Wireless Integrated MicroSensing & Systems
WIMS²
Michigan Engineering

Horizons

Microsystems for the Next Generation

January 2012

Director's Message

Yogesh B. Gianchandani

It's already 2012 and much has happened since we published our last newsletter in 2010. As you will see from this issue, WIMS has changed and grown in important ways during the past year, and we are looking forward to another exciting year ahead.

The first thing you may have noticed is that we have changed our name slightly to the Center for Wireless Integrated MicroSensing & Systems (WIMS²). As we graduated from NSF support in August 2010, we had the opportunity to re-evaluate our mission and adjust our course. The relatively minor change in the name reflects our continuing commitment to the central research themes of our first decade – microsensing and microsystems.

There have been a few changes in the Center leadership as well. Ken Wise retired from the position of Director in August 2010, and now is an emeritus professor. Khalil Najafi stepped back from the position of Deputy Director in August 2009 to serve as Co-Chair of the EECS Department and Chair of the ECE Division. Ken and Khalil co-founded WIMS in 2000, and remain deeply engaged in WIMS². In fact, Khalil is leading a number of the Center's new DARPA-funded research projects in inertial sensors.

Joe Giachino, who founded our industrial program, retired in August 2011, and was replaced by Dr. Andy Oliver. We are excited to have Andy's corporate and national lab perspective. Joe will continue to support us as a visiting scholar. He is organizing and coordinating the Center's new Strategic Advisory Board.

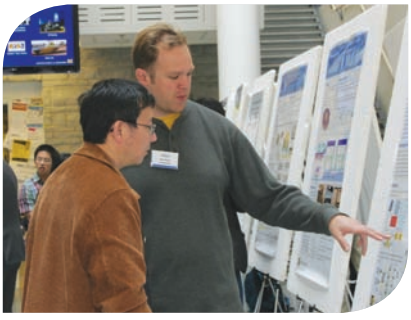
The Strategic Advisory Board will guide WIMS² on engagement with industry and will help identify challenges that have the greatest societal impact. The Board includes Dr. Kurt Peterson, a member of the former WIMS Scientific Advisory Board, who has kindly agreed to serve in this new capacity. Dr. Peterson is a member of NAE, Founder and President at KP-MEMS, Founder of Nova Sensor, and Co-founder of SiTime. In addition to Joe and Kurt, the other members are: Dr. Herbert Bennett, who is a NIST Fellow and Executive Advisor at NIST (National Institute of Standards and Technology), and was formerly at NSF; Roger Grace, President of Roger Grace Associates, who has 30 years of consulting experience and 40 years of engineering experience; Dr. Kalyan Handique, currently CEO at DeNovo Sciences, formerly Vice-president of Becton Dickinson and Co-founder and CTO of HandyLab, Inc.; and Ms. Patti Glaza, of Arsenal Venture Partners, who has 20 years of commercialization experience. We are honored to have their support and guidance.

Since the last newsletter, we have added two new research thrust leaders. Professor Jerome "Jerry" Lynch, from the Civil and Environmental Engineering Department, heads an effort in developing sensors, sensing systems, and data processing for infrastructure monitoring. This Built Environment Thrust harnesses WIMS² strengths in

(Continued on page 2)

Industrial Advisory Board Meeting Held

The Fall 2011 Industrial Advisory Boad Meeting was held on November 10. Nearly 100 industrial representatives, students, faculty, and staff attended the meeting in the Lurie Engineering Center on the U-M's North Campus. In total, 15 different organizations were represented. The meeting was divided into morning and afternoon sessions where 13 faculty members presented their work. There was a poster session at lunch with 45 student posters. After the technical sessions, there were meetings of the industrial advisory board and the associate members. Also, 4 members of our new strategic advisory board met in closed session and provided feedback for the Center. The members of the Strategic Advisory Board in attendance were Joe Giachino, Patti Glaza, Roger Grace, and Kaylan Handique. After the meetings, an excellent dinner at the Dahlmann Campus Inn was followed by an enlightening and entertaining talk by David Chapman from the Advanced Energy Consortium. ■



Director's Message

(Continued from page 1)

wireless and micro-power circuits and builds upon Professor Lynch's original work and expertise in structural health monitoring. Professor Mina Rais-Zadeh, from the Electrical Engineering and Computer Science Department, leads a new thrust in High Frequency MEMS. This Thrust is exploring advanced RF devices and microsystems; high-*Q* optical and acoustic resonators; terahertz modulators, imagers, and sources; miniaturized antennas, metamaterials, plasmonics, and near-field optics. The configuration of thrusts in WIMS^2 will continue to evolve as we adapt to emerging research opportunities in the coming year.

Another new face in the WIMS^2 leadership is Professor Katsuo Kurabayashi, from Mechanical Engineering, who is the Director of International Academic Partnerships. He chaired the *MicRO Alliance Meeting* in October 2011. This event consisted of one and a half days of lectures on a wide range of microsystems topics. It was an immense success, with more than fifty attendees, including those from Alliance partners, WIMS^2 industrial members, and students and faculty from the University of Michigan.

I am pleased to report that our industrial partnership program has undergone some structural changes that make it easier for us to engage with companies and that we have expanded our membership. While the full member benefits and fees have not changed, we have now added an associate member level that is directed primarily at non-profit organizations and small companies. In addition, all geographical regions now have the same membership privileges. Since September 2010, we have gained six associate members and one full member company (the ATRM division of Johnson and Johnson), and we are in discussions with several more potential members. I am also pleased that in 2011 we found ways to enhance the interactions with each of our member companies, extending beyond the standard benefits of membership. (Send us a note if you would like to know more about how we work with companies.)

In addition, our corporate outreach activities in 2011 included the offering of a short course on MEMS Packaging at the *COMS 2011 Conference*. We have several exciting initiatives planned for 2012, including outreach events in Silicon Valley in the spring and at the *Hilton Head MEMS Conference* in June, and our *Spring Industrial Advisory Board Meeting* in Ann Arbor on May 10. Please mark your calendars and plan to attend. ■

WIMS^2 Welcomes New Members

NEW MEMBERS

We are pleased to announce that **Advanced Technologies and Regeneration Medicine, LLC (ATRM)**, an affiliate of Johnson and Johnson, has joined WIMS^2 as a full member. ATRM is a multidisciplinary and integrated medical research and development organization. Their mission is to transform medical devices and therapies through technological innovation. ATRM is a research organization whose focus is on regenerative medicine, drug and biologic device combination products, and implantable devices. The ATRM WIMS^2 representative is Dr. Jingkuang Chen. (www.atrm.com)

NEW ASSOCIATE MEMBERS

ElectroDynamic Applications, Inc. (EDA) is focused on developing new applications for plasma-based technology. EDA specialties include in-space electric propulsion, plasma diagnostics, hypervelocity systems, plus spacecraft and vacuum technologies in general. Their business activities focus on critical technology incubation and high-tech contract research for academic, industrial, and government clients. The EDA WIMS^2 representative is Dr. Thomas Liu. (www.edapplications.com)

Virginia Technologies, Inc. is an award-winning leader in electronic instrumentation with several products including an Embedded Corrosion Instrument for monitoring corrosion in steel reinforced concrete, and Q-Stim — a neurostimulation system that adapts to patient needs. Virginia Technologies has its headquarters in Charlottesville, Virginia, and the WIMS^2 representative is the Company President, Dr. Bob Ross. (www.vatechnologies.com)

Twisthink, LLC is a privately-held firm that designs and develops in the following market categories: automotive, consumer, electronics, residential, healthcare, defense, and industrial/commercial. Many Fortune 100 companies come to them for their expertise in electronics, industrial design, and strategic consulting. They are located in Holland, MI, and the WIMS^2 representative is Kurt Dykema. (www.twisthink.com)

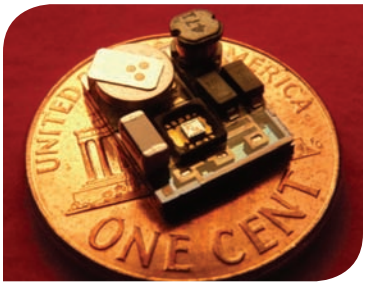
Virtual EM Inc. is a privately-held, high-tech enterprise with the mission to develop disruptive technologies for defense and civilian markets. Since its founding in 2002, it has carried out research and has developed prototypes in such diverse fields as computational electromagnetics and wireless sensor networks. Dr. Tayfun Ozdemir is the WIMS^2 representative. (www.virtualem.com)

KIST, Korea Institute of Science and Technology, headquartered in Seoul, Republic of (South) Korea, focuses on frontier and global agenda type research by taking on large-scale, long-term, and interdisciplinary research and development projects which will strengthen its role as a public research institute and differentiate itself from academia and industry. Dr. Eui Sung Yoon is the contact person. (www.kist.re.kr/en)

Semefab operates three wafer fabs on its Glenrothes, Scotland site supporting 150mm and 100mm wafer flows. Their operation supports a very diverse process portfolio, including MEMS, wafer bonding, CMOS, Power MOS, JFET, and discrete components. Semefab supports volume foundry applications, as well as a technology development and technology commercialization. The contact person is Ian McNaught. (www.semefab.com) ■

Millimeter-scale MEMS Inertial Energy Harvester With Power Management IC

Ethem Erkan Aktakka, Rebecca L. Peterson, and Khalil Najafi

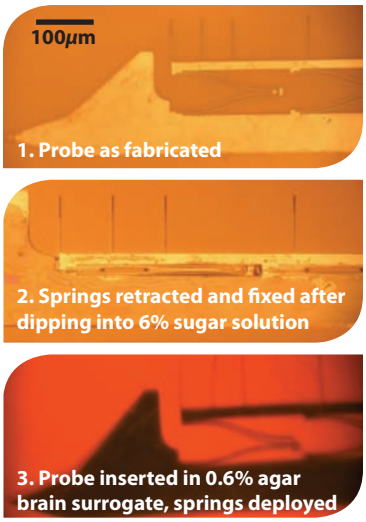


Resonant vibration energy harvester with circuitry.

In order to power fully-autonomous wireless sensor networks, one solution is to use energy harvesting of ambient vibrations. To this end, we have developed a millimeter-scale MEMS inertial energy harvester with a power management integrated circuit. We use aligned, low-temperature (200°C) solder bonding and thinning of bulk PZT ceramics (with <0.5μm uniformity) to integrate these high-performance materials into a MEMS harvester. The harvester consists of a cantilevered PZT + bond layer with tungsten proof mass, packaged in a silicon bottom cap and glass top cap using vertical low-resistivity silicon vias. On top are surface mount components and a custom-designed 0.18μm power management IC containing active diodes, a shunt-pass (bias-flip rectifier), and a trickle charger. The 27mm^3 system is completely self-supplied by vibration energy, and does not require a previously-charged energy reservoir. Currently at the state-of-art, this self-supplied autonomous platform can produce >100μW when excited at 155Hz with 1g acceleration, has a large bandwidth of 13Hz, and can recharge a battery/ultra-capacitor up to 1.85V. This work has industrial and automotive applications and was reported at the *ISSCC 2011 Conference*. This work was supported by DARPA HI-MEMS grant #N66001-07-1-2006. ■

Post-implant Deploying Satellite Sites for Chronic Neural Probes

Daniel Egert, Rebecca L. Peterson, and Khalil Najafi

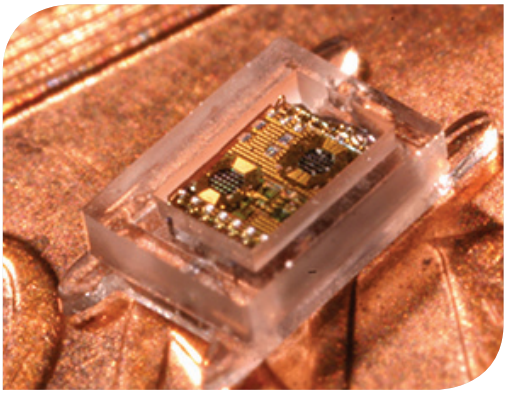


Fabrication, retraction, and post-implant deployment of satellite neural probe sites.

Implanted neural microprobes evoke immune system responses leading to formation of a 100-150μm wide "dead-zone" populated by scar tissue instead of neurons. We have demonstrated a new approach to improve the chronic stability of neural recording probes: to deploy – after implantation – very small satellite recording sites to locations outside the "dead-zone." Arrays of recording sites are attached to an arm that can be moved with respect to the shank using mechanical springs. The individual sites are needles with very fine features that are protected during implantation by the probe shank. Before implantation, the recording sites are retracted and fixed in place using harmless dissolvable glue (e.g., sugar). After implantation, the glue dissolves and the springs push the arm away from the shank so that the deployed sites act like satellites, floating almost freely inside the brain tissue. This approach should decrease tissue reaction to the sites and thus establish a more stable, chronically-applicable electrical interface to neurons. These results were reported at the *Transducers 2011 Conference* in Beijing, China. This work was supported by a DARPA HI-MEMS grant # N66001-07-1-2006. ■

Millimeter-scale Implanted Pressure Monitoring System

Gregory Chen, Hassan Ghaed, Razi-ul Haque, Kensall D. Wise, David Blaauw, and Dennis M. Sylvester



We have developed a cubic millimeter-sized intraocular pressure monitoring system with energy-autonomous operation and wireless communication. The size constraint of implanting a device in the eye creates major challenges for achieving high-resolution pressure measurements, wireless communication, and multiyear device lifetime. The device is implanted with a minimally invasive procedure through a tiny incision that is routinely used for outpatient cataract surgery. The miniature microsystem harvests solar energy that enters the eye through the transparent cornea to achieve energy-autonomy. The microsystem contains an integrated solar cell, thin-film Li battery, MEMS capacitive sensor, and integrated circuits vertically assembled in a biocompatible glass housing. The circuits include a wireless transceiver, capacitance-to-digital converter (CDC), and a DC-DC switched capacitor network.

This is one of the first true millimeter-scale complete computing systems. The processor in the eye pressure monitor is the third generation of the Phoenix Chip, which uses a unique power-gating architecture and an extreme sleep mode to achieve ultra-low-power consumption. The newest system wakes every 15 minutes to take measurements and consumes an average of 5.3 nanowatts. To keep the battery charged, it requires exposure to 10 hours of indoor light each day or 1.5 hours of sunlight. It can store up to a week's worth of information. This research was reported at the *ISSCC 2011 Conference*. ■

Personnel Focus

Jerome Lynch

Associate Professor, CEE and ECE
WIMS² Thrust Leader,
Built Environment and Sensing

Jerome "Jerry" Lynch received the M.S. and Ph.D. degrees in Civil and Environmental Engineering, in 1998 and 2002, respectively, and the M.S. degree in Electrical Engineering in 2003, from Stanford University, Stanford, CA. Currently, he is an Associate Professor of both Civil and Environmental Engineering and Electrical Engineering and Computer Science at the University of Michigan, and is also the Thrust Leader for the Built Environment Sensing Thrust. His research interests are centered in the exciting field of smart-structure technologies. The collection of response data from civil structures is important for assessing long-term structural performance and for rapid diagnosis of structural health. Professor Lynch's research has focused upon the design of wireless, structural-monitoring systems with decentralized computing infrastructures. Embedded with sensors are computationally efficient algorithms for damage detection that can autonomously interrogate measurement data for indications of structural distress. Additional research interests include the use of active sensors, structural control, microelectromechanical systems, nanotechnology, and large-scale systems. Dr. Lynch was awarded the 2005 Office of Naval Research Young Investigator Award, the 2007 University of Michigan Henry Russel Award, and the 2008 University of Michigan College of Engineering 1938E Award. ■

Visit our new Website at
www.wims2.org

Industrial Liaison Report

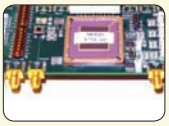
Andy Oliver

The purpose of the WIMS²'s Industrial Outreach Program is to promote interactions between industry and the university including technology transfer, setting up joint projects, assisting with recruiting, facilitating interactions between the faculty and industrial members. To that end, the industrial liaison's office has been busy meeting with almost all of our industrial partners outside of the normal IAB meetings during the last calendar year. Most of these were at the companies' sites. If you would like a visit or a meeting with either the industrial liaison or one of the faculty, please don't hesitate to ask. Member companies are encouraged not to be shy about requesting other services from WIMS². One of the more popular requests has been facilitated access to fabrication resources. One member company asked us to modify the existing design of a device so that they could use it for their own purposes. Another member company came up with a new design and used us to build it. In both cases, WIMS² used staff engineers to build these devices for our members and charged them our cost. This is a very cost-efficient way to leverage the existing experience of our staff to build your devices without requiring your own staff to be trained in our facility. In another example, Stryker used the Resident Engineer Program to design and build a device at the Lurie Nanofabrication Facility while taking advantage of free hallway-type consulting from their offices in the EECS building. Dexter Research, an associate member, has been using the LNF cleanroom with their own staff and WIMS² periodically is asked to assist.

Other forms of assistance include: connecting companies and faculty, consulting, working on company sponsored research and development efforts, writing joint proposals, introducing companies to each other and helping companies interact with other parts of the university. We have also helped our members with mundane things like reserving university conference room, and assistance with the parking at the university. In addition, many of our member companies enjoy giving seminars at the university or visiting with our faculty and students about the latest research results. To schedule a visit, please contact us and we would be happy to arrange it. Contact: 734-615-2325 or ado@umich.edu. ■

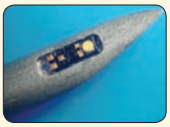
WIMS² Research Thrusts Summary

WIMS² is focused on fundamental and translational research on MEMS, microsystems, and microsensors through research, education, and interactions with industry. The applications for this research are centered on sensors and systems in three areas: 1) biomedical instrumentation, 2) MEM-enabled gas chromatographs, and 3) sensors for infrastructure. The core technologies that support these applications include: micro and nanoscale fabrication, micromachined RF filters and resonators, packaging, power harvesting, low-power circuitry, and wireless interfaces. The combination of core technologies and applications' focus distinguishes WIMS² from other university research efforts.



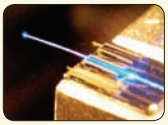
The **Wireless Interfaces Thrust** *(Michael P. Flynn, Thrust Leader)* undertakes basic and applied research in wireless interfaces for microsensor applications. Topics include CMOS RF circuits, low-power transceivers, miniature antennas, novel architectures, digital dominant wireless and sensor networking. The applications for this work are short-range biomedical devices and medium-range moderate data rate environmental sensing applications.

The **Micropower Integrated Circuits Thrust** *(Dennis M. Sylvester, Thrust Leader)* is directed at greatly reducing the power requirements of integrated circuits used in microsystems. Topics of interest include low-power digital and analog circuits, new circuit and system architectures, system software, power management, and energy harvesting.

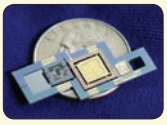


The **Advanced Materials, Processes and Packaging Thrust** *(Yogesh B. Gianchandani, Thrust Leader)* involves developing processing techniques for traditional and non-traditional MEMS materials, such as stainless steel, vacuum and wafer-level packaging, wafer bonding, assembly and interconnect technologies, mechanical protection of microsystems, and thermal management issues. It also includes the investigation of new types of transduction methods for devices ranging from micro-gyroscopes to monolithic gas pumps.

The **High Frequency MEMS Thrust** *(Mina Rais-Zadeh, Thrust Leader)* undertakes research in RF MEMS, Optical MEMS, and THz MEMS from a basic science and applied research perspective. The Thrust is exploring advanced RF devices and microsystems, high-*Q* optical and acoustic resonators, terahertz modulators, terahertz imagers, terahertz sources, miniaturized antennas, metamaterials, plasmonics, and near field optics.



The **Biomedical Devices Thrust** *(Euisik Yoon, Thrust Leader)* includes neural interface technology which was pioneered by the University of Michigan. It also includes work on microfluidic systems for medical applications such as cell sorting and "lab-on-a-chip" applications and other areas such as typing device tissue interactions and flexible systems. This research area leverages basic research in microfabrication, low-power circuits, and wireless and RF devices.



The **Environmental Sensors Thrust** *(Edward T. Zellers, Thrust Leader)* is centered around an integrated gas chromatograph (GC) targeted at rapid gas analysis with sub-part-per-billion sensitivity. Applications include sensing of complex mixtures, explosives, and pollutants. This research leverages technologies developed in the microfabrication area. The small scale of these devices enable greater portability, lower power consumption, and faster response time than larger systems. The Thrust also includes development of novel radiation detectors.

The **Built Environment Sensing Thrust** *(Jerome P. Lynch, Thrust Leader)* is developing microsystems to monitor the health of buildings, bridges, and the status of aircraft fuselages and naval vessel hulls. These devices are often connected together in wireless sensor networks that can communicate, measure, and analyze. Technology from the other research areas such as microfabrication, power harvesting, low-power circuits, and wireless devices are important enabling technologies for this effort. ■

Doctoral Dissertations

Ethem Erkan Aktakka (December 2011)
"Integration of Bulk Piezoelectric Materials into Microsystems"
Chair: Professor Khalil Najafi

Amir Borna (October 2011)
"A Low-Power, Wireless, Multi-Channel Microsystem for Reliable Neural Recording"
Chair: Professor Khalil Najafi

Gregory Chen (April 2011)
"Power Management and SRAM for Energy-Autonomous and Low-Power Systems"
Chair: Professor Dennis M. Sylvester

Jae Yoong Cho (January 2012)
Environmental Resistant Rate- and Rate-Integrating Gyroscopes
Chair: Professor Khalil Najafi

Danial Ehyaie (July 2011)
"Novel Approaches to the Design of Phased Array"
Chair: Professor Amir Mortazawi

Razi-ul Haque (August 2011)
"An Implantable Microsystem for Autonomous Intraocular Pressure Monitoring Based on a Glass-in-Silicon Reflow Process"
Chair: Professor Kensall D. Wise

Yoonmyung Lee (December 2011)
"Ultra-Low Power Circuit Design for Cubic-Millimeter Wireless Sensor Platform"
Chair: Professor David Blaauw

Eric D. Marsman (December 2011)
"A Low-Power DSP Architecture for a Fully Implantable Cochlear Implant System-On-A-Chip"
Co-Chairs: Professors Richard B. Brown and Dennis M. Sylvester

Fatih Mert Ozkeskin (September 2011)
"Bulk Foil Pt-Rh Micro-relays for High Power RF and Other Applications"
Chair: Professor Yogesh B. Gianchandani

Angelique C. Johnson (August 2011)
"An Active Thin-film Cochlear Electrode Array With Monolithic Backing and Curl"
Chair: Professor Kensall D. Wise

Karthik Visvanathan (May 2011)
"Bulk Micromachined Piezoelectric Transducers for Ultrasonic Heating of Biological Tissues"
Chair: Professor Yogesh B. Gianchandani.

Ramsey Zeitoun (June 2011)
"Structured Material Generation and Chemical Handling Advancements in Microfluidic Platforms"
Chair: Professor Mark Burns ■

Recent Events

WIMS^2 hosted an annual international meeting called "MicRO Alliance Symposium," with support from the College of Engineering and the OVPR, on the U-M North Campus on October 7 – 8, 2011. This meeting gathered together faculty, students, and researchers from U-M, University of Freiburg in Germany, and Kyoto University in Japan, the world-renowned research universities in the field of MEMS/NEMS and nanosystems. The workshop has been successful in developing international collaborations between WIMS^2 and IMTEK Freiburg and Kyoto faculty and students for the last eight years. This year, this symposium offered topical short courses for our industrial partners and research seminars by speakers from the participating institutions. The talks presented in the symposium are posted on the WIMS Website (http://www.wims2.org/media/ma_video.html). Contact the WIMS^2 Webmaster Jonathan Plummer (jonplum@umich.edu) for the login and password. The meeting served as a very useful vehicle to promote research and education.

The next meeting will be held in Freiburg, Germany on June 29, 2012.

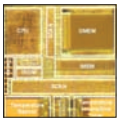
Center for Wireless Integrated MicroSensing & Systems
University of Michigan

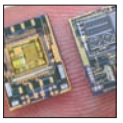
presents

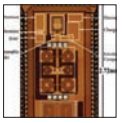
Networking/Mixer Event and Tutorials on Microsystem Technology

April 18, 2012 Location TBD Santa Clara, California

This is an opportunity to meet faculty and arrange collaborations as well as to learn about some of the newest innovations in MEMS and High Frequency MEMS, Biomedical Devices, Low-Power Electronics, and Wireless Technology.







Tentative Schedule

1:00 – 1:30 Introduction to the WIMS^2 Research Center . . . . . Y. Gianchandani
1:30 – 2:15 Recent Innovations in Microsystem Wireless Technology . . . . . M. Flynn
2:15 – 3:00 Advances in High Frequency MEMS . . . . . M. Rais-Zadeh
3:00 – 3:45 Biomedical Devices (Implanted and MicroFluidic) . . . . . E. Yoon
3:45 – 4:30 Miniaturized Gas Chromatograph Technology . . . . . K. Kurabayashi
4:30 – 5:15 Ultra Low Power Microprocessors for Embedded Sensor Applications . . . . . D. Sylvester
5:15 – 8:00 Mixer and Networking

There is no fee for this event.

For more information contact:
Andy Oliver, 734 615 2325 or ado@umich.edu

Register online – www.wims2.org

Member Partners

Agilent Technologies, Inc.
ATRM, LLC
Honeywell International
Stryker Corporation
Texas Instruments, Inc.

Associate Members

Cochlear Corporation
Dexter Research Center, Inc.
ElectroDynamic Applications, Inc.
KIST - Korean Institute of Science and Technology
Sandia National Laboratories
Semefab (Scotland) Ltd
Twisthink, LLC
Virginia Technologies, Inc.
Virtual EM Inc.

Seminar Series

January 6, 2012

Ning Xi
Distinguished Professor
and the John D. Ryder Professor
of Electrical and Computer Engineering
Director of Robotics and Automation Laboratory,
Michigan State University
"Infrared Imaging Using Carbon Nanotube (CNT)
Based Detectors: From Design to Manufacturing"

January 25, 2012

Pedram Mohseni
Associate Professor
Director, BioMicroSystems Laboratory,
Electrical Engineering and Computer Science Department,
and Biomedical Engineering Department
Case Western Reserve University
"Circuits and Systems for Real-time Neurochemical
Sensing and Activity-dependent Intracortical Microstimulation"

Visit our Website at www.wims2.org to find out more information about these seminars and to view them on streaming video.

C. K. Eun and Y. B. Gianchandani, "A Microfabricated Steel and Glass Radiation Detector With Inherent Wireless Signaling," *IOP Journal of Micromechanics and Microengineering*, vol. 21 (1), pp. 1–10, January 2011.

Y. S. Torisawa, B. Mosadegh, S. P. Cavnar, M. Ho, and S. Takayama, "Transwells With Microstamped Membranes Produce Micropatterned 2D and 3D Co-cultures," *Tissue Engineering Part C: Methods*, vol. 17 (1), pp. 61–67, January 2011.

W. Zhu, J. M. Park, M. J. White, G. F. Nellis, and Y. B. Gianchandani, "Experimental Evaluation of an Adaptive Joule-Thomson Cooling System Including Silicon-microfabricated Heat Exchanger and Microvalve Components," *Journal of Vacuum Science and Technology B (JVSTB)*, vol. 29 (2), 021005, January 2011.

N. J. Douville, P. Zamankham, Y. C. Tung, R. Li, B. L. Vaughan, J. White, J. B. Grotbert, and S. Takayama, "Combination Fluid and Solid Mechanical Stresses Contribute to Cell Death and Detachment in a Microfluidic Alveolar Model," *Lab on a Chip*, vol. 11, pp. 609–619, February 2011.

A. T. Evans, S. Chiravuri, and Y. B. Gianchandani, "A Multi-drug Delivery System Using a Piezoelectrically Actuated Silicon Valve Manifold With Embedded Sensors," *IEEE/ASME Journal of Microelectromechanical Systems (JMEMS)*, vol. 20 (1), pp. 231–238, February 2011.

N. K. Gupta and Y. B. Gianchandani, "Thermal Transpiration in Mixed Cellulose Ester Membranes: Enabling Miniature, Motionless Gas Pumps," *Microporous and Mesoporous Materials*, vol. 142, pp. 535–541, February 2011.

M. E. Merriam, S. E. Shore, S. Dehmel, O. Srivannavit, and K. D. Wise, "A 3-D 160-site Microelectrode Array for Cochlear Nucleus Mapping," *IEEE/ASME Journal of Microelectromechanical Systems (JMEMS)*, vol. 58, no. 2, pp. 397–403, February 2011.

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K. T. Beach, S. M. Reidy, R. J. Gordenker, and K. D. Wise, "A Low-mass High-speed μGC Separation Column With Built-in Fluidic Chip-to-chip Interconnects, pp. 813–816.

C. K. Eun and Y. B. Gianchandani, "A Microdischarge-based Radiation Detector Utilizing Stacked Electrode Arrays in a TO-5 Package," pp. 668–671.

S. R. Green and Y. B. Gianchandani, "Miniature Penning Cell Array for On-chip Vacuum Pumping," pp. 1162–1165.

R. M. Haque and K. D. Wise, "A 3D Implantable Microsystem for Intraocular Pressure Monitoring Using a Glass-in-silicon Reflow Process," pp. 995–998.

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T. Li and Y. B. Gianchandani, "An Active Tissue-contrast Sensing Microsystem for Biopsy Needles: Initial Results," pp. 21–24.

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Y. Shim, Z. Wu, and M. Rais-Zadeh, "A High-performance Temperature-stable Continuously Tuned MEMS Capacitor," pp. 752–755.

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IEEE 11th Topical Meeting on Silicon Monolithic Integrated Circuits in RF Systems (SiRF'11), Phoenix, AZ, January 2011

M. Rais-Zadeh, "Design and Fabrication Considerations in Developing High-*Q* MEMS Capacitors and Inductors," (Invited).

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IEEE International Solid-State Circuits Conference (ISSCC), San Francisco, California, February 2011

E. E. Aktakka, R. L. Peterson, and K. Najafi, "A Self-supplied Inertial Piezoelectric Energy Harvester With Power-Management IC," pp. 120–121.

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Y. B. Gianchandani, "Engineering Pain Relief: Microsytems for Intrathecal Drug Delivery," (Invited).

K. Huang and D. Wentzloff, "A 60GHz Antenna-referenced Frequency-locked Loop in 0.13μm CMOS for Wireless Sensor Networks," pp. 284–285.

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D. Sylvester, "Ultra-low Power Design for WSN," (Sunday Night Panelist).

IEEE International Midwest Symposium on Circuits and Systems (MWSCAS), Seoul, Korea, February 2011

Y. Lee, D. Sylvester, and D. Blaauw, "Synchronization of Ultra-low-power Wireless Sensor Nodes,"(Invited).

Pittcon '11 Conference and Expo, Atlanta, GA, March, 2011

Y. B. Gianchandani, "Micro-scale Instruments for Environmental Sensing," Symposium on Micro- and Nano-instruments: Fast, Cheap and Under Wireless Control, (Invited).

E. T. Zellers, S. K. Kim, H. Chang, G. Serrano, S-J. Kim, T. Sukaew, F. Bohrer, J. Bryant, R. Gordenker, K. D. Wise, and K. Kurabayashi, "Microfabricated Gas Chromatographs With Microsensor Array Detectors for Sub-ppb Determinations of Complex Vapor Mixture Components"

SPIE Smart Structures/NDE, San Diego, CA, March 2011

T. Galchev, J. McCullagh, R. L. Peterson, K. Najafi, and A. Mortazawi, "Energy Harvesting of Radio Frequency and Vibration Energy to Enable Wireless Sensor Monitoring of Civil Infrastructure," vol. 7983, pp. 798314.

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T. Li and Y. B. Gianchandani, "Batch Mode Micromanufacturing Based on Micro Electro-discharge Machining and Micro Ultrasonic Machining for Micro Electro Mechanical Systems (MEMS)," pp. 1–8.

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Y. B. Gianchandani, "Microplasmas for Microinstruments: Case Studies in Environmental Sensing," (Invited).

SPIE Conference on Defense and Security, Orlando, FL, April 2011

M. P. Flynn, D. T. Lin, M. Ghahramani, and L. Li, "New Techniques for Efficient Flexible Wireless Transceivers in Nanometer CMOS," (Invited).

IEEE International Conference on Acoustics, Speech, and Signal Processing, Prague, Czech Republic, May 2011

P. K. Yenduri, A. C. Gilbert, M. P. Flynn, and S. Naraghi, "Rand PPM : A Low-power Compressive Sampling Analog-to-Digital Converter."

IEEE International Symposium on Circuits and Systems (ISCAS), Rio de Janiero, Brazil, May 2011

D. Kim, G. Chen, M. Fojtik, M. Seok, D. Blaauw, and D. Sylvester, "A 1.85fW/bit Ultra Low Leakage 10T SRAM With Speed Compensation Scheme."

IEEE International Conference on Solid-State Sensors and Actuators (Transducers), Beijing, China, June 2011

E. E. Aktakka, R. L. Peterson, and K. Najafi, "Thinned-PZT on SOI Process and Design Optimization for Piezoelectric Inertial Energy Harvesting," pp. 1649–1652.

J. Y. Cho, J. A. Gregory, and K. Najafi, "Single-crystal-silicon Vibratory Cylindrical Rate Integrating Gyroscope (CING)," pp. 2813–2816.

M. DeVolder, S. Tawfick, D. Copic, and A. J. Hart, "Hygroscopic Biomimetic Transducers Made From CNT-hydrogel Composites," pp. 1717–1720.

M. DeVolder, S. Tawfick, S. J. Park, D. Copic, and A. J. Hart, "Programmable Transformation of Vertically Aligned Carbon Nanotubes Into 3-D Micro-Structures," pp. 2718–2721.

D. Egert, R. L. Peterson, and K. Najafi, "Parylene Microprobes With Engineered Stiffness and Shape for Improved Insertion," pp. 198–201.

D. Egert and K. Najafi, "New Class of Chronic Recording Multichannel Neural Probes With Post-implant Self-deployed Satellite Recording Sites," pp. 958–961.

T. V. Galchev, J. McCullagh, R. L. Peterson, and K. Najafi, "Harvesting Traffic-induced Bridge Vibrations," pp. 1661–1664.

V. J. Gokhale, J. Roberts, and M. Rais-Zadeh, "High Performance Bulk-mode Gallium Nitride Resonators and Filters," pp. 926–929.

J. A. Gregory, J. Y. Cho, and K. Najafi, "MEMS Rate and Rate-integrating Gyroscope Control With Commercial Software Defined Radio Hardware," pp. 2394–2397.

R. M. Haque, D. E. Serrano, X. Gao, N. Shirazi, V. Keesara, F. Ayazi, and K. D. Wise, "Hermetic Packaging of Resonators With Vertical Feedthroughs Using a Glass-in-silicon Reflow Process," pp. 2303–2306.

E. Hendarto and Y. B. Gianchandani, "Marangoni-driven Micromotor in Liquid Medium," pp. 246–249.

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S. K. Kim, H. Chang, J. G. Bryant, D. R. Burris, and E. T. Zellers, "Field Testing of a Rugged MEMS Gas Chromatograph Prototype: Selective Analysis of Trace-level TCE Vapors in Contaminated Homes," pp. 799–802.

J. Liu, N. K. Gupta, X. Fan, K. D. Wise, and Y. B. Gianchandani, "A Pressure Programmable Gas Chromatography Microsystem Utilizing Motionless Knudsen Pump, Fiber-Integrated Optical Detector, and Silicon Micromachined Separation Column," pp. 803–806.

K. Najafi, T. V. Galchev, E. E. Aktakka, R. L. Peterson, and J. McCullagh, "Microsystems for Energy Harvesting," pp. 1845–1848.

F. Wu, M. Im, and E. Yoon, "A Flexible Fishbone-shaped Neural Probe Strengthened by Biodegradable Silk Coating for Enhanced Biocompatibility," pp. 966–969.

E. T. Zellers, G. Serrano, H. Chang, and L. K. Amos, "A Micro Gas Chromatograph for Rapid Determinations of Explosive Marker Compounds," pp. 2082–2085.

IEEE Radio Frequency Integrated Circuits Symposium (RFIC), Baltimore, MD, June 2011

J. K. Brown and D. D. Wentzloff, "A 1900MHz-band GSM-based Clock-harvesting Receiver With -87dBm Sensitivity."

M. Ghahramani, M. Ferriss, and M. P. Flynn, "A 2.4GHz 2Mb/s Digital PLL-based Transmitter for 802.15.4 in 130nm CMOS."

European Solid-State Circuits Conference (ESSCIRC), Helsinki, Finland, June 2011

S.-I. Chang, K. Al-Ashmouny, and E. Yoon, "A 0.5V 20fJ/Conversion-step Rail-to-rail SAR ADC With Programmable Time-delayed Control Units for Multi-channel Neural Recording Systems," pp. 339–342.

Symposium on VLSI Circuits, Kyoto, Japan, June 2011

S.-I. Chang, K. Al-Ashmouny, M. McCormick, Y.-C. Chen, and E. Yoon, "BioBolt: A Minimally-invasive Neural Interface for Wireless Epidural Recording by Intra-skin Communication," pp. 146–147.

Y. Kim, D. Sylvester, and D. Blaauw, "LC2: Limited Contention Level Converter for Robust Wide-range Voltage Conversion."

NSF Russian-American Workshop on Emerging Trends in Bioelectronics, St. Petersburg, Russia, June 2011

Y. Gianchandani, "Hybrid Micro-technologies for Medical Applications," (Invited).

ACM/IEEE Design Automation Conference, San Diego, CA, June 2011

M. Seok, D. Jeon, C. Chakrabarti, D. Blaauw, and D. Sylvester, "Pipeline Strategy for Improving Optimal Energy Efficiency in Ultra-low Voltage Design."

Haedong Distinguished Scholar Lecture, Seoul National University, Seoul, Korea, June 2011

K. D. Wise, "Wireless Integrated Micro-Systems: Revolution in the Gathering of Information," (Invited).

IEEE International Microwave Symposium (IMS'11), Baltimore, MD, June 2011

Z. Wu, Y. Shim, and M. Rais-Zadeh, "Miniaturized UWB Bandpass Filters Integrated With Notch Filters Using a Si-based Integrated Passive Device Technology," Best Student Paper Award (Finalist).

30th International Conference on Thermoelectrics, Traverse City, MI, July 2011

N. Ghafouri, R. L. Peterson, C. Uher, K. Najafi, "Effect of Substrates on Co-evaporated Bi2Te3 and Sb2Te3 Thin Films."

N. Ghafouri, R. L. Peterson, C. Uher, and K. Najafi, "Thermoelectric Properties Optimization of Thermally Co-evaporated P-type (Bi0.25Sb0.75)2Te3 Thin Films."

IEEE International Geoscience and Remote Sensing Symposium, Vancouver, Canada, July 2011

T. Gaier, B. Lambrigtsen, P. Kangaslahti, B. Lim, A. Tanner, D. Harding, H. Owen, M. Soria, I. O'Dwyer, C. Ruf, R. Miller, B. Block, M. Flynn, and S. Whitaker, "Geostar-II: A Prototype Water Vapor Imager/Sounder for the Path Mission."

IEEE Annual International Conference of Engineering in Medicine and Biology Society (EMBC), Boston, MA, August 2011

K. Al-Ashmouny, S.-I. Chang, and E. Yoon, "A 8.6 μW 3-bit Programmable Gain Amplifier for Multiplexed-input Neural Recording Systems," pp. 2945–2948.

S.-I. Chang, K. Al-Ashmouny, and E. Yoon, "A 1.5V 120nW CMOS Programmable Monolithic Reference Generator for Wireless Implantable System," pp. 2981–2984.

IV International Conference on Surfaces, Materials and Vacuum, Puerto Vallarta, Mexico, September, 2011

O. A. Shenderova, S. Hens, A. V. Sumant, S. Yu, V. J. Gokhale, M. Rais-Zadeh, and G.E. McGuire, "Detonation Nanodiamond in DMSO as Seeding Slurries for CVD Diamond."

56th Annual Conference on Magnetism and Magnetic Materials (MMM 2011), Scottsdale, AZ, October 2011

A. Alfadhel, C. Liang, Y. B. Gianchandani, and J. Kosel, "Microfabrication of Magnetostrictive Sensor Beams Based on NiFe Film Doped With B and Mo for Biomedical Applications."

International Conference on Miniaturized Systems for Chemistry and Life Sciences (μTAS), Seattle, WA, October 2011

Y.-C. Chen, X. Lou, P. Ingram, and E. Yoon, "Single Cell Migration Chip Using Hydrodynamic Cell Positioning," pp. 1409–1411.

M. Ghannad-Rezaie, B. Mishra, C. Collins, and N. Chronis, "A Microfluidic Chip for Immobilizing and *In Vivo* Imaging of Drosophila Larva."

P. Ingram, M. Im, S. McDermott, M. Wicha, and E. Yoon, "Spheroid Cell Culture on PDMS Hydrophobic Surfaces and Integration Into Microfluidic Devices," pp. 1539–1540.

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X. Lou and E. Yoon, "Multi-spectral Fluorescence Microscopy With Embedded Liquid Filters for Point-of-care Applications," pp. 598–600.

A. Tripathi and N. Chronis, "A Doublet Microlens Array for Imaging of Biological Micron-size Objects."

Proceedings of the International Symposium on Innovation and Sustainability of Structures in Civil Engineering, Xiamen, China, October 2011

M. Kurata, J. P. Lynch, G. van der Linden, P. Hipley, and L. H. Sheng, "Long-term Wireless Monitoring Systems for the Monitoring of Long-span Bridges," (Invited Keynote Paper).

11th International Conference on Micro and Nanotechnology for Power Generation and Energy Conversion Applications (PowerMEMS'11), Seoul, Republic of Korea, November 2011

E. E. Aktakka, R. L. Peterson, and K. Najafi, "Multi-layer PZT Stacking Process for Piezoelectric Bimorph Energy Harvesters," pp. 139–142.

IEEE Biomedical Circuits and Systems Conference, San Diego CA, November 2011

A. Borna and K. Najafi, "A Low Power, Low-voltage, User-programmable, Wireless Interface for Reliable Neural Recording."

IEEE International Electron Devices Meeting (IEDM'11), Washington, DC, December 2011

A. Ansari, V. J. Gokhale, V. A. Thakar, J. Roberts, M. Rais-Zadeh, "Gallium Nitride-on-silicon Micromechanical Overtone Resonators and Filters," pp. 485–488.

M. Flynn, "Ultra Low Power Microsystems Using RF Energy Scavenging," (Invited), pp. 235–238.

M. M. Sadeghi, R. L. Peterson, and K. Najafi, "Micro-hydraulic Structure for High Performance Bio-mimetic Air Flow Sensor Arrays," pp. 493–496.

Z. Wu, Y. Shim, and M. Rais-Zadeh, "Switchable Wide Tuning Range Bandstop Filters for Frequency-agile Radios"

American Geophysical Union, Fall Meeting (AGU 2011), San Francisco, CA, December 2011

X. Luo, W. Zhu, B. Mitra, J. Liu, T. Liu, X. Fan, and Y. B. Gianchandani, "A Chemical Detector for Gas Chromatography Using Pulsed Discharge Emission Spectroscopy on a Microchip."

Materials Research Society, Symposium II: BioMEMS – Materials and Devices, Fall Meeting and Exhibit, Boston, MA, December 2011

Y. B. Gianchandani, "Subtractive Microfabrication Processes for Metal Alloys and Ceramic Materials," (Invited).

Y. Gianchandani, "Applications of Sensing and Actuation Materials in Medical Micro-Instruments," (Invited). ■

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