Fall 2005

WIMS WORLD

University of Michigan Michigan State University Michigan Technological University

Director's Message

I was sifting through some boxes in the basement recently when I ran across the little engraved nametag that once rested outside my first office at Bell Telephone Laboratories. In the early 60s, Murray Hill was a great place to start a career. It was still basking in the glow of having launched the first communications satellite (Telstar), opening a new era in telecommunications. I remember well the first live broadcast to Europe—it was pure Americana—the Mormon Tabernacle Choir singing "America the Beautiful" in front of Mount Rushmore. I think all of us were proud to be working at BTL in those days. There was a feeling of unlimited possibilities. It was a national, and a global, resource.

Today, there is no more Bell Labs, at least not like it was, nor are there the other industrial research laboratories that dotted the landscape then. Those places, more perhaps than academia, drove the progress that we have enjoyed in the decades since. One wonders where future progress will come from. Is the U.S. research enterprise still healthy? There was a theory some years ago that since industrial research has fallen victim to the next profit-or-loss statement that universities would pick up the slack, and yet we have seen little increase in industrial funding for research at universities. And from my perspective at least, there has also been relatively little increase in federal funding for university research. The proposal success rate at many federal funding agencies is appallingly low. That may indicate that there are a lot of very bad proposals being written, but it is also likely that there just isn't nearly enough money to fund everything that should be funded. That is especially disturbing given that we live today in an era when our standard of living increasingly depends on technological innovation. We seem to be selling our futures for (perceived) short-term gains. The expression "eating our seed corn" keeps coming to mind. We have simply got to make engineering more attractive as a profession, get more young people into engineering, and increase the funding available for research. These should be national imperatives.

Now I don't mean just blue-sky research. Most of the things I am talking about are very application driven, trying out new ways of doing things with new materials, structures, devices, and circuits. At Bell Labs in the 60s, this sort of thing was in "Area 2." I shared a taxi ride into San Francisco earlier this month with a friend who is looking to move from industry to academia, and we mused a bit about funding and the academic research enterprise. Some federal agencies that used to be known for funding long-range research have recently moved more and more strongly to funding approaches that are short term and increasingly unfriendly to academia. Twelve or eighteen month go/no-go milestones are incompatible with university research and ignore the most important benefits from the highly-successful government-university research partnership that has been in place since World War II—highly-trained technical leaders and innovators. We are eating our seed corn.

Bell Telephone Laboratories at Murray Hill, New Jersey, in 1964: a research powerhouse from which came many of the developments that shaped modern microelectronics and communications technology.

The research engine that has served us so well for so long seems to be sputtering. It may or may not be any harder today for a young faculty member to get going than it was back in the 60s and 70s. Certainly there are a number of programs for bright young faculty today that didn't exist back then. And the NSF Engineering Research Centers Program is one that attempts to strike a balance among fundamental research, enabling technology, and engineered systems. But in other areas, the picture is less rosy. Back in the 50s, in the hit musical "Gigi," Maurice Chevalier sings "I'm so glad that I'm not young anymore!" That's been running through my head a lot lately, but we've got to be more effective if we are going to preserve our technological edge for our children and their children. I hope the WIMS ERC is contributing to that goal.

Ken D. Wise

Director, Engineering Research Center for Wireless Integrated MicroSystems

Inside

Research Highlights

Transpiration Actuation: Microactuation and Self-Assembly Powered by Evaporation

Ruba T. Borno and Michel M. Maharbiz

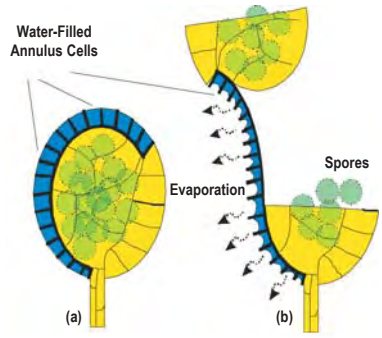


Figure 1 – Illustration of the actuation mechanism of fern sporangium: (a) before and (b) after evaporation-induced opening to release spores.

There is an increasing desire to embed actuation into normally inert materials (so-called "smart materials") for commercial textile, personal protection, and self-assembly manufacturing applications. Additionally, technology miniaturization into the micro- and nano-scale, and the increasing decentralization of sensing and computation, necessitate novel energy-scavenging technologies for WIMS applications. In response, researchers at the University of Michigan have made large-displacement, distributed-force polymer actuators powered only by the surface tension of water and evaporation. The devices were inspired by the hygroscopic spore dispersal mechanism in fern sporangia (Figure 1). A silicone polymer was used to mimic the mechanical characteristics of plant cellulose. The fabricated devices experienced tip deflections up to 4.5mm (10x the device radius) and angular rotations of more than 330° due to the evaporation of water at room temperature (Figure 2). Initial results indicate that the transient water-driven deflections can be manipulated to generate devices that self-assemble into stable configurations (Figure 3). Lastly, an analytical model shows that devices should scale well into the deep submicron. The actuation mechanism presented may provide a robust method for embedding geometry-programmable and environment-scavenged force generation into common materials. This mechanism also enables actuation in WIMS devices powered only be evaporation of water.

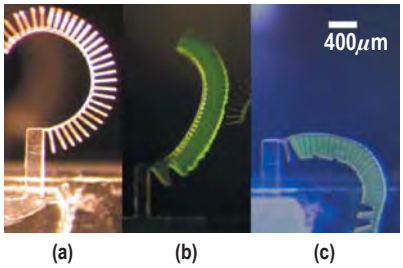


Figure 2 – A microactuator showing actuation due to evaporation: (a) before adding water, (b) after adding water, and (c) fully deflected with water. Fluorescein dye was used to show the liquid.

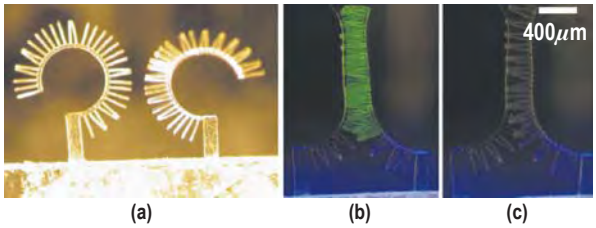
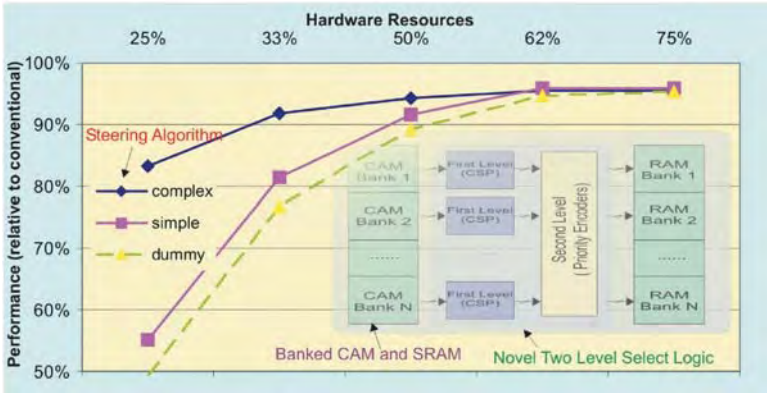


Figure 3 – Two microactuators arranged so that the transient actuation due to evaporation leaves them in a stable configuration after they dry. (a) Microactuators are shown before adding water. (b) After adding water independently to each structure, they interlock into a new configuration. (c) Fluorescein dye is used to show how the liquid phase dries.

Distributed Instruction Queue for Low-Power Microprocessors

Junwei Zhou and Andrew J. Mason



The proliferation of wireless and portable systems and the growing field of sensor networks have heightened the demand for energy-efficient microprocessors. In a superscalar microprocessor, the instruction queue (IQ) is a very energy-inefficient unit consisting of a CAM, select logic, and an SRAM. A distributed IQ has been developed to enable a tradeoff between performance and power consumption through allocation of hardware resources. The distributed IQ introduces an additional instruction-steering stage to improve hardware utilization and achieve higher energy efficiency. Simulations on SPEC 2000 benchmarks show that, with a simple steering algorithm, a distributed IQ with 75% hardware resources can achieve 96% IPC performance compared to the conventional IQ and can still achieve 55% performance with as little as 25% hardware resources. To further improve the IQ, a two-level select logic unit has been implemented. In the first level, cyclic segmented prefix (CSP) circuits implement an oldest-first selection policy, and final select arbitration is achieved by a simple position-based circuit in the second level. With dynamic logic implementation, the two-level select logic reduces delay by 32% compared to the conventional approach.

Single-Channel Microsystem for the Recording of Biopotentials From Motor Cortex of the Brain

Amir M. Sodagar, Gayatri E. Perlin, Khalil Najafi, and Kensall D. Wise

There is growing interest in recording neural activity in the motor cortex of the brain on a long-term basis. The realization of micro-systems for this purpose requires the successful integration of high-density electrode arrays, cables for connecting the electrode signals to integrated amplifiers, an implantable signal processor for separating the signals of interest (neural spikes) from background noise, and an inductively coupled wireless link to transmit the neural signals to the outside world. A single-channel microsystem for performing these functions is in development. A neural signal is amplified, properly filtered, and delivered to a spike detector chip that identifies the neural spikes. The generated serial bit stream is transmitted to the outside world over a reverse telemetry wireless link.

To realize the system, a passive microprobe, a miniaturized ribbon cable, a signal conditioning chip, a spike detector chip, a telemetry chip, and an off-chip SMD resonator are assembled on a silicon platform, as shown in Figure 1.

Figure 2 shows the system's output from an *in-vivo* experiment, in which the sensed signal is preconditioned, its negative spikes (true neural activity) are detected, and the neural spikes only are telemetered to the outside world.

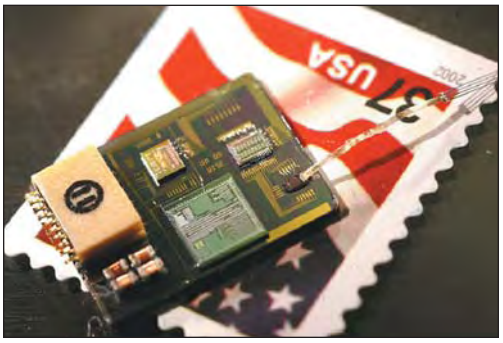


Figure 1 – Single-channel cortical recording prototype system on a silicon platform.

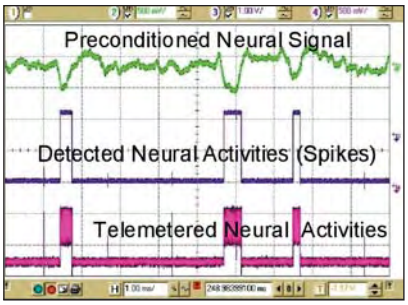


Figure 2 – System results from in-vivo experiments.

Long-Term Vacuum Testing of a Gold-Silicon Eutectic Wafer-Level Vacuum Package

Jay S. Mitchell, Gholamhassan R. Lahiji, and Khalil Najafi

Low-cost, reproducible, vacuum packaging technologies are required for a host of devices including inertial sensors (~100mTorr), infrared sensor arrays (~10mTorr), micro-resonators (10μTorr to 760 Torr), and a wide range of devices that simply require hermetic seals. Of available wafer-bonding technologies, Au-Si eutectic bonding is one of the most attractive because it is easy to use and forms a soft eutectic liquid at just above 363°C allowing for a conformal seal over non-planar surfaces. Using this technique, a cap with a 4μm gold bond ring and 90μm-deep cavities is bonded to a wafer through a carefully controlled sequence. Figure 1 shows a cross section of the package, the sensors used for measuring vacuum, and a wafer with 124 vacuum-sealed devices. Pressures from 1 to 16mTorr with an estimated yield of 80% were achieved when encapsulating thin-film Nanogetters™. (Pressures 1,000 times higher were measured for packages without getters.) Figure 2 shows data for 14 packages that have been sealed for 435 days with less than ± 2mTorr pressure fluctuation. In accelerated testing, packages were held at 150°C for 100 hours and thermally cycled from -65°C to 150°C for 50 cycles with negligible change in pressure.

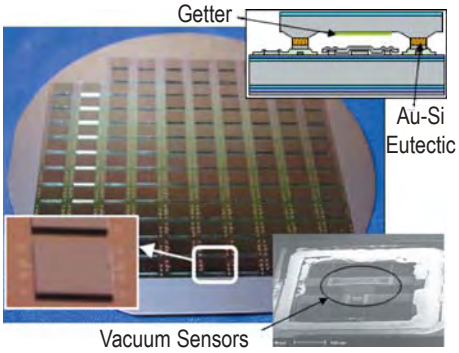


Figure 1 – A wafer containing 124 vacuum packaged devices, a cross section of a packaged device (top right) and vacuum sensors that were encapsulated and used for package characterization.

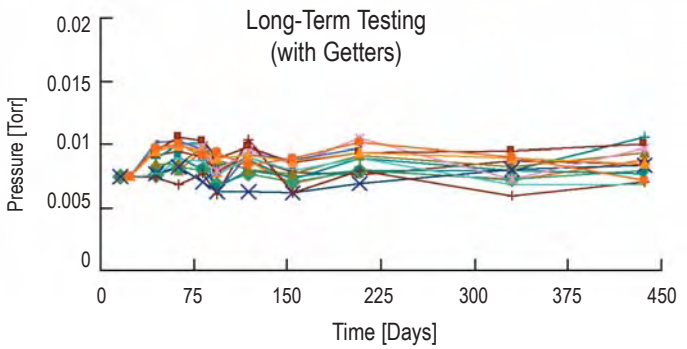
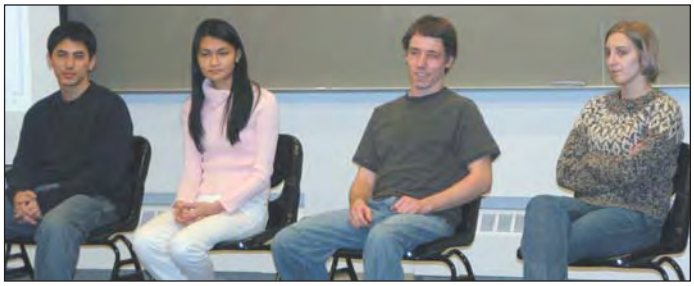


Figure 2 – Data from 14 devices in which the measured pressure has fluctuated by no more than ±2mTorr in 435 days.

Education Highlights

Research Opportunities for Undergraduates Presented

The WIMS Center sponsored its annual "Introduction to WIMS Undergraduate Research" open house on November 30th, to inform students about the Center and recruit them to participate in research experiences with graduate student mentors. This exposure is expected to heighten their desire to pursue courses in WIMS technology and to encourage continuance into graduate school in a WIMS-related field. Ken Wise gave an overview of the Center's history, purposes, and future goals. Faculty members followed with short presentations on the different WIMS thrusts and specific research projects, followed by questions and answers. Next, two former undergraduate participants and two graduate student mentors gave a panel discussion and answered questions from the audience. The open house concluded with a poster session enabling informal discussions and questions between the graduate students and prospective undergraduates.



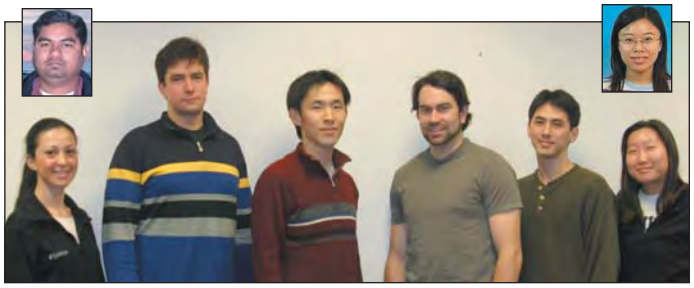
From left to right – Graduate student mentor Mark Richardson, undergraduate student researchers Seow Yuen Yee and John DeBusscher, and graduate student mentor Becki Veeneman.

High School Students Attend U of M Tech Day 2005

High school students and their parents visit the WIMS Center booth.

The University of Michigan College of Engineering sponsored "Tech Day 2005" where high school students and their parents were invited to attend and become familiar with the options of a higher education. The WIMS Center provided a booth showcasing the exciting opportunities for students interested in MEMS and microsystems and the unique research being advanced at the Center. The exhibit included posters depicting the organization of the Center Administration and Research Thrusts, as well as the two testbeds. Two WIMS graduate students, Rebecca Veeneman and Willie Steinecker from the Student Leadership Council, handed out brochures and candy bars with the Center's logo. They spoke with approximately 200 high school students who were considering attending the University of Michigan and approximately 50 parents. They found that both parents and students were extremely interested in microsystems and getting involved with WIMS. The option of retrieving information from the WIMS Center website was especially well accepted by the parents.

Newly Elected Student Leaders



The Student Leadership Council (SLC) held its annual election meeting in December and chose the following students to serve for 2006 (left to right):

President . . . . . Ruba Borno
Vice President . . . . . Tzeno Galchev
Industrial Chair . . . . . Jae-Yoong Cho
Education Chair . . . . . (absent) Rebecca Veeneman
Social Chair . . . . . Scott Wright
Public Relations Chair . . . . . Mark Richardson
Activities Chair . . . . . Christine Eun
MSU Chair . . . . . (inset top right) Ming Gu
MTU Chair . . . . . (inset top left) P. Santosh Karre

Faculty/Student Awards

The IEEE Sensors Council recognized **Christine Eun** for Best Student Paper Award at IEEE Sensors 2005. Hers was chosen from among 628 papers submitted. To complement the recognition, Christine also received $500. The citation for the paper is as follows: C. K. Eun, R. Gharpurey, and Y. B. Gianchandani, "Broadband Wireless Sensing of Radioactive Chemicals Utilizing Inherent RF Transmissions from Pulse Discharges," *IEEE Conference on Sensors*, Anaheim, California, November 2005.

Recent Events

Industrial Advisory Board Given Research Update at Semi-Annual Meeting

The WIMS ERC Semi-Annual Industrial Advisory Board Meeting was held at the Kensington Court Ann Arbor on October 25–26, 2005. WIMS Director, Ken Wise gave the ERC update. WIMS Thrust leaders highlighted the latest advances in their areas of research, and students gave one-minute slide presentations to add individual project details. The opportunity to exchange information allowed IAB members to review and comment on the Center's ongoing research.

This year, the Center has 131 projects combining innovation in four research areas: micropower integrated circuits, wireless interfaces, sensors and actuators (MEMS), and advanced packaging. At four different poster sessions, IAB members had the opportunity to meet with graduate students, who hosted their posters and discussed the projects in greater detail. Presented with a significant level of detail, IAB members examined current results and considered upcoming directions. This also gave the graduate students the opportunity to meet directly with representatives of industry and make contacts for future endeavors. Strong and enthusiastic support from the IAB members was evident and appreciated.

One of the highlights of the IAB Meeting was the presentation of the Student Leadership Council's Outstanding Leadership Award. Asli Burcu Ucok received the award for her dedication to WIMS and the SLC, and for her generous service in helping others.

Industrial advisory board members discuss posters with students.

SLC President Neil Welch presents Outstanding Leadership Award to graduate student Asli Burcu Ucok.

Personnel Focus

"New and Improved" Course Sparks "New and Improved" Cell Phone Designs

Professor Ann Marie Sastry believes in change. She expects her students to develop technological innovations; she demands the same from herself, with an added component: she strives to improve the engineering curriculum itself. She recently overhauled the mechanical engineering senior laboratory course, with great results: students loved the course, their projects were successful, and the faculty achieved a huge sense of accomplishment.

Professor Sastry challenged her 113 students to improve cell phone battery design, primarily to reduce size and cost, tailored to actual user needs. Student teams did not have unlimited time in the lab. "They had to zero in on the experiments most important for their particular user profiles, and they were responsible for conducting surveys to inform their work," explains Sastry. One of Sastry's former students, Dr. Kimberly Cook (PhD '04, now Assistant Professor at Drexel University), facilitated the instruction, sharing her customized test rigs and data analysis codes. Student Instructors Fabio Albano and Chris Cadotte and Research Scientist Yun-Bo Yi were also "crucial to the success of the class," adds Professor Sastry.

Ultimately, the students' successful designs included hybrid power, novel phone casings for larger batteries, and decreased capabilities to draw less power. Sastry offers this praise: "They came up with many creative ideas for satisfying users, and they learned to apply statistics in a meaningful, logical way."

Overall, Sastry sums up the advantages of the retooled course: "It was a winner all-around: in mentoring graduate students, in applying research done in our own department, and in having undergraduates solve a real engineering problem. We set the bar high, and the class met us there."

Presentations and Publications

Conference Presentations

International Conference on Miniaturized Chemical and Biochemical Analysis Systems (μTAS), Boston, MA, October 2005

K. Baek, Y. Li, M. N. Gulari, and K. D. Wise, "A Chronic Drug Delivery Probe With On-Chip Corrugated Microvalves"

T. Bansal and M. M. Maharbiz, "A Chemical Microgradient Array for Cell Culture"

A. Basu and Y. B. Gianchandani, "Microthermal Techniques for Mixing, Concentration, and Harvesting of DNA and Other Microdroplet Suspensions"

H. Kim, K. Najafi, A. Astle, L. P. Bernal, and P. Washabaugh, "Fabrication and Performance of a Dual-Electrode Electrostatic Peristaltic Gas Micropump"

IEEE International Conference on Sensors, Irvine, CA, October/November 2005

Y. Li, K. Baek, M. N. Gulari, D. Lin, and K. D. Wise, "A Vacuum-Isolated Thermal Microflowmeter for *In-Vivo* Drug Delivery"

A. Bhuyan, H. Lei, B. Gregory, K. Takahata, and Y. B. Gianchandani, "Pulse and DC Electropolishing of Stainless Steel for Stents and Other Devices"

C. K. Eun, R. Gharpurey, and Y. B. Gianchandani, "Broadband Wireless Sensing of Radioactive Chemicals Utilizing Inherent RF Transmissions from Pulse Discharges"

R. K. Franklin, M. D. Johnson, K. A. Scott, J. Shim, H. Nam, D. R. Kipke, and R. B. Brown, "Iridium Oxide Reference Electrodes for Neurochemical Sensing With MEMS Microelectrode Arrays"

H. Kim, A. Astle, K. Najafi, L. P. Bernal, P. Washabaugh, and F. Cheng, "Bi-Directional Electrostatic Microspeaker With Two Large-Deflection Flexible Membranes Actuated by Single/Dual Electrodes"

C. Kun, A. Mason, and S. Chakrabartty, "A Dynamic Reconfigurable A/D Converter for Sensor Applications"

B. Mitra and Y. B. Gianchandani, "Microdischarge-Microplasma Hybrids for Detection of Vapors at Atmospheric Pressure"

S. Mutlu and Y. B. Gianchandani, "Maskless Electrochemical Patterning of Gold Films for BioSensors Using Micromachined Polyimide Probes"

M. T. Richardson and Y. B. Gianchandani, "A Passivated Electrode Batch μEDM Technology for Bulk Metal Transducers and Packages"

J. Zhang, Y. Huang, N. Trombly, C. Yang, and A. Mason, "Electrochemical Array Microsystem With Integrated Potentiostat"

ASME Annual International Mechanical Engineering Congress and Exposition, Orlando, FL, November 2005

A. Astle, L. P. Bernal, K. Hanseup, K. Najafi, and P. Washabaugh, "Theoretical and Experimental Performance of a High Frequency Micropump"

J. Park, S. Mutlu, and Y. B. Gianchandani, "Nano-Scale Abrasion Studies of Materials Used in MEMS Devices and Packages"

K. Udeshi, M. T. Richardson, J. J. Hung, L. Que, G. Rebeiz, and Y. B. Gianchandani, "A Dual-EDM Reverse Damascene Process for RF Switches and Other Bulk Metal Devices"

Industrial Liaison's Report

WIMS Spring IAB Meeting May 23–24, 2006

Having just completed our October Industrial Advisory Board Meeting, the November National Science Foundation Engineering Research Center Annual Meeting, and the Holiday Bowl Season, we are now able to place additional efforts into technology transfer and commercializing technology.

The Center is continuing to work closely with the Zell Lurie Institute (ZLI) to teach our students the skills required to develop new technologies into viable products and businesses. The results from the joint project with ZLI, "Program for Research Commercialization Potential," have impacted courses now being given at the Ross School of Business through ZLI. The business course "Driving the Innovation Process" is a new graduate-level elective (open to WIMS students) that addresses how to master the innovation process to commercialize technology. While the course is focused on guiding the formation of technology-based new ventures, the lessons learned through this course are applicable to students interested in corporate strategy, marketing, general management, and social entrepreneurship. Slightly more than half of the enrollment in this course is composed of graduate students from the College of Engineering; the remainder are Ross MBA students.

Our WIMS seminars have also included presentations from the Technology Transfer Office, the Zell Lurie Institute, and WIMS graduates who have successfully launched businesses.

The opportunity offered to WIMS students to become aware of and competent in the business of high technology will make them significant contributors to the organizations they join upon graduation. In the evolving international technical community, it is becoming a necessity to understand the business of the technology, as much as it is to understand the technical nuances. The WIMS ERC offers students the opportunity to combine their technical expertise with business acumen.

If you or one of your colleagues is interested in sharing your experiences with our students, please contact me, so that we can schedule a seminar.

My email address is giachino@eecs.umich.edu, and my phone number is 734-615-3096.

As always, please visit when in the Ann Arbor area.

Joseph M. Giachino
Associate Director, Industry

IEEE International Electron Devices Meeting (IEDM), Washington, DC, December 2005

M. Agah and K. D. Wise, "PECVD-Oxynitride Gas Chromatographic Columns"

Y. W. Lin, S. S. Li, Z. Ren, and C. T.-C. Nguyen, "Low Phase Noise Array-Composite Micromechanical Wine-Glass Disk Oscillator"

J. Wang, M. N. Gulari, and K. D. Wise, "An Integrated Position-Sensing System for a MEMS-Based Cochlear Implant"

J. Wang, Y. Xie, and C. T.-C. Nguyen, "Frequency Tolerance of RF Micro-mechanical Disk Resonators in Nanocrystalline Diamond and Polysilicon Structural Materials"

Other Conference Presentations

D. Kim, C. Hsin, and M. Liu, "Asymptotic Connectivity of Low Duty-Cycled Wireless Sensor Networks," IEEE Military Communication Conference (MILCOM), Atlantic City, NJ, October 2005.

J. Shim, J. Y. Cho, H. Nam, G. S. Cha, R. J. White, H. S. White, and R. B. Brown, "Nanopore-Based All-Solid-State Ion-Selective Microelectrodes," Korea Chemical Society Meeting, Wonju, Korea, October 2005.

H. K. Chan, M. Takei, and S. W. Pang, "Granular Adsorbent Loading and Wafer Bonding for Si Microcavity Preconcentrators," American Vacuum Society 52nd International Symposium, Boston, MA, November 2005.

P. S. Karre and P. L. Bergstrom, "Fabrication of Quantum Islands for Single Electron Transistors Using Focused Ion Beam Technology," IWPSD '05 Thirteenth International Workshop on the Physics of Semiconductor Devices, New Delhi, India, p. 4, December 2005.

Publications

M. Agah, J. A. Potkay, G. R. Lambertus, R. D. Sacks, and K. D. Wise, "High-Performance Temperature-Programmed Microfabricated Gas Chromatography Columns," IEEE/ASME Journal of Microelectromechanical Systems (JMEMS), 14, pp. 1039–1050, October 2005.

G. R. Lambertus, C. S. Fix, S. M. Reidy, R. A. Miller, D. Wheeler, E. Nazarov, and R. D. Sacks, "Silicon Microfabricated Column With Microfabricated Differential Mobility Spectrometer for GC Analysis of Volatile Organic Compounds," Analytical Chemistry, October 2005.

C. J. Lu, W. H. Steinecker, W. C. Tian, M. Agah, J. A. Potkay, M. C. Oborny, J. Nichols, H. K. Chan, J. A. Driscoll, R. D. Sacks, S. W. Pang, K. D. Wise, and E. T. Zellers, "First Generation Hybrid MEMS Gas Chromatograph," Lab On A Chip, volume 5, pp. 1123–1131, October 2005.

K. D. Wise, "Silicon Microsystems for Use in Neuroscience and Neural Prostheses: Interfacing With the Central Nervous System at the Cellular Level," IEEE Eng. in Medicine and Biology Magazine, 24, pp. 22–29, October 2005.

J. Chae, B. H. Stark, and K. Najafi, "A Micromachined Pirani Guage With Dual Heat Sinks," IEEE Transactions on Advanced Packaging, 28, issue 4, pp. 619–625, November 2005.

W. C. Welch, J. Chae, and K. Najafi, "Transfer of Metal MEMS Packages Using a Wafer-Level Solder Transfer Technique," IEEE Transactions on Advanced Packaging, 28, issue 4, pp. 643–649, November 2005.

J. R. Clark, W. Hsu, M. A. Abdelmoneum, and C. T.-C. Nguyen, "High-Q UHF Micromechanical Radial-Contour Mode Disk Resonators," IEEE/ASME Journal of Microelectromechanical Systems (JMEMS), 14, pp. 1298–1310, December 2005.

H. Kim and K. Najafi, "Characterization of Low-Temperature Wafer Bonding Using Thin Film Parylene," IEEE/ASME Journal of Microelectromechanical Systems (JMEMS), vol. 14, issue 6, pp. 1347–1355, December 2005.

R. H. Olsson III and K. D. Wise, "A Three Dimensional Neural Recording Microsystem With Implantable Data Compression Circuitry," Journal of Solid-State Circuits, 40(12), pp. 2797–2804, December 2005.

K. J. Otto, P. J. Rousche, and D. R. Kipke, "Microstimulation in Auditory Cortex Provides a Substrate for Detailed Behaviors," Hearing Research, 210, pp. 112–117, December 2005.

J. Subbaroyan, D. C. Martin, and D. R. Kipke, "A Finite-Element Model of the Mechanical Effects of Implantable Microelectrodes in the Cerebral Cortex," Journal of Neural Engineering, 2, pp. 103–113, December 2005.

J. C. Williams, M. Holecko, S. P. Massia, P. J. Rousche, and D. R. Kipke, "Multi-Site Incorporation of Bioactive Matrices Into MEMs-Based Neural Probes," Journal of Neural Engineering, 2, pp. L23–L28, December 2005.

Doctoral Dissertations

University of Michigan, 2005

Nelson Sepulveda-Alancastro, "Polycrystalline Diamond RF MEMS Resonator Technology and Characterization"
Postgraduate Position: Assistant Professor
University of Puerto-Rico at Mayaguez
Advisor: Professor Dean Aslam

Timothy J. Harpster, "Hermetic Packaging and Bonding Technologies for Implantable Microsystems"
Postgraduate Position: Senior Research Engineer
Intek, Inc., Westerville, Ohio
Advisor: Professor Khalil Najafi

Hubert Hyungil Lim, "Effects of Electrical Stimulation of the Inferior Colliculus on Auditory Cortical Activity: Implications for an Auditory Midbrain Implant (AMI)"
Postgraduate Position: Post-Doctoral Research Scientist
Medical University of Hannover, Germany
Advisors: Professors David J. Anderson and John C. Middlebrooks

Melissa L. Trombley, "Localized Annealing of Polysilicon Microstructures by Inductively Heated Ferromagnetic Films"
Postgraduate Position: Process Engineer in the Ion Plant Division
Intel Corporation, Chandler, Arizona
Advisor: Professor Paul L. Bergstrom

Kabir J. Udeshi, "On-Chip High-Voltage Generation Using Mechanical Oscillators"
Postgraduate Position: Currently seeking industry position
Advisor: Professor Yogesh B. Gianchandani

Seminar Series

*** October 4, 2005**
Professor William C. Tang
UC Irvine
"Biomechanics at the Microscale"

*** October 11, 2005**
Professor Wei Lu
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