Winter 2008

WIMS WORLD

Director's Message

This past term was, as winter terms usually are, a bit like running a gauntlet. First there was the *IEEE MEMS Conference* in Tucson, where we presented a number of important papers and hosted a reception and alumni dinner. Then there was the *2007 WIMS Annual Report*, which thanks to our staff met its usual high standards, as did our subsequent *NSF Annual Report*. Our Scientific Advisory Board met with us in March and were very supportive of our plans for the future, urging us to be bold and focus on system integration, using microsystems to solve important societal problems. But the biggest event of all was the dedication of our new fabrication facility. It adds a new 5,000-square-foot cleanroom supported by 38,000 square feet of new infrastructure and is a superb facility, second to none among academic research laboratories for work in solid-state electronics and microsystems. We recently ordered the furnaces for this facility—20 tubes supporting everything from oxidation/diffusion to in-situ-doped polysilicon and a broad range of LPCVD dielectrics. Additional tools for dry etching, film deposition, and state-of-the-art electron-beam lithography are planned.

We are very fortunate to have these wonderful new facilities. The funding for them has all come from private sources—from donors who want Michigan to be the very best. It represents a tremendous commitment on their part and a challenge to us to make it pay off by solving key problems in areas such as health care, security, defense, energy systems, and the environment. It is fitting that this new laboratory was named by Anne Lurie, a principal donor, for her late husband. It will be known as the Robert H. Lurie Nanofabrication Facility. In typical engineering fashion, we've already shortened it to an acronym—the LNF.

The dedication festivities began with an elegant dinner hosted by the College of Engineering. The highlight of the evening for me was the after-dinner entertainment provided by violinist Xiang Gao, a 1997 graduate of the University of Michigan's School of Music. It brought back a flood of memories. I took violin lessons during my K–12 years from a wonderful violinist—Carol Rose. Now I should say that in music, as in art, I was somehow left out of the talent distribution line, and I sometimes went from lesson to lesson having scarcely looked at the pieces she assigned me. My only excuse is that after rehearsing an hour a day with the high-school orchestra and Thursday evenings with the local symphony, other pressures were often just too great. She somehow endured, and what I took away was a tremendous appreciation of music. Just participating was enough, and playing with our local symphony was an especially choice experience. We used to hire about half of the Chicago Symphony Orchestra to beef up our numbers for concerts, allowing me to claim that I used to play with the Chicago Symphony! But, I never heard a violinist perform better than Xiang Gao did at the LNF dedication dinner. He was fantastic. Neither have I ever heard a better violin. He was playing the 1699 "Lady Tennant" Stradivarius. Heck, I had never even *seen* a Stradivarius, and that evening I actually touched one's case!

Antonio Stradivari, *by Edgar Bundy, 1893, and one of his violins.*

If you look at our new facility, it's a lot like a Stradivarius. It has been done absolutely first class, thanks to our donors and to our very capable staff, who were intimately involved in its design from the very start. But it's now up to us to make it talk—to make it effective. We are the violinists who will take the capability of the LNF and use it to literally change the world. At least that is the challenge that lies before us. ■

Ken D. Wise

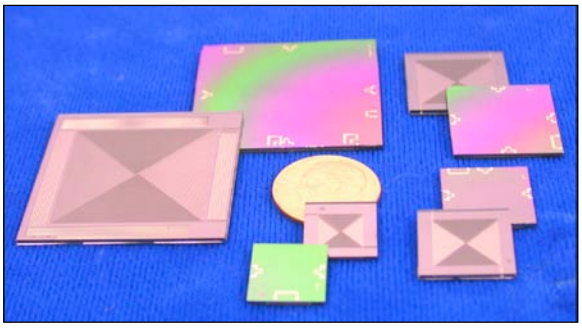
Director, Engineering Research Center for
Wireless Integrated MicroSystems

Research Highlights

Reliable and Efficient Separation Columns With Thermally Stable Stationary Phases

Gustavo Serrano and Edward T. Zellers

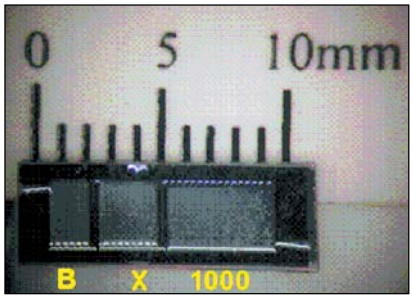
Several of the most critical factors affecting the performance of the WIMS μGC relate to the DRIE-Si/glass channels used as gas chromatographic (GC) separation microcolumns, specifically, the consistency and uniformity of stationary phase deposition, the deactivation of surface-adsorption sites on the microcolumn walls, and the stability of the stationary phase following repeated thermal cycling. This year, we demonstrated that films of polydimethylsiloxane (PDMS) can be reliably and reproducibly deposited in microcolumns 0.5 to 3m long and cross-linked *in situ* to provide unprecedented separation efficiency and stable performance even up to 200°C in air.



In addition, use of hexamethyldisilazane (HMDS) as a surface deactivation agent was shown to be highly effective. The values of chromatographic efficiency achieved, up to 4,900 plates/meter, are the highest values ever reported. The variation in efficiency among multiple-coated columns is <5% (rsd, n = 10), which is remarkably low and demonstrates that the coating process is robust. Pre-treatment with HMDS dramatically reduced peak broadening associated with wall adsorption by polar analytes. The PDMS stationary phase was stable to very high temperatures in air, which bodes well for using such microcolumns to separate compounds with very low vapor pressures (e.g., explosives, pesticides, etc.) in field applications using ambient air as the carrier gas. ■

Fundamental Studies Impact the Design and Performance of a Multi-Stage Micro-Preconcentrator

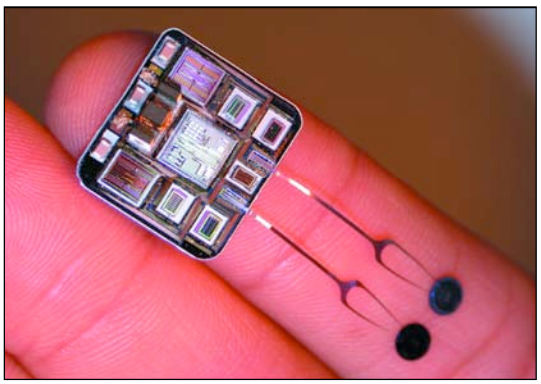
Rebecca A. Veeneman and Edward T. Zellers



Most anticipated applications of microanalytical systems to environmental monitoring require detection of target compounds in the parts-per-billion or parts-per-trillion concentration range. Because detector technologies are not sensitive enough to achieve limits of detection in this range, a preconcentration step is necessary prior to separation and detection. The microfabricated adsorbent preconcentrator/focuser (μPCF) we are developing for the WIMS μGC serves this purpose. This year, we have completed critical characterizations of the μPCF in which fundamental models of vapor adsorption capacity and breakthrough volume were used to correlate material properties and operating parameters to device performance. Adsorption studies of the graphitized-carbon adsorbents used in the device revealed two distinct adsorption-energy regimes that dictate the capacity for vapor adsorption over the relevant concentration range. This behavior has never been observed before and will permit further reductions in the size of the PCF (and power demands) without sacrificing capacity. Through tests of the multi-stage μPCF (shown above) we have characterized the dependence of the adsorption capacity on the volumetric flow rate in the context of classical theory, and we have defined the limits on the allowable flow rates for target vapors of interest. This project exemplifies the application of fundamental science to the design and operation of WIMS microsystems. ■

A Wireless Implantable Cortical Microsystem

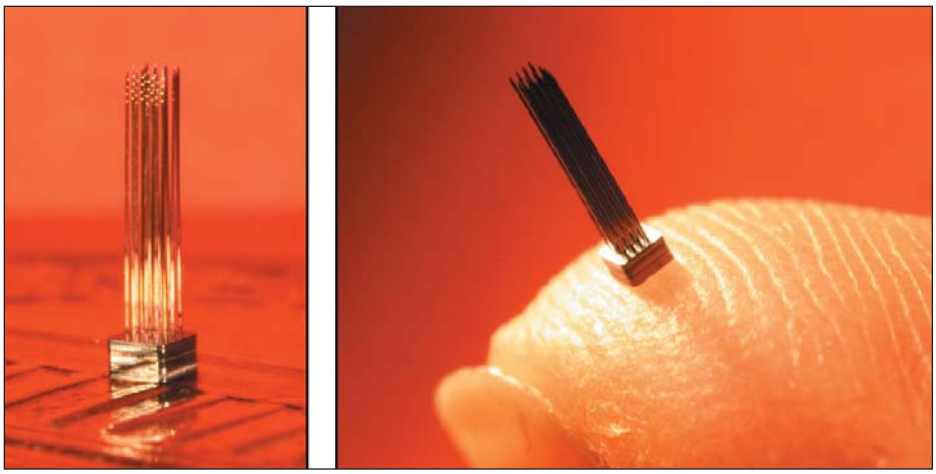
Amir Sodagar and Kensall D. Wise



A 64-channel, single-unit, neural recording microsystem has been developed and tested for the first time. The penny-size device is capable of wirelessly recording from different regions of the brain, detecting action potentials (spike events) above a user-programmed threshold on all the channels simultaneously, or digitizing any one of the channels with 8-bit resolution. The system is powered and programmed through an inductive frequency-shift-keyed (5MHz/10MHz) telemetry link. Outgoing neural information is amplified, compressed, Manchester encoded, OOK modulated, and wirelessly transmitted to an external host. This present microsystem consumes 14.4mW, measures 1.55cm x 1.4cm, and weighs 275mg. Scaling to a three-chip version of the system is underway. ■

A Low-Rise 3-D Cortical Interface

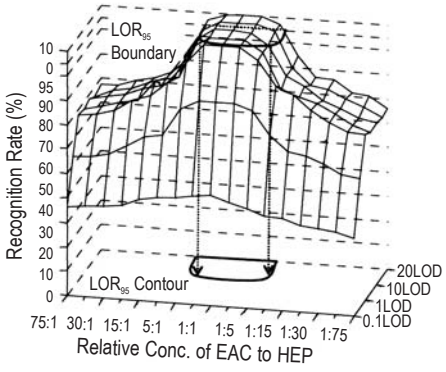
Kensall D. Wise



Past work has produced 3-D electrode arrays using microassembled planar 2-D probes, but the arrays have been tedious to assemble using micromachined spacers, limiting their availability for practical use. Also, they have had relatively high rise above the cortical surface and have consumed a wide footprint there due to the use of lead transfer wings on the probes. A new 3-D probe structure has been developed that overcomes these problems, resulting in a low-rise (100–500μm) structure that allows the dura to be replaced over the implant and that occupies barely more area on the surface than the array itself. Assembly is simplified by eliminating the wings and spacers, embedding the arrays in a solid block. The approach also permits simple high-density interconnects to a hybrid circuit chip that provides signal selection, amplification, and buffering. A four-probe prototype array is shown, consisting of 64 sites on 200μm centers in three dimensions with 16 40μm-wide, 4mm-long shanks. The interface is shown with the 1mm x 1mm x 0.5mm base resting on a penny and on a fingertip. ■

Limits of Recognition for Multi-Transducer Arrays

Chunguang Jin and Edward T. Zellers



In the vast majority of studies of microfabricated sensor arrays for analysis of volatile organic compounds (VOC), the sensors employed in the arrays operate on the same transduction principle. With most of these single-transducer (ST) arrays, a thin interfacial film of a sorptive polymer serves to reversibly concentrate vapors near the surface of each sensor. It stands to reason that arrays of transducers operating on different principles, which we refer to as multi-transducer (MT) arrays, should enhance the capability for vapor recognition by probing different aspects of the vapor-polymer interactions. Indeed, a study we completed this year demonstrated that MT arrays consisting of different combinations of polymer-coated capacitors, cantilevers, and calorimeters yielded performance superior to that of ST arrays of similar dimension. In an extension of that work we explored the performance of such MT arrays in analyzing simple mixtures as a function of the absolute and relative concentrations of the mixture components. The "limit of recognition" (LOR), defined as the maximum recognizable mixture composition range, was used as the metric of performance. Using an optimal 8-sensor MT array, we found that binary vapor mixtures could be recognized reliably at component-relative concentration ratios up to only 16:1, and that ternary mixtures could be recognized only if the relative concentration ratio between any two of the components was ≤7:1. Importantly, most of the binary-mixture LOR contours (see figure to the right) are significantly asymmetric with respect to composition. These findings have significant implications for detection strategies applied to specific applications of the WIMS μGC, so they are being used to guide on-going development efforts toward these ends. ■

Education Highlights

WIMS Education Impacts Culture of Engineering Education: A Look at WIMS Pre-College Initiatives

A primary school student observes the Data Acquisition Cube tracking oscillatory motion in a classic pendulum experiment, at the YES! Expo in November 2007.

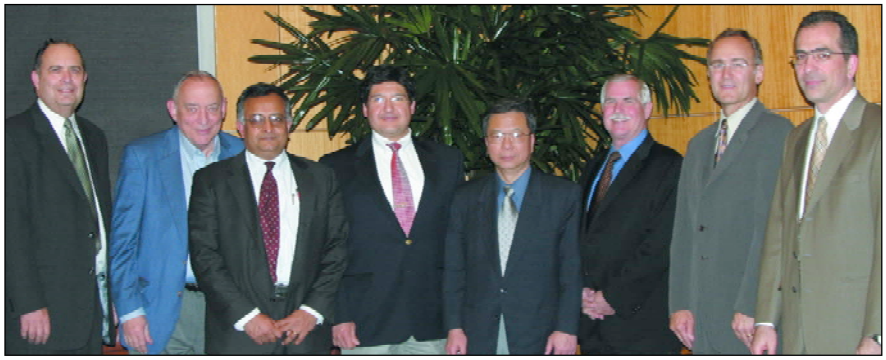
This article is the third of a three-part series covering the impact of WIMS education programs on engineering education. The first article highlighted project-oriented courses: MTU's Integrated Microsystems Enterprise (IME) multi-term major design experience (MDE) and U-M's Integrated Microsystems Laboratory single-term MDE. The second article described initiatives enabling undergraduates to participate in research, mentored by graduate students. This article looks at our outreach to students in grades K–12. Our pre-college effort has two goals: increase the number of students selecting science, engineering, or math majors in college, and improve those students' qualifications for entry. To do this, we deploy a comprehensive set of academic in-school, enrichment, and teacher education initiatives. Our first step was taken at MSU during summer 2000, and since then our pre-college initiatives have expanded significantly.

During the past academic year and summer, for example, the Center offered five weekend and four summer programs. The summer programs have enrolled nearly 1,500 students, with phenomenal enrollments of underrepresented minorities and females in grades 7–12 (51.36% females and 68.29% underrepresented minorities, amongst 1,028 students and 34 programs). Three programs, moreover, were specifically targeted for Native American students, and a start-up company, Nanobrick, was founded on educational activities developed by Professor Dean Aslam. Furthermore, with leadership from MSU's WIMS Pre-College Associate, Drew Kim, two exciting hardware components were developed for the pre-college community: (1) an electronic thermometer with wireless readout, and (2) NEMO, a robotic fish boasting electro-activated-polymer swimming motion. NEMO, the electronic thermometer, and LEGO Mindstorm NXT projects are highlights of MSU's Design Day. Elsewhere, MTU's IME team is developing a Data Acquisition Cube (DAC) to provide plug-and-play capability for various pre-college, classroom experiments. During the last year, the team delivered the DAC to seven school districts and highlighted it at the Youth in Engineering and Science (YES!) Expo in Detroit.

At U-M, Girls in Science and Engineering provide leadership for two programs, and the Center has hosted middle-school students in weekend programs since 2002. Overall, the Center sponsors many continuing community activities, including regional LEGO Robotics tournaments in East Lansing, the Sally Ride Festival in September, and the YES! Expo in November. Two recent donations will help us maintain our pre-college programs. The Motorola Foundation's Innovation Generation grant provides $50,000 of support to the WIMS for Teens summer program. And Shell's Students Interested in Technology, Engineering and Science grant helped MSU host a FIRST LEGO League qualifying tournament in November 2007. ■

Recent Events

Scientific Advisory Board Meets on March 20



The Center's Scientific Advisory Board at their meeting on March 20, 2008. From left: Center Director Kensall D. Wise, Robert M. Nerem (GaTech), Sandip Tiwari (Cornell), Gilbert V. Herrera (Sandia), Chih-Ming Ho (UCLA), Kurt E. Petersen (Consultant and MEMS pioneer), Lawrence D. Burns (GM), and Center Deputy Director Khalil Najafi.

As the microelectronics industry nears the end of the scaling roadmap and looks beyond Moore's law, it is likely to focus on expanding in interdisciplinary new areas such as health care, energy, and the environment. Microsystems will provide the path to these applications. Our Scientific Advisory Board meeting this spring considered how to transition WIMS to an Institute that can continue to lead this revolution. The SAB concluded that "… this ERC is unique in the science and engineering community. Its singular strength has been in opening up new directions for applications and the development of technology that goes well beyond what was imaginable at the time of its inception … new directions in biology, neurosciences, health [care], environment, and commercialization. …The potential impacts are enormous and pervade many areas that have the attention of humanity. … the time is right for greater emphasis on integration of the receivers of these technologies." They urged us to be bold in defining an effort that spans the University and beyond. The SAB recommendations will be the basis for further discussions at a retreat to be held in July. ■

Detroit Area Pre-College Engineering Program

The Center annually organizes a Detroit Area Pre-College Engineering Program (DAPCEP) to increase interest in Science, Technology, Engineering, and Mathematics (STEM) careers among middle-school students. This year's DAPCEP ITEST program was heavily focused on teaching the students about MEMS and nanotechnology. The 7th-grade students received lessons from WIMS faculty on the major areas of research in MEMS and built LEGO robots related to those various research areas. One such lesson was given by Professor Kensall Wise on microelectrode arrays. Following an overview of the devices by Professor Wise, the students added such arrays to their robots. In addition to learning about MEMS devices, the students also received lessons on general engineering concepts such as the physics of motion and digital circuit theory. The five-week program ended with the students receiving a tour of the Lurie Nanofabrication Facility (LNF) and participating in hands-on activities where they performed their own processing on wafers, explored the insides of a desktop computer, and tested a number of commercial products developed as a result of nanotechnology. Overall, the students responded positively to the program's hands-on approach of exploring MEMS/STEM fields, and some expressed their hope to return again next year. ■

Congratulations go to **TRASA BURKHARDT**, who—after almost 20 years at the University of Michigan—recently marked her 10-year anniversary with the EECS Department. Trasa has been Secretary to Professor Khalil Najafi for all ten years and to Professor Yogesh Gianchandani for the last six, not to mention other professors who have come and gone over the years, including Professors Carlos Mastrangelo, Clark T.-C. Nguyen, and Michel Marharbiz. Trasa says she has enjoyed working with all the different people in the EECS Department and looks forward to the next ten years.

The Center would like to welcome **NICOLE FRIZZELL** who was hired in January 2008, as an administrative assistant for WIMS ERC Professors and Thrust Leaders Dennis Sylvester and Michael Flynn. In this position, she performs a full suite of office support duties and provides special assistance in preparing for major WIMS Center conferences. Previously, Nicole worked as an administrative assistant at the U-M's Institute for Social Research. ■

Personnel Focus

Scott Hanson received the Bachelor's and Master's degrees in electrical engineering from the University of Michigan in 2004 and 2006, respectively. He continues to study at the University of Michigan as a doctoral candidate conducting research under Professor Dennis Sylvester, the Center's Micropower Thrust leader. Mr. Hanson served as an intern at IBM on two different occasions. In 2004, he worked in a development role as a logic designer, and in 2006, he worked in a research role studying low-voltage digital circuit design. Mr. Hanson has also been an active member of the College of Engineering and EECS Department communities throughout his time at the University. In 2004, he served as the President of *Eta Kappa Nu*, the electrical and computer engineering honor society. Currently, he represents the Electrical Engineering Department as a member of the Graduate Student Advisory Committee, which focuses on a wide range of issues important to graduate students in the College of Engineering.

Much of Mr. Hanson's research has been directed toward the development of ultra-low-power microcontrollers for use in wireless integrated microsystems. In 2005, he took a lead role in the development and testing of the Subliminal Processor, the most energy-efficient microprocessor ever reported. Subliminal, which had power requirements on the order of nanowatts, was used in an early version of the intraocular pressure sensor developed by the Center. In 2007, Mr. Hanson and his colleagues, Mingoo Seok and Yu-Shiang Lin, developed the Phoenix Processor under the direction of Professors Dennis Sylvester and David Blaauw. The Phoenix Processor, which has a sleep-mode power consumption on the order of pico-watts, was the first microcontroller to be designed from the ground up with dual sleep-mode and active-mode power minimization as the primary goal. Mr. Hanson is currently working with Mr. Seok and Mr. Lin to integrate the Phoenix Processor with the intraocular pressure sensor mini-testbed. The miniscule power budget of the Phoenix Processor is expected to create exciting opportunities not only in the intraocular pressure sensor application but also in other implantable devices such as pacemakers and insulin pumps. ■

Recent Events

Robert H. Lurie Nanofabrication Facility Dedication Ceremony Highlights

Industrial Liaison's Report

In January, the ERC hosted an informational suite at the MEMS 2008 conference held in Tucson, Arizona. The suite provided a place where conference attendees could obtain an overview of the Center's research, discuss their research interest with other attendees, and, more importantly, meet with the Center's researchers at the conference. This conference was attended by engineers and scientists from around the world and, as such, offered the Center an excellent opportunity to explore mutual interests with both attendees from new companies and attendees from member companies who could not attend our Industrial Advisory Board meeting. While we enjoy visiting new venues, it is not the same as having people come to Ann Arbor.

Your visit to the Center offers us an opportunity to demonstrate research and showcase facilities that are available to WIMS researchers and our member companies. In particular, the expansion of the Robert H. Lurie Nanofabrication Facility will ensure that our capabilities will continue to be state-of-the-art. The addition will include 5,000 square feet of cleanroom space for microsystems and nanotechnology and 2,800 square feet for wet chemistry. However, it is not the facilities that have made the Center successful. It is the faculty, staff, and, above all else, the students. Indeed, the Center prepares our students to be able to contribute in both an academic and industrial environment. The Center's training in system solutions, rather than just device development, has made our graduates rapid contributors and leaders in their post-graduation careers.

As the ERC continues to grow and evolve, the one element that we need to maintain is continuing to attract the best students and to train them to be the engineering leaders of tomorrow. I invite you to come to the Center, meet with the researchers, and discuss how we can help make your company meet the challenges of the future. One of the best ways to meet

January 2008 MEMS Conference, Tucson, Arizona.

our students and to interact with the faculty is to give a seminar. If you, or one of your colleagues, is interested in visiting the Center or giving a seminar please contact me at (734) 615-3096 or giachino@eecs.umich.edu to schedule the date.

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

Joseph M. Giachino
Associate Director, Industry

Presentations and Publications

Conference Presentations

IEEE International Conference of Nano/Micro Engineered and Molecular Systems, Sanya, China, January 2008

H. Chan, M. Varney, D. M. Aslam, and K. D. Wise, "Fabrication and Characterization of All-Diamond Microprobes for Electrochemical Analysis," pp. 532–535

IEEE International Conference on Micro Electro Mechanical Systems (MEMS), Tucson, Arizona, January 2008

H. Chan, D. M. Aslam, S. Wang, G. Swain, and K. D. Wise, "Fabrication and Testing of a Novel All-Diamond Neural Probe for Chemical Detection and Electrical Sensing Applications," pp. 244–247

A. T. Evans, J. M. Park, S. Chiravuri, and Y. B. Gianchandani, "Dual Drug Delivery Device for Chronic Pain Management Using Micromachined Elastic Metal Structures and Silicon Microvalves," pp. 252–255

A. Gross, B. Huang, G. S. Hwang, C. Lawrence, N. Ghafouri, S. Lee, H. Kim, C. Uher, M. Kaviany, and K. Najafi, "A Multi-Stage In-Plane Micro-Thermoelectric Cooler," pp. 840–843

N. K. Gupta and Y. B. Gianchandani, "A Knudsen Pump Using Nanoporous Zeolite for Atmospheric Pressure Operation," pp. 38–41

M. T. Richardson and Y. B. Gianchandani, "Real-Time Wireless Monitoring of Workpiece Material and Debris Characteristics in Micro-Electro-Discharge" pp. 379–382

W. C. Welch III and K. Najafi, "Gold-Indium Transient Liquid Phase (TLP) Wafer Bonding for MEMS Vacuum Packaging," pp. 806–809

W. Zhu, M. J. White, G. F. Nellis, S. A. Klein, and Y. B. Gianchandani, "A Perforated Plate Stacked Si/Glass Heat Exchanger With In Situ Temperature Sensing for Joule-Thomson Coolers," pp. 844–847

ACM/IEEE Asia-South Pacific Design Automation Conference, Seoul, Korea, January 2008

M. R. Guthaus, D. Sylvester, and R. B. Brown, "Clock Tree Synthesis With Data-Path Sensitivity Matching," pp. 498–503

ACM/IEEE International Conference on VLSI Design, Hyderabad, India, January 2008

A. Ghosh, R. Rao, J. Kim, R. B. Brown, and C. Chuang, "On-Chip Process Variation Detection Using Slew-Rate Monitoring Circuit," pp. 143–147

IEEE International Solid-State Circuits Conference (ISSCC), San Francisco, California, February 2008

M. S. McCorquodale, S. M. Pernia, J. D. O'Day, G. Carichner, E. D. Marsman, N. Nguyen, S. Kubba, S. Nguyen, J. Kuhn, and R. B. Brown, "A 0.5–480MHz Self-Referenced CMOS Clock Generator With 90ppm Total Frequency Error and Spread Spectrum Capability," 51, pp. 350–351

Publications

S. Hanson, M. Seok, D. Sylvester, and D. Blaauw, "Nanometer Device Scaling in Subthreshold Logic and SRAM," *IEEE Transactions on Electron Devices*, vol. 55, (1), pp. 175–185, January 2008.

F. Iancu, X. Zhu, Y. Tang, D. M. Aslam, and N. Muller, "Design and Fabrication of Microchannel Test Rig for Ultra-Micro Wave Rotors," *Microsystem Technologies*, vol. 14 (1), pp. 79–88, January 2008.

C. Jin, P. Kurzawski, A. Hierlemman, and E. T. Zellers, "Evaluation of Multi-Transducer Arrays for the Determination of Organic Vapor Mixtures," *Analytical Chemistry*, vol. 80 (1), pp. 227–236, January 2008.

K. Das, R. B. Brown, and C. Chuang, "Reducing Parasitic BJT Effects in Partially-Depleted SOI Digital Logic Circuits," *Microelectronics Journal*, 39, pp. 275–285, February 2008.

S. Joo and R. B. Brown, "Chemical Sensors With Integrated Electronics," *Chemical Reviews*, vol. 208, issue 2, pp. 638–651, February 2008.

K. D. Wise, "Big Plans for Small Tools," *Search & Discovery*, The University of Michigan, pp. 4–7, Winter 2008.

Doctoral Dissertations

Fabio Albano, "Design and Optimization of Power Supplies for Wireless Integrated MicroSystems"
University of Michigan, 2008
Postgraduate Position: Senior Research Engineer, Sakti3, Inc., Ann Arbor, MI
Advisor: Professor Ann Marie Sastry

Amar Sarbbasesh Basu, "Microthermal Devices for Fluidic Actuation by Modulation of Surface Tension"
University of Michigan, 2008
Postgraduate Position: Assistant Professor, Wayne State University
Advisor: Professor Yogesh B. Gianchandani

Mark A. Ferriss, "Fractional-N Synthesizer Architectures With Digital Phase Detection"
University of Michigan, 2008
Postgraduate Position: Postdoctoral Fellow, University of Michigan, Ann Arbor, MI
Advisor: Professor Michael P. Flynn

P. Santosh Kumar Karre, "Fabrication and Characterization of Room Temperature Operating Single Electron Transistors Using Focused Ion Beam Technologies"
Michigan Technological University, 2008
Postgraduate Position: Postdoctoral Fellow, Michigan Technological University, Houghton, MI
Advisor: Professor Paul L. Bergstrom

Jongwoo Lee, "A 64-Channel Programmable Closed-Loop Deep Brain Stimulator With 8-Channel Neural Amplifier and Logarithmic ADC"
University of Michigan, 2008
Postgraduate Position: Senior Analog Engineer, BitWave Semiconductor, Inc., Boston, MA
Advisors: Professors Michael P. Flynn and Daryl R. Kipke

Dan Shi, "A Fully Integrated CMOS Receiver"
University of Michigan, 2008
Postgraduate Position: Design Engineer, Intel, Hillsboro, OR
Advisor: Professor Michael P. Flynn

Raghav Vanga, "Relaxor Piezoelectric Film Actuators, Waveguides and Photonic Crystals: Fabrication and Characterization"
Michigan Technological University, 2008
Postgraduate Position: Measurement Characterization Scientist, Corning Incorporated, Manufacturing, Technology and Engineering Division, Corning, NY
Advisor: Professor Miguel Levy

Hui Xia, "Fabrication of C54-$TiSi_2$ Thin Films Using Pulsed Cathodic Arc Deposition and Rapid Thermal Annealing"
Advisor: Professor Paul L. Bergstrom

Judy Zhong, "A Portable Gas Chromatograph With Tunable Separation and Microsensor Array Detection: Design, Characterization, and Environmental Health Applications"
University of Michigan, 2008
Postgraduate Position: R & D Scientist, Thermo Fisher Scientific, Environmental Instrument Division — Air Quality Instruments, Franklin, MA
Advisors: Professor Edward T. Zellers

Seminar Series

***January 21, 2008**
Uwe Schnakenberg, Ph.D., and
Andreas Buchenauer
Institute of Materials in Electrical Engineering,
Aachen University in Germany
"Microfluidic Systems for Biocatalytical Reactions in Microtiter Plates"

***February 13, 2008**
Jason Weigold, Ph.D.
Founder of MEMStaff, Inc.
"Development of High Volume MEMS Products (Or Tales from the Advanced Development Group at Analog Devices' Micromachined Products Division)"

***February 20, 2008**
Rebecca Veeneman and **Qiongyan (Judy) Zhong**
Graduate Students, Departments of Chemistry and Environmental Health Sciences,
University of Michigan

(**Veeneman**) "Characterization of Carbon Nanotubes and Graphitized Carbons as Adsorbents in a Microfabricated Vapor Preconcentrator/Focuser"

(**Zhong**) "A Novel Multi-Vapor Analyzer: Characterization and Application to Analyzing Breath Biomarkers of Lung Cancer"

***March 6, 2008**
Masoud Agah, Ph.D.
Assistant Professor
Bradley Department of Electrical and Computer Engineering, Virginia Tech University
"Three-Dimensional Silicon Micromachining and Its Application in Cancer Diagnosis"

***March 7, 2008**
Leland Chang, Ph.D.
Manager of Design and Technology Solutions,
IBM T. J. Watson Research Center
"Rethinking Embedded Memory for High Performance Microprocessors"

***March 12, 2008**
Professor Toshikazu Nishida
Interdisciplinary Microsystems Group
Department of Electrical and Computer Engineering, University of Florida
"Noise Floor of MEMS-Based Piezoresistive Microphones"

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