Summer 2009

WIMS WORLD

Director's Message

When I was a graduate student, I recall reading an article that suggested that neuroscience was, at that time, "data rich and theory poor." I think what it meant was that physiologists had successfully recorded from millions of individual neurons but had no idea what those neurons were doing functionally or what the data really meant. We had lots of *data* but no real *information* (i.e., knowledge or understanding of things we needed—or wanted—to know). I am forced to admit some forty years later that our work on neural interfaces has made this situation in neuroscience much worse and can only hope this is somehow a necessary prelude to distilling information out of all this data. We've mostly solved the data acquisition problem, but the distillation process will not be easy. A lot of things are like that. We live in an age where *data* is everywhere, but it's hard to extract useful *information* from it. And I thought this was supposed to be the *information* age.

In the good old days, there were only four television channels but there was always something to watch. I just got a new home communications provider and now have over 200 channels, but it's hard to find anything worth watching on any of them. When it comes to news, this graduates from being a nuisance to a very real problem. The major news networks still try to be objective, but others stir so much "commentary" into the mix that it is hard to sift fact from fiction (and sometimes bigoted fiction at that). A friend recently described one of our major "news" channels as "a little to the right of Hitler" and another (just a button-click away) as "a little to the left of Lenin." Rather than just informing us on important issues, they push one particular point of view. Presidential campaigns used to take six months at modest cost; today, they cost a lot and take years. In the end, no candidate looks very good and too many people have become cynical about government in general. Fortunately, the electorate is still more sensible than the people who run the networks. If that ever stops being the case, the country will be in real trouble. Like neuroscience, the data problem in society is getting worse. The Internet, of course, is an amazing resource, especially with search engines like *Google* providing access to almost anything anytime anywhere. But ultimately we have to be knowledgeable enough to sift information from the sea of data.

174 YEARS OF NEWSPAPER HISTORY Pages 2-5

1835 – 2009

Readers weigh in on the closing of The Ann Arbor News Page 6

Headlines that made an impact on the community Page 8

Boy on a pony a memorable sight in Sumpter Township Page 9

THE ANN ARBOR NEWS

THURSDAY, JULY 23, 2009

FINAL EDITION

It's been a great run; thanks and goodbye

LAUREL CHAMPION

Farewell, Ann Arbor

One of the big events this summer was the loss of our local newspaper. *The Ann Arbor News* closed its doors after 174 years of publishing, only to be reborn as a ".com" experiment to see if its syndicate owner can make more money letting people get their news from the Internet. Most of the people I talked to didn't like this a bit. We'll still have a lot of data, but less information. The demise of the *News* was important enough to make the August 17 issue of *TIME*. Maybe it's a generational thing, but I need someone to sift through the data and tell me what is going on by providing me with information I can trust. Where's Walter Cronkite when we need him? Newspapers in general are in trouble, but when the venerable *Chicago Tribune* filed for Chapter 11, it was testimony to the fact that something is really wrong. They may not have been making enough money, but we will all be the poorer for it.

We engineers seem to be fully engaged in contributing to these data overload problems. When I started out, there were only two or three major microelectronics conferences, and the sensor papers were typically limited to a single session tucked away down some obscure hallway. Today you could go to a MEMS conference almost every week all year, and to keep all these meetings viable, someone invented poster sessions. (They seem more or less equivalent to what the scanner did for the memory business, although perhaps not as useful.) Poster sessions are especially helpful to conference organizers because if you admit enough papers and at least the authors show up, it will ensure a successful meeting. The problem is that program committees sometimes aren't able to vet the papers very well. In the avalanche of submissions, too many papers that are really progress reports tend to get accepted. We are getting increased data flow, but not necessarily increased information.

I guess these problems are, after all, perhaps just a generational thing. In 1980, Gordon Moore, worrying about possible saturation of the global market for logic gates, remarked that his generation might not know what to do with all of them, but the kids then in high school wouldn't have any trouble at all. That was right then and something similar may apply today. Maybe the kids now in high school can design our future microsystems to be smart enough that they can distill their data into real information for us. I sure hope so. ■

Ken Wise

Director, Engineering Research Center
for Wireless Integrated MicroSystem

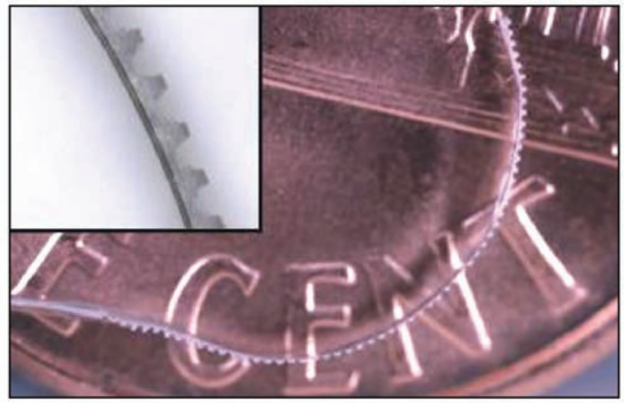
Research Highlights

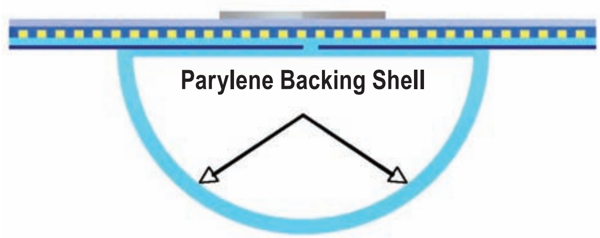
A Robust, Batch-Fabricated, High-Density Cochlear Electrode Array

Angelique C. Johnson and Kensall D. Wise

Cochlear implants for the deaf are the most successful of all neural prostheses; however, pitch perception remains relatively poor due to wire limitations. Commercial wire-bundle cochlear arrays are limited to about twenty wires (sites) by the size of the scala tympani into which the arrays must be inserted. Thin-film arrays can offer significant advantages by increasing the number of sites (increased pitch specificity), allowing deeper insertion (greater pitch range), and reducing cost through batch fabrication. However, any thin-film array must be robust enough for safe insertion into the helical cochlea, stiff enough for deep insertion, and flexible enough to enable a modiolus-hugging curl to position the sites close to receptor cells and reduce insertion trauma.

A robust cochlear electrode array has been developed having 32 IrO sites on 250μm centers and a built-in backing structure to set the stiffness and curl (Figure 1). The arrays are composed of stacked parylene and metal layers (Figure 2). Parylene was chosen as a robust array material for its low Young's modulus (~4–5GPa), high elongation to break (~270%), ease of processing, and biocompatibility. To achieve curl and manipulate the highly flexible parylene arrays, bimorph beams and parylene backing rings have been integrated into the device. Stimulation thresholds comparable to those of much larger commercial devices have been achieved in the guinea pig cochlea. ■

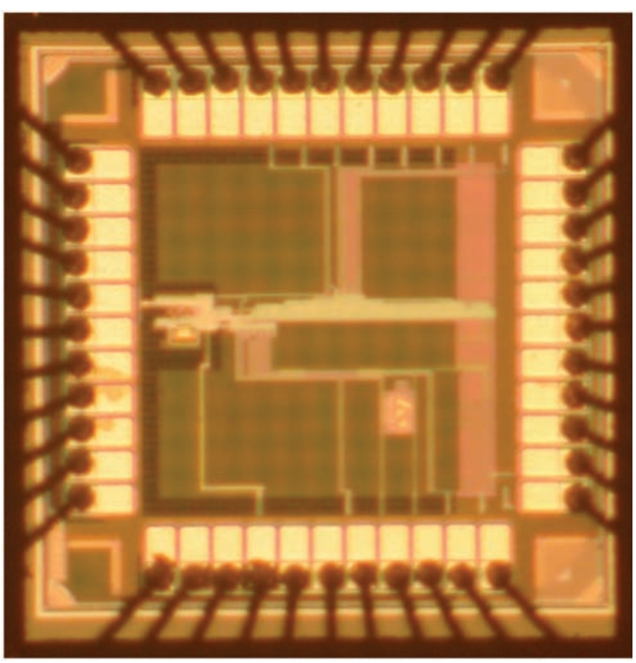




A 32-site, parylene cochlear electrode array having a monolithically fabricated backing structure (Figure 1). The inset shows a side view of the array. A cross-section of the array is shown in Figure 2.

An Ultra-Low-Power PWM Analog-to-Digital Converter

Michael P. Flynn and Shahrzad Naraghi

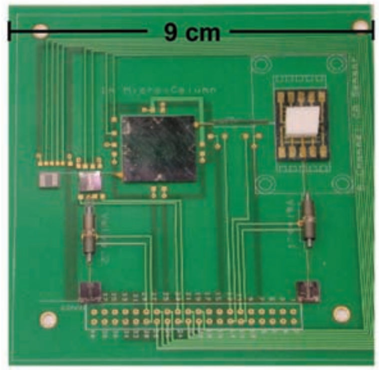


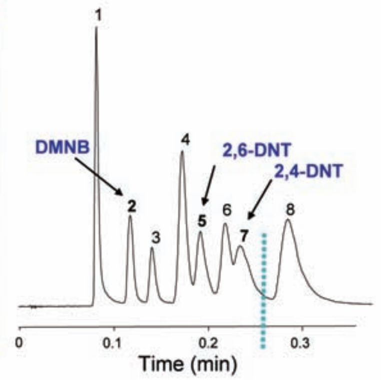
PPM ADC in 90nm CMOS.

Low-power, small-size analog-to-digital converters (ADC) have numerous applications in areas ranging from power-aware wireless sensing nodes for environmental monitoring to biomedical monitoring devices in point-of-care (PoC) instruments. Despite continued improvements to ACDs in recent years, we still strive to make them smaller and more power efficient. An important goal is to achieve ultra-low-power analog-to-digital conversion in nanometer-scale complementary metal-oxide-semiconductor (CMOS), very-large-scale integrated (VLSI) circuits. Fortunately, a new ADC approach shows promise. In particular, time-based techniques for data conversion have demonstrated significant reductions in power consumption, while keeping the silicon chip area small, compared to today's state-of-the-art ADC architectures. Performance, importantly, has not been sacrificed. The time-based conversion technique was demonstrated on a prototype 9-bit, 1MS/s ADC implemented in 90nm digital CMOS (see Figure). Its total power consumption is only 14μW, and the device occupies a die area of only 0.06mm^2. ■

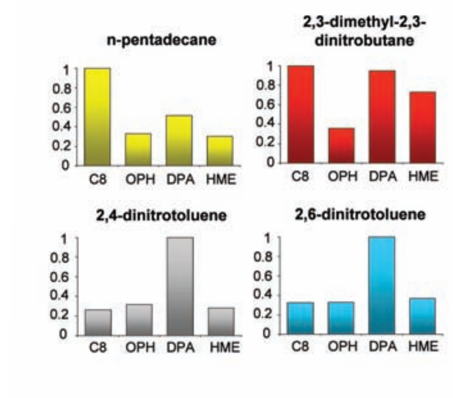
High-Speed Determinations of Explosive Marker Compounds

Gustavo Serrano, Hungwei Chang, Forest Bohrer, and Edward T. Zellers





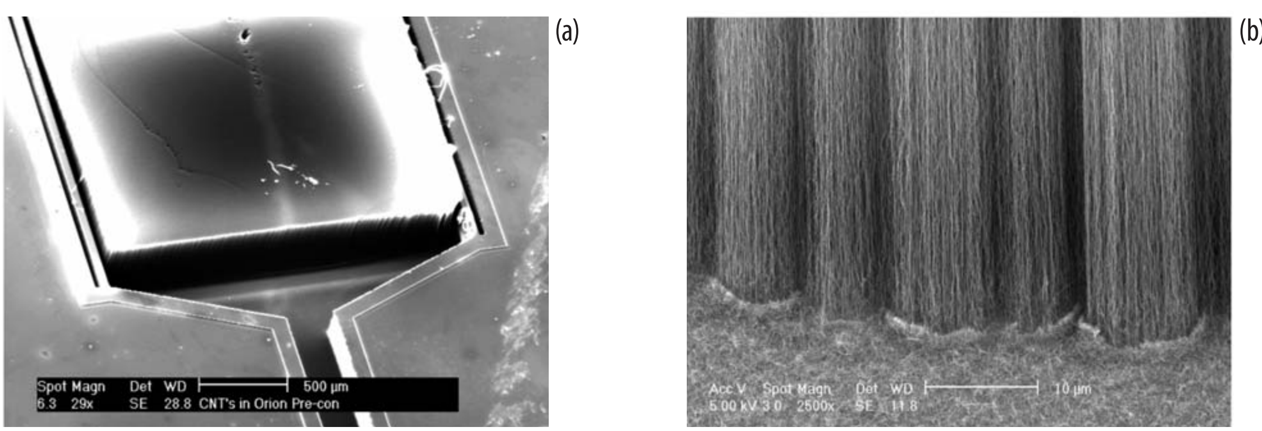
In response to the need for ever-better methods of screening passengers and luggage for concealed explosives at transportation terminals, we are developing microsystems that can rapidly differentiate markers of nitro-aromatic explosives (e.g., TNT) from background interferences at trace concentrations in ambient air. The INTREPID prototype (upper left panel) is a gas chromatographic microsystem (μGC) designed to rapidly capture, preconcentrate, inject, separate, and selectively detect targeted marker compounds. Using our recently redesigned microcolumns we have been able to separate three volatile marker compounds (i.e., the tagant, DMNB, and the natural decomposition products of TNT, 2,4-DNT and 2,6-DNT) from n-alkanes of similar volatility in < 15 seconds (upper right panel). Combining rapid separations with the response patterns obtained from the nanoparticle-coated chemiresistor-array detector used in the INTREPID (lower panel) permits discrimination of targets from overlapping interferences and increases the reliability of the determinations. The limit of detection is projected to be < 0.26 nanograms, which corresponds to a concentration of < 35 parts-per-trillion in a 1-L air sample. ■



Carbon Nanotube Growth in Preconcentrator Chambers

Sameh Tawfick, Katharine Beach, Rebecca A. Veeneman, Edward T. Zellers, and A. John Hart

Carbon nanotubes (CNTs) are seamless hollow cylinders that have unique and exceptional mechanical, thermal, electrical, and chemical properties. Our ability to fabricate highly organized CNT assemblies, having critical dimensions ranging from micron to millimeter scales, offers opportunity to harness the properties of CNTs in MEMS devices. Specifically, use of CNTs in the WIMS μGC could enable both very sensitive vapor preconcentration and low-power operation. We have recently demonstrated growth of CNT "forests" within the cavity of a preconcentrator die. The structure shown below was created by depositing a thin film of Fe inside the cavity, followed by growth of CNTs in a C_2H_4/H_2 atmosphere at approximately 750°C. Upon introduction of the reaction gases to the CNT-growth furnace, the CNTs self-organized into the vertically aligned forest, which contains over 20 billion CNTs per cm^2, where each CNT is smaller than 10nm in diameter. We also found that CNT forests adsorb benzene vapor with 200%–1000% higher sensitivity (saturating 2500 micrograms/g at < 50ppb) than commercial porous carbon (Carbopack), indicating potential for integrated CNTs to significantly improve the performance of the WIMS μGC system. ■



SEM images of (a) CNT forest grown in preconcentration chamber; (b) Sidewall of CNT forest, showing vertically aligned structure.

Recent Events

WIMS ERC Fall Picnics

The U-M WIMS ERC's annual picnic was held on Thursday, September 17, at Gallup Park's Old Pavilion in Ann Arbor. ERC members took advantage of a warm, sunny day to enjoy the end of summer in a relaxed atmosphere together with colleagues, friends, and families. ■










On Friday, September 25, the WIMS ERC students at MTU held their first social event for the 2009 academic year at the McLain State Park on the banks of Lake Superior. ■


Education Highlights

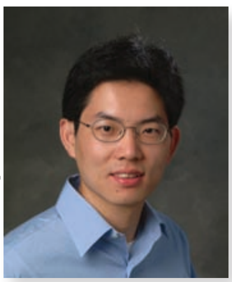
Grant to Expose Teachers to Research, Translate Excitement to Classroom

EAST LANSING, Mich. — Michigan State University has been awarded a three-year grant by the National Science Foundation to establish a first-of-its-kind Research Experiences for Teachers in Engineering Site program on Bio-Inspired Technology and Systems in Michigan.

The NSF Engineering Research Center for Wireless Integrated MicroSystems, or WIMS, will co-host the RET site.

The RET site aims to train a cadre of leaders of middle and high school teachers in the areas of science, technology, engineering, and mathematics by engaging them in cutting-edge research in diverse areas, such as artificial muscles, robotic fish, biosensors, biomechanics, biofuels, digital evolution, and biomolecular engineering.

photo credit: Erin Groom



Professor Xiaobo Tan

"This in turn is expected to lead to the development of innovative curricula in biology, physics, chemistry, and technology that excites precollege students and livens up classroom learning," said Xiaobo Tan, Assistant Professor in MSU's College of Engineering and lead on the project.

The site will partner with a number of schools in Michigan, including Holt Public Schools, Utica Community Schools, and the Detroit Area Pre-College Engineering Program, and will work closely with industry leaders like Motorola, Consumers Energy, and TechSmith.

Drew Kim

"Working in an international environment actually helps you in the classroom," said John Thon, a teacher at Holt Junior High School. "It prepares you for making connections with kids with different learning styles as the dynamics of the United States change."

"The $500,000 award is funded under the American Recovery and Reinvestment Act of 2009, which is particularly meaningful considering the current dire economic situation in Michigan," Tan said. "By exposing teachers to the cutting-edge research that bears impact on important global issues such as environment, energy, food and health care, and by transitioning such knowledge and excitement to the classroom, we hope young students will see and pursue science and engineering-based learning and career paths leading to a bright future."

"Working with the teachers is the exciting part to me," said Drew Kim, assistant to the dean for recruitment, scholarships, and K–12 engineering education. "We want to expose teachers to the cutting-edge research we're doing and then help them translate that excitement to the students in the classroom." ■

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Personnel Focus

Rebecca (Becky) L. Peterson joined the research faculty of the University of Michigan in September 2009 and is currently an Assistant Research Scientist in the Electrical Engineering and Computer Science Department. She earned a B.S. degree from the University of Rochester, New York, in 1996, an M.S. degree from the University of Minnesota (2000), and a Ph.D. degree from Princeton University (2006), all in Electrical Engineering. From 1996 to 1998, she worked for Guidant Corporation (now Boston Scientific) on custom integrated circuit design for implantable cardiac pacemakers and defibrillators. From 2006 to 2009, Becky held a dual position at the University of Cambridge, England, as a Post-Doctoral Research Associate at the Cavendish Laboratory in the Department of Physics, and an Associate Lecturer at Newnham College.

Dr. Peterson's past work has focused on the development of materials and fabrication technologies for a variety of electronic devices, ranging from solution-processed metal oxide semiconductors for application in thin-film transistor backplanes of active-matrix displays (funded by Panasonic Corporation), to uniaxially-strained-silicon MOSFETs achieved via silicon/silicon-germanium heteroepitaxy and wafer-bonding for charge carrier mobility enhancement in high-performance integrated circuits (in collaboration with Naval Research Labs), to oxidized porous silicon for millimeter-wave transmission lines (with DuPont). Her current research is on integration of novel electronic materials and devices with MEMS on both soft/flexible and hard substrates for energy scavenging and sensing applications. As a Research Scientist, she will be collaborating with Professor Khalil Najafi, former Center Deputy Director.

Dr. Peterson has taught undergraduate electrical engineering at the University of Cambridge and at Princeton University, where she won a Teaching Award from the Association of Princeton Graduate Alumni. She was the recipient of graduate fellowships from the National Science Foundation, the Automatic RF Techniques Group, and the American Association of University Women Educational Foundation. She is honored to be part of the WIMS ERC. ■

Special Feature

Yogesh Gianchandani Named WIMS ERC Deputy Director

Yogesh B. Gianchandani has been named Deputy Director of the WIMS ERC, with primary responsibility for leading efforts to define and implement the new WIMS Institute. The Institute will still be centered in U-M's College of Engineering but will involve expanded University-wide research initiatives. Yogesh brings to this position a unique background in microsystems and an in-depth knowledge of future trends. He received his Ph.D. in Electrical Engineering from the University of Michigan in 1994, and after three additional years as a Research Fellow at U-M, joined the faculty at the University of Wisconsin, Madison. In 2001, he returned to the University of Michigan, where he is now Professor of Electrical Engineering and Computer Science. From April 2007 to September 2009, he served at the National Science Foundation as the Microsystems Program Director within the Electrical, Communication, and Cyber Systems Division (ECCS). He has published over 200 papers in journals and conferences, has 30 U.S. patents issued or pending, and was co-editor of the book series *Comprehensive Microsystems: Fundamentals, Technology, and Applications*, published in 2008. He served as a General Co-Chair for the *IEEE/ASME International Conference on MicroElectroMechanical Systems* in 2002. In assuming the role of Center Deputy Director, Yogesh replaces Khalil Najafi, who was key in launching the ERC and recently became Chair of Electrical and Computer Engineering at U-M. Khalil has contributed a great deal to the success of the WIMS ERC, including important breakthroughs in sensors, actuators, wafer-level packaging, and energy scavenging, and we look forward to his continued involvement in all aspects of the microsystems program at U-M and the WIMS Institute. ■

Industrial Liaison's Report

WIMS ERC
10-Year Celebration
May 18–19, 2010

The summer has moved quickly here at the Center as we prepare to enter our 10th year as an NSF-sponsored Engineering Research Center and evolve into an Institute. At our Industrial Advisory Board meeting, we shared our views for the Institute with our members and discussed ways to make the Institute an even more collaborative experience for all of us. The exercise of planning for the Institute caused me to reflect on how the industrial landscape has changed since the ERC was launched in 2000. In the last century, many corporations had extensive internal research activities and vertical integration of manufacturing. Today, few corporations have extensive internal research organizations and many are no longer vertically organized for development and manufacturing. This offers an excellent opportunity for the Institute and companies to explore how to effectively and efficiently bridge the "valley of death" from feasibility demonstration to product. The ERC (soon, Institute) has the capability to provide systems for evaluation by our researchers and to assist companies in productizing the systems. The availability of the Lurie Nanofabrication Facility (LNF) offers industry the capability of developing processes on state-of-the art equipment at a fraction of the cost needed to maintain and staff individual facilities. As our research also utilizes the LNF the transition from feasibility demonstration to prototype to product can be accelerated. The challenge for the ERC and industry is to have more engagement in the stage where the other group is the lead. For industry this requires engagement in the research phase where fundamental decisions are being made that will impact the cost and manufacturability of the product. For the ERC it means that we need to be engaged with the industrial partner to understand the industrial cost targets and performance specifications as they move into the prototype stage. The future requires that both industry and universities grow to meet the challenges of the 21st century.

As always, please visit the Center when in the Ann Arbor area, so we can share our latest technical facilities and have you tour our Lurie Nanofabrication Facility.

If you, or one of your colleagues, is interested in giving a seminar, please contact me to schedule a date at (734) 615-3096 or giachino@eecs.umich.edu. ■

Joseph M. Giachino
Associate Director, Industry

Presentations and Publications

Conference Presentations/Papers

IEEE Symposium on VLSI Circuits, Kyoto, Japan, June 2009

J. Kang and M. P. Flynn, "A 12b 11MS/s Successive Approximation ADC With Two Comparators in 0.13m CMOS"

IEEE Workshop on Analog Circuit Challenges in Biomedical Applications, Dallas, Texas, July 2009

K. D. Wise, "Circuit Challenges in Biomedical Microsystems"

UK Summer School on Electronic Design Leadership, Glasgow, Scotland, July 2009

K. D. Wise, "Emerging Microsystems for Improved Health Care," and "Neural Interfaces: Electronic Windows on the Nervous System"

ASME 3rd International Conference on Energy Sustainability, San Francisco, California, July 2009

E. Romero, M. R. Neuman, and R. O. Warrington, "Passive Energy Harvesting From Human Activities," pp. 1–8.

International Conference on Engineering Education and Research, Seoul, Korea, August 2009

L. C. McAfee, Jr., "Design of a Premier Evaluated Pre-College Program"

L. C. McAfee, Jr., "Pre-College Program Designed to Benefit Graduate Students"

International Symposium on Low Power Electronics and Design (ISLPED), San Francisco, California, August 2009

A. Ghosh, R. Rao, and R. B. Brown, "A Centralized Supply Voltage and Local Body Bias-Based Compensation Approach to Mitigate Within-Die Process Variation," pp. 45–50.

Symposium on MEMS and NanoTechnology for Army Applications, Tank Automotive Research, Development, and Engineering Center (TARDEC), Warren, Michigan, September 2009

D. Aslam, "Single-Material MEMS and NEMS Using Polycrystalline Diamond"

K. D. Wise, "Chemical Analysis Using MicroAutonomous Sensing Platforms"

IEEE Custom Integrated Circuits Conference (CICC), San Jose, California, September 2009

M. Ferriss, D. Lin, and M. P. Flynn, "A Fractional-N PLL Modulator With Flexible Direct Digital Phase Modulation"

Eurosensors XXIII, Lausanne, Switzerland, September 2009

T. Galchev, H. Kim, and K. Najafi, "A Parametric Frequency Increased Power Generator for Scavenging Low-Frequency Ambient Vibrations"

31st Annual International IEEE Conference of the IEEE Engineering in Medicine and Biology Society (EMBS), Minneapolis, Minnesota, September 2009

K. M. Al-Ashmouny, C. Boldt, J. Ferguson, A. Erdman, A. D. Redish, and E. Yoon, "IBCOM (Intra-Brain Communication) Microsystem: Wireless Transmission of Neural Signals Within the Brain"

A. Borna, T. Marzullob, G. Gage, and K. Najafi, "A Small, Light-Weight, Low-Power, Multichannel Wireless Neural Recording Microsystem"

S. I. Chang and E. Yoon, "A 1μW 85nV/√Hz Pseudo Open-Loop Preamplifier With Programmable Band-Pass Filter for Neural Interface System"

S. I. Chang and E. Yoon, "A Low-Power, Area-Efficient, 8-Bit SAR ADC Using Dual Capacitor Arrays for Neural Microsystems "

Y. B. Gianchandani, "Hybrid Micro-Technologies for Medical Applications," pp. 6691–6692

J. Gregory, A. Borna, S. Roy, X. Wang, B. Lewandowski, M. Schmidt, and K. Najafi, "Low-Cost Wireless Neural Recording System and Software"

E. Romero, R. O. Warrington, and M. R. Neuman, "Body Motion for Powering Biomedical Devices," pp. 2752–2755.

COMS 2009 International Conference on Commercialization of Micro and Nano Systems, Copenhagen, Denmark, September 2009

D. Aslam, Z. Cao, and S. Hatch, "Single-Material MEMS and NEMS Using Polycrystalline Diamond"

D. Aslam, S. Hatch, R. Raza, and A. Basit, "Energy Scavenging From Static Charges on Human Body for MEMS and NEMS Applications"

E. Romero, M. R. Neuman, and R. O. Warrington, "Micro Energy Harvesters for Powering Biomedical Applications"

Medical Physics and Biomedical Engineering, World Congress, Munich, Germany, September 2009

E. Romero, R. O. Warrington, and M. R. Neuman, "The Use of Body Motion for Powering Biomedical Devices"

Journal Articles

A. Basu, Y. B. Gianchandani, "Doublet Stirring of Aqueous Samples Using Microfabricated Thermal Probes," in review, July 2009.

A. Basu and Y. B. Gianchandani, "A Programmable Array for Contact-Free Manipulation of Floating Droplets on Featureless Substrates by the Modulation of Surface Tension," *IEEE/ASME J. Microelectromechanical Systems*, in press, July 2009.

I.-J. Cho and E. Yoon, "A Low-Voltage Three-Axis Electromagnetically Actuated Micromirror for Fine Alignment Among Optical Devices," *Journal of Micromechanics and Microengeering*, vol. 19, 085007, July 2009.

S. S. Kellis, P. A. House, K. E. Thomson, R. B. Brown, and B. Greger, "Human Neocortical Electrical Activity Recorded on Nonpenetrating Microwire Arrays: Applicability for Neuroprostheses," *Neurosurgery Focus*, vol. 27, no. 1, E9, July 2009.

L. Yu, Y. Huang, X. Jin, A. J. Mason, and X. Zeng, "Ionic Liquid Thin Layer EQCM Explosives Sensor," *Sensors and Actuators B: Chemical*, 140, pp. 363–370, July 2009.

J. M. Park, A. T. Evans, K. Rasmussen, T. R. Brosten, G. F. Nellis, S. A. Klein, and Y. B. Gianchandani, "A Microvalve With Integrated Sensors and Customizable Normal State for Low Temperature Operation," *IEEE/ASME J. Microelectromechanical Systems*, vol. 18, no. 4, pp. 868–879, August 2009.

A. Basu, Y. B. Gianchandani, "Scanning Probe Thermochemical Patterning in the Context of Nano Scale Lithography," *Nature Nanotechnology, News and Views* (invited article), in press, September 2009.

Y. B. Gianchandani, S. Wright, C. Eun, C. Wilson, B. Mitra, "Exploring Microdischarges for Portable Sensing Applications," *Analytical and Bioanalytical Chemistry (ABC) Journal*, (invited paper), DOI 10.1007/s00216-009-3011-6, vol. 395, no. 3, pp. 559–575, September 2009.

E. Romero, R. O. Warrington, and M. R. Neuman, "Energy Scavenging Sources for Biomedical Sensors," *Physiological Measurement*, vol. 30, pp. R35–R62.

A. M. Sodagar, G. E. Perlin, Y. Yao, K. Najafi, and K. D. Wise, "An Implantable 64-Channel Wireless Microsystem for Single-Unit Neural Recording," *IEEE Journal of Solid-State Circuits*, vol. 4, pp. 1–14, September 2009.

S. Wright and Y. B. Gianchandani, "Contaminant Gas Removal Using Thin-Film Ti Electrode Microdischarges," *Applied Physics Letters*, vol. 95, no. 11, article 11504, pp. 1–3, September 2009.

New Host and Sponsor for Fall SLC Donut Mixer

Our monthly Coffee/Donut Mixer for people from both academia and industry who are involved in microsystems-related activities was for the first time hosted by the Nanotechnology and Integrated Microsystems Student Association (NIMSA) on October 1, with special sponsorship from Schlumberger Inc. NIMSA is a new organization founded by the WIMS SLC to support the academic excellence, professional development, and interrelationships of all students in the areas of nanotechnology and microsystems. The mixer was very well attended by WIMS ERC members, LNF users, and SSEL members, who enjoyed this tasty break while networking, swapping processing tips, discussing research ideas, and getting to know their colleagues in the microsystems field. ■

Visit our Web site at http://wimserc.org to find out more information about these seminars and to view them on streaming video. You can also see a schedule of upcoming seminars, as well as a listing of publications.

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