electronics

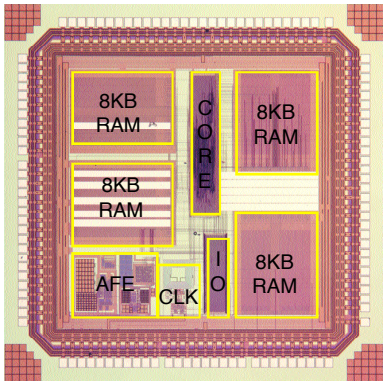
Data Logging System



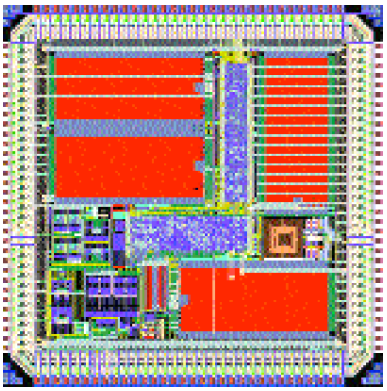
WIMS MICROCONTROLLER UPDATE

In trying to further improve the WIMS Microcontroller, we continue to explore novel architectural and circuit techniques to reduce power while maintaining an acceptable level of computational throughput. A Gen-0 baseline architecture has been fabricated in TSMC 0.18µm CMOS, and the digital core has been functionally verified at up to 43MHz operation. Notable features of this chip are the low voltage analog front end (AFE) and the on-chip CMOS-MEMS clock generator block (CLK) shown above. Preliminary testing of the AFE has demonstrated 12-bit resolution at a 75Hz conversion rate. The next generation of this chip, shown at right, will be fabricated in August 2003 and incorporates a totally redesigned AFE that should achieve even higher resolution than the prior version. Also, recent modifications to the WIMS instruction set will provide power efficient compiler support. Dynamic clock frequency selection has been added, which allows software to choose operating frequencies ranging from 3kHz to 94MHz that are generated from a 188MHz clock supplied by the on-chip clock generator block. Future versions of this chip will incorporate advanced power saving techniques to maximize the battery life of the WIMS systems.

~Robert Senger



Gen-0 WIMS Microcontroller Fabricated in TSMC 0.18µm CMOS (2.8mm x 2.8mm die)



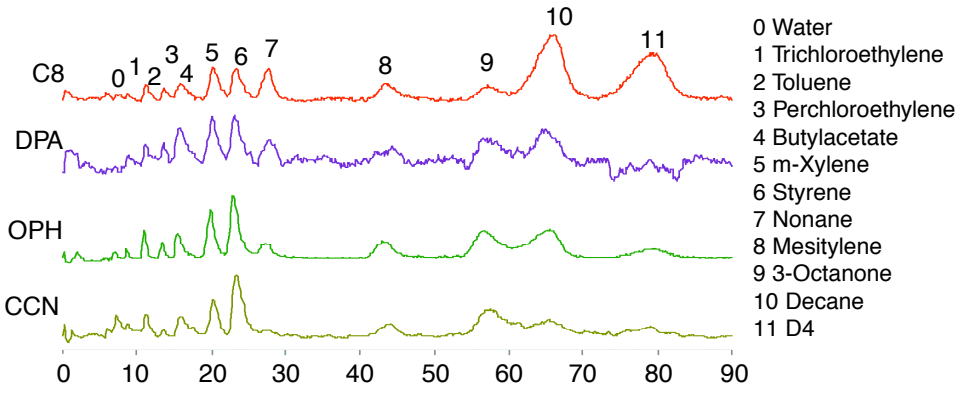
Gen-1 WIMS Microcontroller Designed in TSMC 0.18µm CMOS (3.6mm x 3.6mm die)

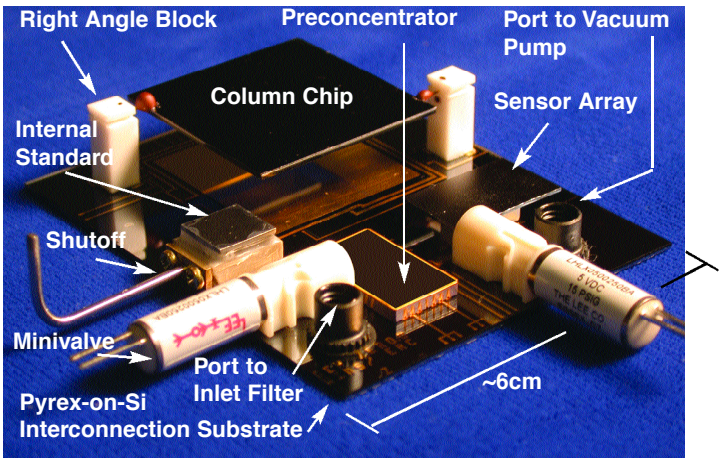
PROTOTYPES DEBUT

The Center's first MEMS Micro Gas Chromatograph (μGC) subsystem, referred to as the "Gen-00 prototype," made its debut in a series of highly successful demonstrations at the combined NSF Site Visit/IAB Meeting this past May. All of the key μGC analytical components (namely, a passive calibration-vapor source, three-stage preconcentrator/focuser, 3-meter separation column, and integrated vapor-sensor array) are fabricated from silicon and collectively occupy approximately 1cc. Plumbed via a fluidic interconnection substrate in combination with fused silica microcapillaries, the μGC is coupled with a commercial minidiaphragm pump and minivalves to perform analyses of various mixtures of toxic volatile organic compounds. Following preconcentration and separation of an 11-vapor mixture, parallel outputs emanate from an array of four chemiresistors (shown at top right). Projected detection limits are in the low part-per-billion (ppb) concentration range (unoptimized). A slightly different prototype, the "Gen-0" (at right), also has been assembled. It uses a sophisticated interconnection scheme and is mounted on, and electrically connected to, a printed circuit board containing a custom low-power microcontroller (initially in FPGA form); multinode sensor bus; analog-to-digital converter; capacitive ambient sensors (T, P, RH); and a commercial wireless transceiver. Fabrication of the electrostatically actuated, multistage micropump and latching microvalves will begin after successful preliminary testing.

~Edward Zellers

Four Parallel Outputs from μGC Chemiresistors





Gen-0 Prototype

INDUSTRIAL LIAISON'S REPORT

During July we held our Second WIMS ERC Retreat where approximately 80 students, faculty, and staff had an opportunity to meet and address the future direction of the ERC. Retreat participants had an opportunity to confront the major challenges to achieving our goals, including how to better couple our member companies with the ERC. The ERC is appreciative of the support for the Retreat provided by the Michigan Economic Development Corporation and, especially, Sandia National Laboratories. Sandia's significant donation underwrote most of the cost and is much appreciated.

The May IAB meeting provided our members two days to mingle with our students and faculty while they reviewed the Center's 114 projects. The IAB meeting also provided an opportunity for member companies to give brief presentations of their activities in the MEMS area. To encourage interaction between our students and member companies, this fall we will provide our members with a list of students available to intern in the coming year. This proactive measure should allow sufficient planning time for both the member companies and the students.

The next IAB meeting will be held October 15 and 16 at the Crowne Plaza in Ann Arbor, Michigan. In the meantime, if you are in the Ann Arbor area, we invite you to simply stop by anytime. We are always pleased to see our members on an informal basis.

Joseph M. Giachino
Associate Director
Industry

SEMINAR SERIES

January 7, 2003
Deborah Lickness
Deere and Company
MEMS Opportunities in John Deere Sensor Applications

January 14, 2003
Prof. Mark A. Shannon
University of Illinois, Urbana-Champaign
Silicon-Polymer MEMS Processing: Transforming Applications in Actuation, Sensing and Power

January 21, 2003
Prof. Don Reinhard
Michigan State University
Polycrystalline Diamond Film Optics

January 28, 2003
James R. Baker, Jr., MD
University of Michigan
Nanomolecular Therapeutics

February 4, 2003
Dr. Shari Ferrans
EV Group
Integrated Devices via State of the Art Alignment and Advanced Bonding Techniques

February 11, 2003
Prof. Chia-Jung (Vincent) Lu
University of Michigan
Portable Analytical System Employing Tunable Separation and Microsensor Array Detection for Volatile Organic Compound Monitoring

February 18, 2003
Haluk Kulah
University of Michigan
A Multi-Step Electromechanical Sigma-Delta Converter for Micro-g Capacitive Accelerometers

Hao Yu
University of Michigan
Low-Power Interface Circuits for Bio-Implantable Microsystems

March 4, 2003
Prof. Roger Howe
University of California, Berkeley, Berkeley Sensor and Actuator Center
Will MEMS Ever Really Matter to the Semiconductor Industry?

March 5, 2003
Dr. Shiuh-Wuu Lee
Intel Corporation, Logic Technology Development Group
Roles and Challenges for Technology CAD in Process Technology and Product Development

March 11, 2003
Prof. Ming C. Wu
University of California, Los Angeles
Optical MEMS from Micro to Nano Scale

March 18, 2003
Dr. Jeffrey DeNatale
Rockwell Scientific Company
RF MEMS - Device and Applications Studies

March 25, 2003
Prof. Victor Bright
University of Colorado
Innovative Fabrication, Integration, and Packaging for Reliable Microsystems

March 28, 2003
Prof. Masahiro Yamaguchi
Tohoku University, Research Institute of Electrical Communications
Ferromagnetic RF MEMS - Materials and Possible Applications

April 1, 2003
Dr. Arturo Ayon
Sony
Including a Microfabrication Foundry in Your Business Model

April 2, 2003
Prof. Ken D. Wise
University of Michigan
Integrated Sensors, MEMS, and Microsystems: Interfacing Electronics to the Non-Electronic World

April 8, 2003
Don Feuerstein
Suss MicroTec, Inc.
Driving Down the Cost of MEMS Production Through Wafer Level Test

April 17, 2003
Dr. Leonidas Ocola
Argonne National Laboratory
Requirements and Limitations for Nanoscale Electron-Beam Patterning

April 18, 2003
Roya Maboudian
University of California, Berkeley
Tribological and Materials Issues for High Reliability MEMS

June 17, 2003
Prof. L. Jay Guo
University of Michigan
Nanoimprinting Technology and its Applications

June 24, 2003
Dr. Long Que
University of Michigan
A Water Spectroscopy Microsystem with Integrated Discharge Source, Dispersion Optics, and Sample Delivery

June 24, 2003
Dr. Shamus McNamara
University of Michigan
A Micromachined Knudsen Pump for On-Chip Vacuum

PUBLICATIONS

IEEE MicroElectroMechanical Systems Conference, Kyoto, Japan, January 2003

J. Chae, H. Kulah, and K. Najafi
An In-plane High-Sensitivity, Low-Noise Micro-G Silicon Accelerometer

T. J. Harpster and K. Najafi
Field-Assisted Bonding of Glass to Si-Au Eutectic Solder for Packaging Applications

J. A. Potkay, J. A. Driscoll, M. Agah, R. D. Sacks, and K. D. Wise
A High Performance Microfabricated Gas Chromatography Column

B. H. Stark, Y. Mei, C. Zhang, and K. Najafi
A Doubly Anchored Surface Micromachined Pirani Gauge for Vacuum Package Characterization

X. W. Zhu, S. Guillaudeu, D. M. Aslam, U. Kim, B. H. Stark, and K. Najafi
All Diamond Packaging For Wireless Integrated Microsystem Using Ultra-fast Diamond Growth

Other Publications in January/February

J. Csicsvari, B. Jamieson, K. D. Wise, and G. Buzsaki
Mechanisms of Gamma Oscillations in the Hippocampus of the Behaving Rat
Neuron, 37, January 2003

K. K. Das and R. B. Brown
Ultra Low-Leakage Power Strategies for Sub-1 V VLSI: Novel Circuit Styles and Design Methodologies for PD-SOI CMOS Technology
16th IEEE International Conference on VLSI Design, New Delhi, India
January 2003

M. Müller, L. Bernal, P. Washabaugh, H. Kim, and K. Najafi
Resonance Effects of Electrostatically Actuated Acoustic Jets
41st Aerospace Sciences Meeting and Exhibit, Reno, NV, January 2003,
AIAA Paper 2003-1272

W. Tian and S. W. Pang
Thick and Thermally Isolated Si Microheaters for Microfabricated Preconcentrators
Journal of Vacuum Sciences and Technology B, Vol 21, Issue 1
January/February 2003

K. K. Das and R. B. Brown
Novel Circuit Styles for Minimization of Floating Body Effects in Scaled PD-SOI CMOS
IEEE Computer Society Annual Symposium on VLSI, Tampa, FL
February 2003

H. Kulah, J. Chae, N. Yazdi, and K. Najafi
A Multi-Step Electromechanical Sigma-Delta Converter for Micro-g Capacitive Accelerometers
International Solid-State Circuits Conference 2003, San Francisco, CA
February 2003

IEEE Southwest Symposium on Mixed-Signal Design, Las Vegas, NV, February 2003

M. Ghovanloo and K. Najafi
A Fully Digital Frequency Shift Keying Demodulator Chip for Wireless Biomedical Implants

P. Mohseni and K. Najafi
A Wireless FM Multi-Channel Microsystem for Biomedical Neural Recording Applications

1st International IEEE EMBS Conference on Neural Engineering: Merging Engineering with Neuroscience, Capri, Italy, March 2003

M. Ghovanloo, K. D. Wise, and K. Najafi
Towards a Button-Sized 1024-Site Wireless Cortical Microsystem

R. H. Olsson III, M. N. Gulari, and K. D. Wise
A Fully-Integrated Bandpass Amplifier for Extracellular Neural Recording

Other Publications in March-May

M. S. McCorquodale, F. H. Gebara, K. L. Kraver, E. D. Marsman, R. M. Senger, and R. B. Brown
A Top-Down Microsystems Design Methodology and Associated Challenges
Designers' Forum: Design Automation and Test in Europe Conference and Exhibition, Munich, Germany
March 2003

D. Rickard, R. Berger, E. Chan, B. Clegg, S. Patton, R. Anderson, R. B. Brown, D. Sylvester, M. R. Guthaus, H. Deogun, K. J. R. Liu, C. Pandana, and N. Chandrachoodan
BAE SYSTEMS Mission Specific Processor Technology
28th Annual Government Microcircuit Applications and Critical Technology Conference, Tampa, FL
March 2003

C. A. Rich and K. D. Wise
A High-Flow Thermopneumatic Microvalve with Improved Efficiency and Integrated State Sensing
IEEE Journal of MicroElectroMechanical Systems
April 2003

W. Zhang, D. Burke, H. Zhang, S. Choi, Y. Lee, R. B. Brown, and M. E. Meyerhoff
Electron-Relay Enabled Immunosensors using Magnetic Microspheres
Michigan Life Sciences Corridor Biotechnology Conference, Novi, MI
April 2003

S. M. Martin, R. M. Senger, E. D. Marsman, F. H. Gebara, M. S. McCorquodale, K. L. Kraver, M. R. Guthaus, and R. B. Brown
A Low-Power Microinstrument for Chemical Analysis of Remote Environments
NASA Symposium on VLSI Design, Coeur d'Alene, ID
May 2003

M. S. McCorquodale, M. K. Ding, and R. B. Brown
Study and Simulation of CMOS LC Oscillator Phase Noise and Jitter
International Symposium on Circuits and Systems, Bangkok, Thailand
May 2003

PRESENTATIONS

Invited Plenary Talk, SPIE's Micromachining and Microfabrication Symposium, San Jose, CA, January 2003
K. Najafi
Micropackaging Technologies for Integrated Microsystems: Applications to MEMS and MOEMS

DOCTORAL DISSERTATIONS

John R. Clark
VHF and UHF Micromechanical Disk Resonators for Wireless Communications
University of Michigan 2003
Job at Discera
Advisor: Prof. Clark Nguyen

Brian G. Jamieson
Highly-Parallel Recordings of Unit and Local Field Potentials with Active and Passive Neural Probes in Freely-Moving Animals
University of Michigan 2003
Job at NASA
Advisor: Prof. Ken D. Wise

Kevin Otto
Intracortical Microstimulation for Sensory Inputs in Brain-Machine Interfaces
University of Michigan/Arizona State University 2003
Post-Doctoral Fellow at UM
Advisor: Prof. Daryl Kipke

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

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