Spring 2006

WIMS WORLD

University of Michigan Michigan State University Michigan Technological University

Director's Message

We just completed the Sixth-Year Review of our Center and I am even more aware this year than in the past of the heroic efforts of our faculty, students, and (especially) staff. There were many late nights as we struggled with presentations, last-minute research results, and testbed demonstrations. The efforts caused me to reflect many times on a theme I talked about in the last newsletter—the importance of *teaming*. In industry, teaming is (or should be) the name of the game, but in academia it is not all that common, and yet no organization can succeed without it. And the words of U of M President Mary Sue Coleman that "there is something *magical* about team-building" kept coming to mind. If this Center has a secret behind its success it is *teaming*.

Teaming doesn't happen automatically, but I believe it can be taught. One example occurred in the course *Integrated Microsystems Laboratory* this past winter term. We had an all-time record of 48 students taking the course, and, working in four-person *teams*, each group defined, designed, fabricated, and tested a monolithic microsystem of their choice during the 14-week term. This would be difficult enough for an experienced engineer, but these students came from electrical, mechanical, chemical, and biomedical engineering backgrounds and many had never seen a layout tool. They designed MEMS chips and mixed-signal readout circuits, and I was very proud of their efforts. More importantly, by the end of the course I think *they* were proud of their efforts. Now, some of the chips did not work flawlessly, but I think at the end of the course *all* of the students knew what they would do differently if they had it to do all over again. And, confronted with a difficult interdisciplinary task, they learned teaming. They got a great example from our staff, who pitched in as needed to make things work and to help the different groups over the various hurdles in understanding what to do and how to do it. This *team* included the course instructor, the graduate student teaching assistant, a process engineer, an instrumentation engineer, and a set of doctoral students who served as mentors to the various groups. But beyond that, the students came to rely on, and learn from, each other. They learned *teaming*. It is true that the groups had differing degrees of synergy, but overall, the team members shared the load more or less equally and came to be mutually supportive. They became *teams*. A high point for me came when I was reading one of the midterm reports. At the end, the students included brief IEEE-style biographies of themselves, defined their project roles, and gave their group motto—"all for one and one for all!" That made me feel very good indeed.

Teaming is something I value among our staff, our faculty, our Student Leadership Council, and our student researchers. It means doing whatever is needed. It means sharing and not worrying about who gets the credit. It comes about by having important problems to solve that are too big for any single person and that are so important that they become a quest. As I look at the ERC, it is in the areas where teaming is most effective where we seem to make the most progress … and have the most fun doing it.

If there is an area where we don't do a good job, it is in keeping our students engaged after they graduate. Making sure this newsletter gets to all of them is a start, but one of my goals for this year is to (finally) organize an alumni brochure, so our current students can see where their predecessors are and what they are doing, and so our former students can keep track of each other. In doing so, perhaps we can help this concept of *teaming* reach out over decades.

Ken D. Wise

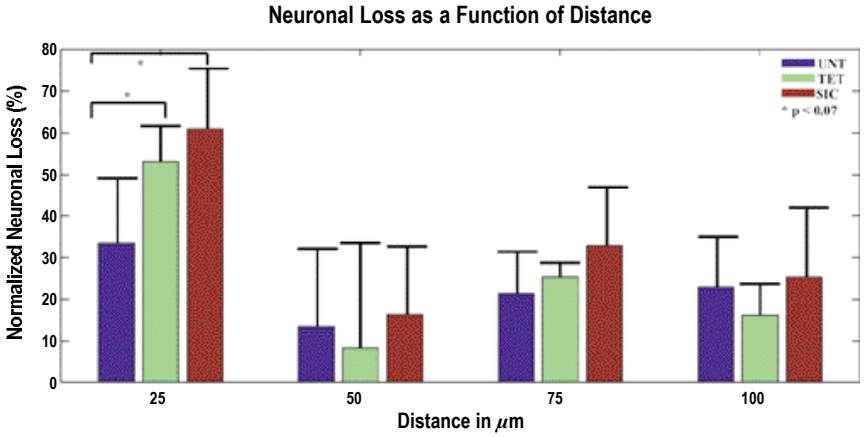
Director, Engineering Research Center for Wireless Integrated MicroSystems

Research Highlights

The Role of Flexible Polymer Interconnects in Chronic Tissue Response Induced by Intracortical Microelectrodes

Jeyakumar Subbaroyan and Daryl R. Kipke

Chronic tissue response induced by tethering is one of the major causes for implant failure in intracortical microelectrodes. We have explored the hypothesis that flexible interconnects can provide strain relief against forces of "micromotion" and hence can result in maintaining healthy tissue surrounding the implant. Finite element modeling results indicate that flexible interconnects, made from polyimide (E = 2 GPa) and polydimethylsiloxane (E = 6 MPa), reduce interfacial strain by 66% and two orders of magnitude, respectively. Three implants—an untethered probe, a tethered probe ("stiff"), and a free-floating probe ("flexible") in a fluidic chamber—were implanted in rat motor cortices. Quantitative immunohistochemistry results indicate that significant neuronal loss and up regulation of glial fibrillary acidic protein (GFAP), a marker for reactive astrocytes, occurred up to 100μm from the probe-tissue interface for all implants. Untethered probes caused significantly less neuronal loss (n = 3, p < 0.07) than both tethered and flexible implants in the first 25μm from the probe-tissue interface. These results are of considerable importance in the design of implantable neural microsystems.

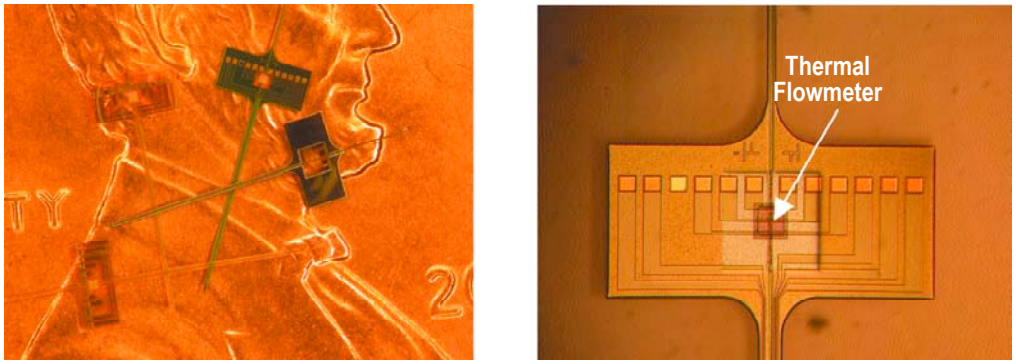


Normalized neuronal loss plotted as a function of distance from probe-tissue interface (UNT - Untethered implant, TET - Tethered implant, and SIC - Free-floating implant).

A Chemical-Mechanical-Polishing/Trench-Refill-Based Drug-Delivery Probe with In-Line Flow Measurement

Yang Li, Mayurachat Gulari, Sanford Bledsoe, and Kensall D. Wise

A new drug-delivery probe based on chemical-mechanical-polishing (CMP) and trench-refill techniques has been designed and fabricated as part of the ERC's efforts to develop implantable neural microsystems. With these new techniques, the dimensions of the channel cross-section can be reduced to less than 50μm^2 and channel formation yield is improved to above 90%. Probes made of dielectrics and silicon in combination or pure dielectrics have been fabricated along with integrated electrical recording sites for monitoring cellular activity as a function of drug dose. Testing has established the robustness of these new structures for *in-vivo* applications. In-line thermal flowmeters have been integrated into the probes surrounded by a dielectric thermal-isolation structure that is expected to improve thermal efficiency by at least 20% compared with earlier devices. Together with the reduced channel cross-section, flow resolutions as low as 200pL/sec are expected.

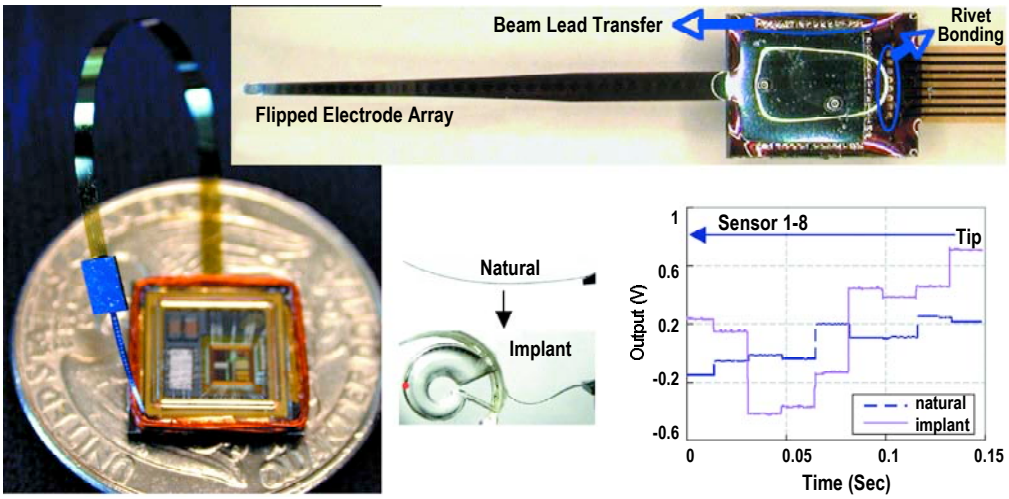


Dielectric-Silicon and all-dielectric drug-delivery probes fabricated using a new CMP/trench-refill process and containing in-line flowmeters.

An Integrated Position-Sensing System for a MEMS-Based Cochlear Prosthesis

Jianbai Wang, Jamie F. Hetke, Pamela T. Bhatti, Timothy J. Harpster, Brendan Casey, Mayurachat Gulari, and Kensall D. Wise

The WIMS ERC is developing an implantable MEMS-based cochlear prosthesis that provides high-density stimulation and embedded position sensing to achieve high-quality sound perception, minimize insertion damage, and optimize implant placement in restoring hearing to the profoundly deaf. A custom integrated circuit (ASIC) mounts on the rear of a 32-site thin-film electrode array, interfacing with a hermetically packaged WIMS microcontroller and wireless chip over an 8-lead polymeric cable. The 2.4mm x 2.4mm ASIC chip operates on 5 volts and performs command validation, stimulus generation, sensor selection, offset compensation, and signal conditioning (amplification and band-limiting). The electrode array incorporates polysilicon piezoresistors to sense array position and wall contact. The position sensors have typical gauge factors of 15, while the wall contact sensor at the tip of the array provides a contact signal of more than 100mV. Arranged in eight segments that cover the length of the array, the position sensors allow overall array shape to be determined to better than 50μm.



In the WIMS cochlear prosthesis (left), a hybrid multi-site electrode (right top) is flip-chip bonded to a signal-processing chip (ASIC). Array position/shape and wall contact are monitored by sensors distributed along the shank (right bottom).

Faculty/Student Awards

Assistant Professor Jerome P. Lynch has been selected to receive a 2007 Henry Russel Award. This award, which recognizes both exceptional scholarship and conspicuous ability as a teacher, is one of the highest honors the University of Michigan bestows upon junior members of its faculty. It will be presented during the next Henry Russel lecture on March 13, 2007.

Jing Wang, PhD candidate in electrical engineering, received a 2006 American Society for Engineering Education (ASEE) Outstanding Student Instructor Award. Jing was selected from an impressive group of 23 nominated Graduate Student Instructors (GSIs), the very top of the almost 250 GSIs within the University of Michigan College of Engineering. The selection committee was composed of a broadly representative group of undergraduates, graduate students, faculty, staff, and administration.

Ruba Borno and **Jorge Pernillo**, WIMS ERC graduate students in electrical engineering, were each awarded an Intel Foundation PhD Fellowship. This program awards two-year fellowships to PhD candidates pursuing leading-edge work in fields related to Intel's business and research interests.

Ruba Borno was also recently awarded the Marian Sarah Parker Prize for Outstanding Woman Graduate Student in the U of M's College of Engineering. The Parker Prize is presented to a female graduate student who has demonstrated academic excellence, leadership qualities, and noteworthy contributions to the University or community.

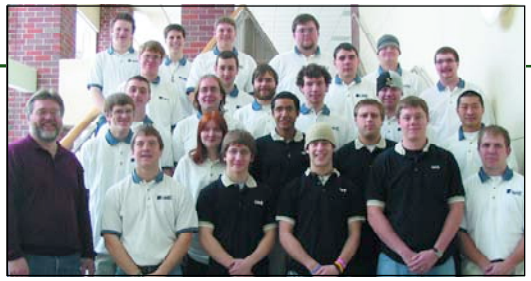
Special Feature

Integrated Microsystems Enterprise

The Integrated Microsystems Enterprise (IME) is one of the ERC's flagship educational programs, enabling scientific and technological education at all ages using integrated systems development at the micro scale. Initiated in September 2001, this undergraduate program at Michigan Technological University is focused on developing a portable sensor platform that can wirelessly communicate processed sensory information to a variety of portable or desktop computers using Bluetooth or Zigbee wireless protocols.

The Data Acquisition Cube (DAC) is the cornerstone of the development efforts in IME and is shown in Figure 1. It was developed by undergraduates and faculty as an enabling technology for precollege science and engineering education, coupling a sensor-enabled portable platform (the DAC) with custom software operating on wirelessly enabled Palm OS and Windows platforms. Inertial, pressure, strain, temperature, pH, and light sensors have been demonstrated on this platform. The DAC platform will be utilized in the classroom in the local intermediate school district near Michigan Technological University through a partnership with the local schools and science and mathematics teachers. Hardware and software will be delivered in October 2006 to each district in the region through a continuing Teacher Workshop program supported by the ERC. The successful demonstration of the Data Acquisition Cube has resulted in several commercial application spin-offs,

Figure 1 – The Data Acquisition Cube at left, is the cornerstone of the Transportable Research Instrument concept for precollege science and mathematics visualization. At right is an exploded view of the Cube's components.



Professor Paul Bergstrom and the 2005–2006 Integrated Microsystems Engineering Enterprise team at MTU.

including the Roadbed Assessment Transmitter (RAT) and Cardiopulmonary Resuscitation Training Sensor, shown in Figures 2 and 3, respectively. These sensor platforms are designed to be the size of typical aggregate and include sensory input, data logging, and wireless data transmission upon request. The RAT is an embedded sensor platform for temperature, density, and chloride concentration for distributed sensing of civil infrastructure during construction and through subject lifetime. The CPR Training Sensor has been developed in

Figure 2 – The Roadbed Assessment Transmitter is roughly the size of aggregate and includes embedded data logging and wireless transmission.

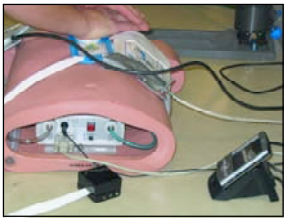


Figure 3 – The CPR Training Sensor is intended for use during actual CPR effort in the field. Sensory input and signal processing will result in more effective CPR delivery.

partnership with a small Michigan company in order to enhance the efficiency of CPR for qualification and actual delivery. Other spin-off platforms include the recent development of a system designed to mitigate motion fatigue for people in transports over rough terrain.

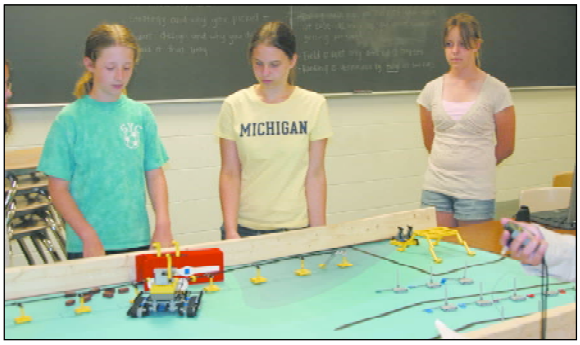
Recent Events

Hilton Head Solid-State Sensors, Actuators, and Microsystems Workshop 2006

The Michigan contingent at the June 2006 Hilton Head Solid-State Sensors, Actuators, and Microsystems Workshop included over two dozen attendees. Michigan presented 18 of the 132 papers given at the meeting, more than any other organization. Michigan alumnus Leland "Chip" Spangler served as technical program chairman (a fact that we maintain had absolutely no effect whatsoever on the success of Michigan paper submissions) and will be general chairman at the next such meeting in 2008. Joseph Giachino received recognition and high praise for his long service as treasurer of this and all the other Hilton Head meetings since 1984.

Education Highlights

Girls In Science and Engineering (GISE) Summer Day Camp



These participants and their robot won the competition.

For one week in June, 111 girls just completing 7th and 8th grades, from 54 cities and 64 schools, came to the U of M for the Girls In Science and Engineering (GISE) summer day camp. The camp was sponsored by U of M's Women In Science and Engineering program (WISE), in cooperation with the U of M's Medical School, College of Engineering, College of Literature, Science, and Arts, and the WIMS ERC.

Fourteen of these girls spent half of each day participating in a WIMS-affiliated educational outreach program, where they designed and programmed unique robots to perform specific tasks. The WIMS ERC was instrumental in jump-starting this program, by serving as a consultant; providing support, training, and inspiration; and by encouraging more young girls to become interested in the field of engineering. The Center also provided space, equipment, and computers for these fourteen students. As a result of the affiliation with the GISE program, a WIMS LEGO Robotics girl's team has been established.

As a whole, the GISE camp activities engage girls in science- and engineering-related hands-on activities that are both fun and challenging. Campers choose a focus project in a particular subject area to attend each morning, e.g., chemistry, computer science, engineering, human genetics, physics, or robotics, taught by U of M faculty, staff, and students. Afternoons are spent in a variety of hands-on science and engineering activities, including group collaborative competitions, laboratory tours, and learning about science and engineering careers.

One evening, the girls stayed late to eat in the dorm and listen to U of M researchers talk about science and engineering topics. On the last evening, parents and family members attended an informative session by U of M admissions counselors. Parents and campers alike praised the camp for its balance of academics and fun, and for the opportunity of bringing science- and engineering-minded girls together.

Personnel Focus

Drew Kim, newly appointed Assistant to the Dean, is Director of Recruitment and K–12 Education in the Engineering Department at Michigan State University. Kim is also Program Associate for K–12 education at the WIMS ERC. He is busy recruiting students outside of Michigan to increase the number studying engineering. With the number of college students entering the field of engineering dropping of late, the college is stepping up its recruitment efforts. Kim says, "K–12 outreach is important because it gets young people into the pipeline. If we don't put efforts into preparing students early on in science, math, and engineering, the U.S. will not continue to be a powerhouse in engineering."

Kims relies on numerous ways to teach K–12 students about engineering concepts, and to raise interest in engineering studies. Outreach programs that are available include High School Engineering Institute (HSEI), Detroit Area Pre-College Engineering Program (DAPCEP), Wireless Integrated MicroSystems (WIMS) for Teens, and Women in Engineering (WIE).

Three of the most popular are the outreach programs that use the LEGO MINDSTORM Robotics Invention System, a kit that consists of bricks, motors, sensors, gears, and software. The largest such program is the FIRST LEGO League (FLL), which is aimed at students aged 9 to 14. The MSU College of Engineering sponsored two teams from area schools in the past; that number will now increase to ten, thanks to a generous $33,000 grant from Shell Oil Company. Kim is ecstatic: "This Shell grant is very timely. It's a great way for us to reach out to the community and collaborate with students, teachers, and parents in area schools in order to produce well-prepared 'future engineers.'" Bringing high school students to MSU's research labs is another way to attract them into the field of engineering.

"Statistics show that a high percentage of pre-college students who attend engineering programs like these at MSU end up enrolling as students at MSU," Kim explains. Specific recruitment objectives include (1) developing consistent correspondence with prospective students and parents that is personal and timely in order to keep MSU Engineering on their "radar" screen, (2) refining and centralizing records of prospect inquiries and campus visits with the college, (3) working closely with the college's Diversity Programs Office to continue to recruit strong minority prospects, (4) centralizing communication with high schools and community colleges in specific markets to promote MSU and the College of Engineering, (5) collaborating with the Undergraduate Studies Office to track prospects and obtain the most recent survey data to modify the recruiting strategy accordingly, (6) refining the College of Engineering Website to make it more attractive to prospective students, and (7) working with Engineering Development to identify engineering alumni who may support the recruitment initiatives and specify ways they can assist in recruiting students from their "home" communities.

The college is counting on alumni and faculty to help with the recruitment process, serve as good resources, and foster a diverse set of high-quality students. Kim beckons, "If you know students who are interested in an engineering career, send them our way."

For more information, contact Drew Kim at kima@egr.msu.edu. or 517-353-7282.

Recent Events (continued)

NSF Site Team Visit and Industrial Advisory Board Meeting Held in May

Poster Sessions and Laboratory Tours

The WIMS ERC hosted its annual NSF Site Team Visit and Industrial Advisory Board Meeting on the University of Michigan's North Campus, May 23–25, 2006. This year, the meetings were held concurrently in the Lurie Engineering Building, Duderstadt Center, and the new Computer Science and Engineering Building. WIMS ERC Director Ken Wise gave a Center update, and the thrust leaders apprised participants of the latest advances in their areas of research.

Participants toured the new laboratories in the EECS building and saw demonstrations set up by WIMS ERC graduate students, who displayed the latest advances in projects, such as the environmental monitoring testbed, which features the micro gas chromatography system and supporting technologies, including software. Another laboratory displayed the ad-hoc networking, data-collection and embedded intelligence capabilities of the Narada wireless sensing units using the IEEE 802.15.4 communication protocol. These units are optimized for use in structural health monitoring and control, but researchers are also developing the 802.15.4 protocol for future implementation on the WIMS microcontroller.

During the poster sessions, IAB members and the NSF site team had the opportunity to meet with WIMS ERC graduate students at their posters to discuss the projects in greater detail. This also allowed the students to meet directly with representatives of industry and make contacts for future endeavors.

Industrial Liaison's Report

WIMS ERC Fall IAB Meeting
October 24–25, 2006

We have just completed a very exciting time for the Center. In late May, the Industrial Advisory Board and the NSF Site Team came to the Center for an in-depth review of our programs. Immediately after the completion of these reviews, some of our researchers were off to present at the International Symposium on Capillary Chromatography, while another group of researchers presented papers at the Solid-State Sensors, Actuators, and Microsystems Workshop. At the same time, several students staffed an informational booth at SENSORS EXPO, where they also presented a paper. This whirlwind of activity all occurred in the span of three weeks.

This activity can, in large part, be attributed to the fact that much of our students' research is now culminating in systems that show commercial promise. Both the academic community and the business community continue to recognize that microsystems, and in particular, wireless microsystems, are a growth area. Our member companies have had the opportunity to follow the development of both our research and our students. This sustained interaction among member companies, students, and faculty has given each a better understanding of the others' mutual aims and goals. The better communication between students and companies has led companies to recognize that the training the WIMS students receive in systems engineering makes them more productive more quickly in an industrial environment than without such exposure. WIMS students learn firsthand that teamwork and system-based approaches are critical to success. That is, they understand that the individual projects must support the system overall. The Center plans to continue developing our systems to make them commercially viable while incorporating leading-edge technology.

If you, or one of your colleagues, are interested in sharing your activities with our students, please contact me at either 734-615-3096 or giachino@eecs.umich.edu so we can schedule a seminar.

As always, please visit when in the Ann Arbor area so we can share our latest technical developments and our progress with the laboratory expansion.

Joseph M. Giachino
Associate Director, Industry

Presentations and Publications

Conference Presentations

2006 Materials Research Society Spring Meeting, San Francisco, CA, April 2006

E. K. Purcell, J. Seymour, and D. R. Kipke, "A Neural Stem Cell-Seeded Open Channel Probe," Session CC7.4

J. Subbaroyan, K. Pennington, and D. R. Kipke, "Chronic Tissue Response Induced by Flexible Polymer Interconnects at the Electrode-Tissue Interface," Session CC2.5, Paper #0926–CC02–04

IEEE International Symposium on Circuits and Systems (ISCAS), Kos Island, Greece, May 2006

H. S. Savci, Z. Wang, A. Sula, N. S. Dogan, and E. Arvas, "A 1-V UHF Low Noise Amplifier for Ultralow-Power Applications," Lecture

Z. Wang, H. S. Savci, and N. S. Dogan, "1-V Ultra-Low-Power CMOS LC VCO for UHF Quadrature Signal Generation," Lecture

Solid-State Sensors, Actuators, and Microsystems Workshop, Hilton Head Island, SC, June 2006

K. Baek, Y. Li, M. N. Gulari, and K. D. Wise, "A Pneumatically-Actuated Microvalve for Spatially-Selective Chemical Delivery," *Digest*, pp. 155–158

C. K. Eun, R. Gharpurey, and Y. B. Gianchandani, "A Magnetically Enhanced Wireless Micro-Geiger Counter," *Digest*, pp. 236–239

T. V. Galchev, W. C. Welch III, and K. Najafi, "Silicon-On-Silicon (SOS): A New CMOS Compatible Low-Temperature MEMS Process Using Plasma Activated Fusion Bonding," *Digest*, pp. 100–102

H. Kim, A. Astle, K. Najafi, L. P. Bernal, and P. Washabaugh, "Integrated Peristaltic 18-Stage Electrostatic Gas Micro Pump with Active Microvalves," *Digest*, pp. 292–295

H. Kim, A. Jauregui, C. Morrison, K. Najafi, L. P. Bernal, and P. Washabaugh, "Low-Power Electrostatic Helmholtz-Resonance Microjet Generator for Propulsion and Cooling," *Digest*, pp. 296–299

M. M. Maharbiz, "Self-Assembly of a BioMEMS Syllabus: Teaching BioMEMS Through the Developing Organism," *Educational Poster Digest*, pp. 48–50

L. C. McAfee Jr., K. Najafi, Y. B. Gianchandani, K. D. Wise, and M. M. Maharbiz, "A MEMS/Microsystem Curriculum with International Dissemination," *Educational Poster Digest*, pp. 1–6

J. S. Mitchell and K. Najafi, "Backside Resistive Localized Heating for Low Temperature Wafer-Level Bonding and Packaging," *Digest*, pp. 352–355

J. S. Mitchell, G. R. Lahiji, and K. Najafi, "Long-Term Reliability, Burn-In and Analysis of Outgassing in Au-Si Eutectic Wafer-Level Vacuum Packages," *Digest*, pp. 376–379

K. Najafi and M. M. Maharbiz, "What Should a First College Course on MEMS Be?," *Educational Poster Digest*, pp. 55–58

J. M. Park, R. P. Taylor, A. T. Evans, T. R. Brosten, G. F. Nellis, S. A. Klein, J. R. Feller, L. Salerno, and Y. B. Gianchandani, "A Piezoelectrically Actuated Ceramic-Si-Glass Microvalve for Distributed Cooling Systems," *Digest*, pp. 248–251

J. A. Potkay, G. R. Lambertus, R. D. Sacks, and K. D. Wise, "A Low-Power Pressure- and Temperature-Programmable microGC Column," *Digest*, pp. 144–147

M. T. Richardson, R. Gharpurey, and Y. B. Gianchandani, "Wireless Sensing of Discharge Characteristics for Quality Control in Batch Mode Micro-Electro-Discharge Machining," *Digest*, pp. 404–407

A. B. Ucok, J. Giachino, and K. Najafi, "Testing and Assembly of WIMS Cubes Containing Passive and Active Integrated Cables," *Digest*, pp. 400–403

K. D. Wise, K. T. Beach, T. F. Briggs, R. J. Gordenker, and M. N. Gulari, "An Interdisciplinary Laboratory Course in Microsystem Development," *Educational Poster Digest*, pp. 10–13

S. W. Yoon, S. Lee, N. C. Perkins, and K. Najafi, "Shock Protection Using Soft Coatings as Shock Stops," *Digest*, pp. 396–399

W. Zhu, D. W. Hoch, G. F. Nellis, S. A. Klein, and Y. B. Gianchandani, "A Planar Glass/Si Micromachining Process for the Heat Exchanger in a J-T Cryosurgical Probe," *Digest*, pp. 51–55

Other Conference Presentations

Society for Biomaterials Annual Meeting and Exposition: New Applications and Technologies, Pittsburgh, PA, April 2006

E. K. Purcell and D. R. Kipke, "In Vitro Development and Characterization of a Cortical Neural Stem Cell-Seeded Alginate Scaffold"

2006 NSTI Nanotechnology Conference and Trade Show, Boston, MA, May 2006

K. D. Wise, "Wireless Integrated Microsystems: Coming Revolution in the Gathering of Information," (Invited Keynote), *Digest NSTI Nanotech '06*, vol. 3, pp. 455–458

American Society for Engineering Education Annual Conference (ASEE), Chicago, IL, June 2006

D. M. Aslam, "Technology Assisted Science, Engineering and Mathematics (TASEM) Education at All Levels Using K–PhD Concept," Paper #2645

L. C. McAfee Jr., Y. B. Gianchandani, K. Najafi, M. M. Maharbiz, K. D. Wise, "MEMS and Microsystem Courses with National and International Dissemination," Paper #2332

Publications

L. L. Chu, L. Que, A. D. Oliver, and Y. B. Gianchandani, "Lifetime Studies of Electrothermal Bent-Beam Actuators in Single Crystal Silicon and Polysilicon," *Journal of Microelectromechanical Systems*, vol. 15, no. 3, pp. 498–506, June 2006

A. DeHennis and K. D. Wise, "A Fully Integrated Multisite Pressure Sensor for Wireless Arterial Flow Characterization," *Journal of Microelectromechanical Systems*, vol. 15, no. 3, pp. 678–685, June 2006

T. Li and Y. B. Gianchandani, "A Micromachining Process for Die-Scale Pattern Transfer in Ceramics and its Application to Bulk Piezoelectric Actuators," *Journal of Microelectromechanical Systems*, vol. 15, no. 3, pp. 605–612, June 2006

D. F. Lemmerhirt and K. D. Wise, "Chip-Scale Integration of Data-Gathering Microsystems," *Proceedings of the IEEE*, vol. 94, vol. 6, pp. 1138–1157, June 2006

Doctoral Dissertations

Nader Behdad, "Developing High-Performance, Multi-Functional, and Miniaturized Integrated Antennas"
University of Michigan, 2006
Postgraduate Position: Assistant Professor at University of Central Florida, Fall 2006
Advisor: Kamal Sarabandi

Jia-Yi Chen, "Design of Low-Power Super-Regenerative Receivers"
University of Michigan, 2006
Postgraduate Position: Senior Engineer, Qualcomm, San Diego, CA
Advisor: Michael P. Flynn

Yuan Xie, "Micromachined Extensional Wine-Glass Mode Ring Resonators for Wireless Communication"
University of Michigan, 2006
Postgraduate Position: Avago Technologies, San Jose, CA
Advisor: Clark T.-C. Nguyen

Xiangwei Zhu, "CVD Polycrystalline Diamond (Poly-C) Thin Film Technology for MEMS Packaging"
Michigan State University, 2006
Advisor: Dean M. Aslam

Seminar Series

* **April 4, 2006**
Professor Cristina E. Davis
Department of Mechanical and Aeronautical Engineering
University of California, Davis
"Integrated Sensor Systems for Clinical Diagnostics and Biodefense"

April 11, 2006
Aravind Padmanabhan, PhD
Honeywell
"MEMS/Microsystems Technology Developments at Honeywell Automation and Control Solutions"

* **April 18, 2006**
Professor Dan Merfeld
Jenks Vestibular Physiology Laboratory
Massachusetts Eye and Ear Infirmary
Harvard Medical School
"Vestibular Prosthetics: A Series of Multi-Species Investigations"

* **May 4, 2006**
Professor Kensall Wise
University of Michigan
WIMS ERC
"WIMS Overview"

* **May 9, 2006**
WIMS ERC Research Thrust Leaders
University of Michigan
"Overview of the WIMS Center Research Thrusts"

* **May 12, 2006**
Stewart S. Taylor, PhD
Communications Circuit Lab
Corporate Technology Group
Intel
"CMOS RF Roadmap"

* **May 16, 2006**
Professor Alan C. Seabaugh
Department of Electrical Engineering
University of Notre Dame, Indiana
"Tunneling Devices and Circuits"

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