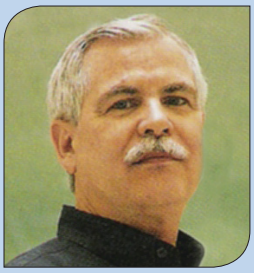
Wireless Integrated MicroSensing & Systems
WIMS²
Michigan Engineering

Horizons

Microsystems for the Next Generation

July 2012

Guest Editorial



Kurt F. Petersen
Member of NAE,
Founder and President at KP-MEMS,
Founder of Nova Sensor,
Co-Founder of SiTime and
WIMS² Strategic Advisory Board Member

Start-up Financing in the Current Economy

Fundamental strategic changes in the funding of start-up companies have occured since the economic meltdown of 2008. In more "normal" times, venture capitalists (VC) looked primarily at the 3 fundamental factors for Series A funding. In order of importance, these are 1) the Team should, ideally, have previous start-up experience and work well together, 2) the Market should be large, on the order of $1B, and 3) the Technology should have legs, that is, it should be capable of continuing improvements leading to increased market penetration. NovaSensor, Cepheid, and SiTime, which I co-founded (and which are, today, in high volume production), all comprised very experienced founding teams, huge addressable markets, and incredibly versatile technologies. Today, however, these factors would not be sufficient to secure Series A financing.

Since 2008, VCs have become MUCH more risk averse. The VC population today is less than half what it was in 2007. VCs are focusing more and more on internet and software, which require less capital and typically have much quicker exits than hardware and biotech start-ups. As an aside, I always say hardware start-ups take at least 7 years to begin to be successful. In addition, the realization that the VC industry actually had a net zero return on investment from 2000 through 2010 dramatically influenced the decision-making process for the VC funding of early-stage hardware start-ups.

In response to this much-less-friendly funding environment, the start-up community has evolved in significant ways. First, start-ups today are much leaner and much "scrappier" than in prior years, operating for several years with very small, often unpaid teams. Second, start-ups are scrambling for early product and technology demonstrations, increasingly using government funds (DARPA, NIH, DOE, NSF). Third, start-ups are aggressively pursuing and engaging with large, strategic companies for product endorsements, for investments, for non-recurring engineering, and even for early exits by acquisition. Fourth, start-up companies pursue small angel investors, in lieu of typical VC investors, much more frequently than they used to. Fifth, start-ups are looking for funding in countries other than the U.S. including China, Singapore, and Russia. My last start-up, Verreon, secured a $750K DARPA contract. Verreon also put in place a very tight relationship with Qualcomm and even hired people who would be desirable Qualcomm employees. Eighteen months after founding Verreon

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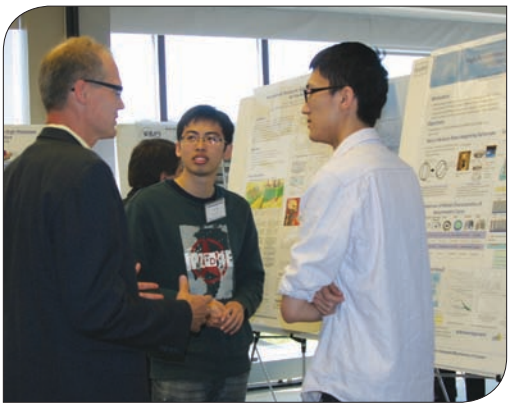
Spring Industrial Advisory Board Meeting

WIMS²'s Spring Industrial Advisory Board Meeting was held on May 11. Over 110 industrial representatives, students, faculty, and staff attended the meeting in the Lurie Engineering Center on U-M's North Campus. In total, 21 different organizations were represented. There were 7 faculty presentations. The students presented their work at both 'shotgun' oral presentations and at two poster sessions. There were also presentations by two of our associate members, Suyashree Bhonsle from Virginia Technologies and Tayfun Özdemir from Virtual EM. After the technical sessions, meetings of the Industrial Advisory Board, associate members, and the Strategic Advisory Board provided feedback for the Center. An excellent dinner at the Dahlmann Campus Inn was followed by an enlightening and entertaining talk by Mr. Roger Grace from Roger Grace Associates on "Critical Success Factors for the Commercialization of MEMS: The 2011 MEMS Industry Report Card." The following day, several of the industrial members had private meetings with the faculty and students. ■



Guest Editorial

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in late 2008, the company was acquired by Qualcomm. Similarly, Jyve, founded by Janusz Bryzek in 2009, was acquired by Fairchild 18 months after its founding.

As a member of the Band of Angels in Silicon Valley, an angel investment organization, I see many 4–5 person, very frugal start-up companies with modest company valuations, trying to raise a few $100K. More often than not, they already have customers and/or endorsements from large companies, as well as significant intellectual property in place (filed patents). In addition, the always-difficult path toward production and commercialization has been considered by the team, much more thoughtfully and thoroughly than previous generations of start-up companies.

The path to production and commercialization is one of my "hot buttons". In the past, many MEMS start-up companies have given short shrift to this all-important aspect of the start-up experience. I have heard the claim "inventing the technology/product is more important than manufacturing the product". I have the totally inverse opinion, manufacturing the product is much more difficult, takes much more time, and requires much more skill and discipline than inventing the product.

So, big changes are definitely underway in the early stage financing of start-up companies. Some groups bemoan these trends, claiming that new inventions are being "lost" because funding is not as readily available. However, I believe these changes are good. They are forcing more frugality, more early market endorsements, more carefully considered products, and more commercialization-savvy attitudes into the start-up mentality. ■

WIMS² Welcomes New Members

WIMS² is pleased to introduce the following companies and partners who have joined since our January 2012 newsletter.

New Full Member

RICOH
imagine. change.

Ricoh is a global technology company specializing in office imaging equipment, production print solutions, document management systems and IT services. WIMS² is working with one of their subsidiaries, Ricoh Innovations, Inc. (RII) in Menlo Park, CA. RII was founded in 1997 with the challenge of creating new technology and business opportunities for the worldwide Ricoh group. RII's parent company, Ricoh Company, Ltd., is a 75-year-old company with fiscal year 2010 sales in excess of $23 billion. With more than 100,000 employees worldwide, Ricoh is also one of the world's leading environmental companies, committed to sustainable business everywhere.

New Associate Partners

Denso is a leading supplier of advanced automotive technology systems and components for all the world's major automakers. It operates in 35 countries and has joined WIMS² as an associate for a one year trial. Next year it will upgrade to full member status.

DENSO

ePack uses its technology and packaging expertise to help MEMS component companies bring new and exciting devices to market. A spinout from WIMS, ePack provides custom packaging solutions so customers can focus on the functionality of their devices.

ePack
solving MEMS packaging

Fleetilla, based in Trenton, Michigan, is a global provider of vehicle tracking, asset tracking, cloud-based GPS fleet management and other telematics solutions. Fleetilla's products and solutions are used to manage car fleets, bus fleets, truck fleets, delivery vans, service vehicles, mobile generators, construction equipment, and other mobile resources in a wide variety of industries.

fleetilla

InvenSense is the leading providers of MEMS gyroscope, and motion processing technologies for consumer electronics products such as smartphones, tablets, game controllers, and wearable sensors. Founded in 2003, InvenSense is publically traded fabless MEMS sensor manufacturer headquartered in Sunnyvale, California.

InvenSense

PicoCal develops micromachined sensors and actuators for semiconductor, nanotechnology, material characterization, and biological applications. PicoCal's core technology is a family of micro-cantilevers for atomic force microscopy, scanning probe microscopy, manufacturing, chemical sensing and biological sensing.

PICOCAL

New Strategic Partners

The **MEMS Industry Group (MIG)** is the leading trade association advancing MEMS across global markets. MIG enables the exchange of non proprietary information among members, provides access to reliable industry data that furthers MEMS technology, and promotes greater commercial development of MEMS enabled products and devices.

MEMS INDUSTRY GROUP®

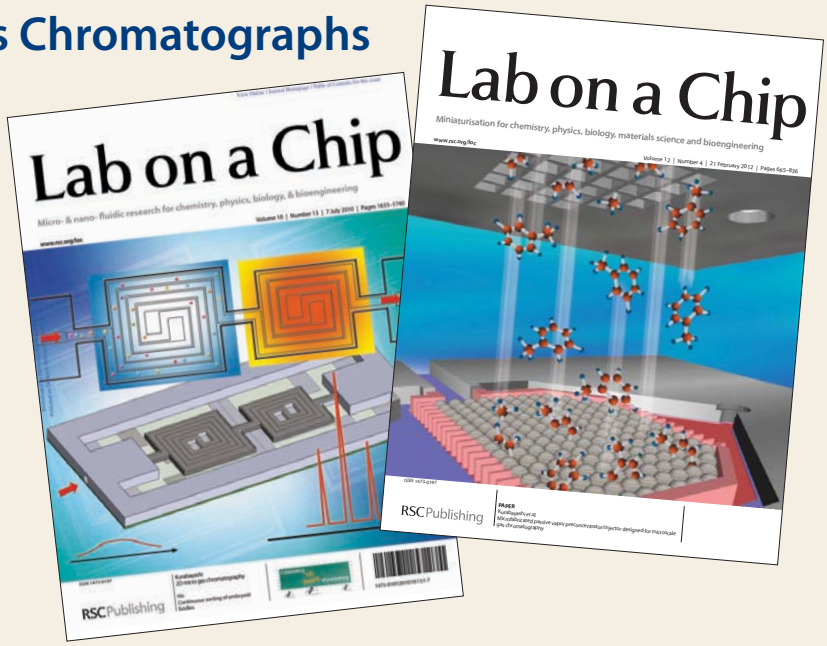
Roger Grace Associates has been a technology marketing consulting company since 1982, providing a broad range of services to clients including: business development, market research, integrated marketing communications, and strategy development. Roger Grace, the principal and founder, is a member of the WIMS² Strategic Advisory Board. ■

ROGER GRACE ASSOCIATES
MARKETING COUNSEL

One of the exciting recent developments at WIMS^2 has been the development of several micro gas chromatograph (μGC) systems made using Silicon-micromachining technology. Because of the applications focus and the interdisciplinary aspect of the work, it is one of the flagship projects of the Center and we take a great deal of pride in it. Faculty contributors include: Professors Ted Zellers, Kensall Wise, Katsuo Kurabayashi, Xudong (Sherman) Fan, and Yogesh Gianchandani. Critical expertise in systems integration has been provided by Technical Director Robert Gordenker. A number of students and post doctoral scholars have contributed to these efforts. A few of these include: Forest Bohrer, Jonathan Bryant-Genevier, Hungwei Chang, Will Collin, Naveen Gupta, Sun Kyu Kim, Jing Liu, Dibyadeep Paul, Gustavo Serrano, Thitiporn Sukaew, and Lindsay Wright.

Lab on a Chip Features Micro Gas Chromatographs on the Cover

WIMS^2 Center faculty Katsuo Kurabayashi and Ted Zellers, with their PhD students, Jung Hwa Seo and Sun Kyu Kim, have co-authored an article published in the journal *Lab on a Chip* on a micro-scale passive vapor preconcentrator/injector. The article was featured on the cover of the February 21, 2012 issue. This is the second cover of *Lab on a Chip* on which the Kurabayashi Group's work has been featured within the past 18 months. The previous article (co-authored with Prof. Zellers, Prof. Ken Wise, former student Sung Jin Kim, and others) concerned a microfabricated thermal modulator for comprehensive two-dimensional (micro) gas chromatography. A patent on the former device was filed through the U-M Tech Transfer Office with the U.S. Patent and Trademark Office in January 2012, and a patent on the latter was filed in October 2009.



Micro Gas Chromatograph for Detecting Explosives

Prof. Edward T. Zellers

One of the μGC prototypes developed in Professor Zeller's lab is INTREPID. This fieldable μGC is tailored for rapid determinations of trace-level vapor concentrations of marker compounds of the explosive TNT, specifically 2,4- dinitrotoluene (2,4- DNT) and 2,3-dimethyl-2,3-dinitrobutane (DMNB, an explosive taggant). INTREPID was designed for use as part of airport screening procedures. A top view of the current field prototype is shown. Similar to the SPIRON μGC, it uses a high-volume sampling module with a microanalytical module consisting of a microfocuser, a single microcolumn, and a nanoparticle-coated chemiresistor array detector. It is completely autonomous and completes a full analysis every 2 min. with calculated detection limits under 500 parts-per-trillion of each target. In the analysis of the mixture of the two markers and 20 other compounds, all targets were completely resolved from the interferences and unique response patterns were obtained. Post-doctoral fellow Hungwei Chang was responsible for the first INTREPID prototype, and graduate students Gustavo Serrano, Will Collin, and Lindsay Wright have done the latest assembly, optimization, and characterization work. This project was funded by the U.S. Department of Homeland Security, Science and Technology Directorate.

Inside the INTREPID µGC explosive detector.

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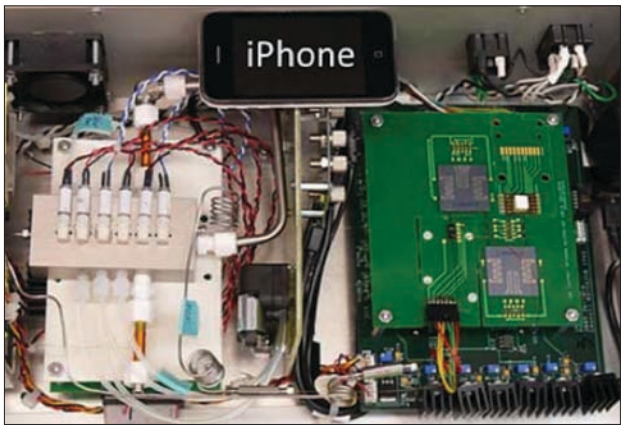
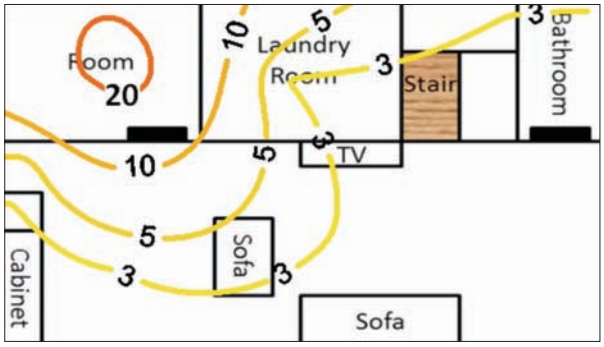
Microfabricated Gas Chromatograph for On-Site Determinations of TCE in Indoor Air Arising From Vapor Intrusion

Prof. Edward T. Zellers





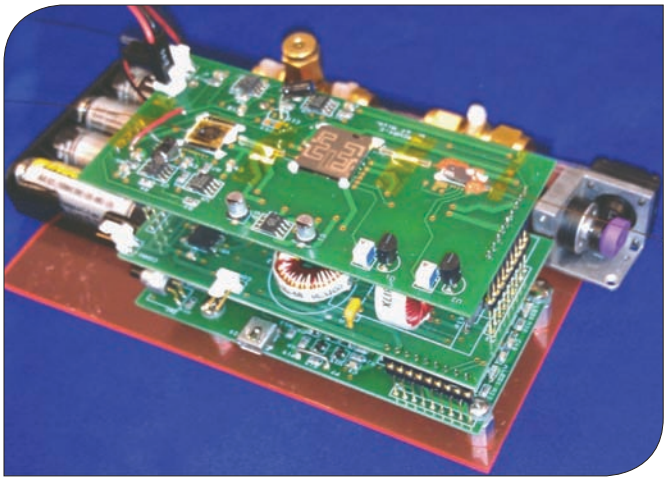
SPIRON (top) and experimental measurements from SPIRON (bottom) of TCE concentration inside a dwelling.

WIMS^2 faculty member Ted Zellers (Thrust Leader for Environmental Sensors and Systems) has recently published the results of inaugural field tests of two identical prototype microfabricated gas chromatographs adapted for the in-situ determination of trichloroethylene (TCE) in indoor air in support of vapor intrusion (VI) investigations. Dubbed SPIRON, each μGC prototype has a pre-trap and partially selective high-volume sampler of conventional design, a micromachined-Si focuser for injection, dual micromachined-Si columns for separation, and an integrated array of four microscale chemiresistors with functionalized gold nanoparticle interface films for multi-channel detection. Scrubbed ambient air is used as the carrier gas. The projected single-sensor detection limit was 0.052 ppb for an 8-L air sample collected and analyzed in 20 min. In recent field tests performed in homes near Hill Air Force Base in Utah, SPIRON μGC TCE determinations fell within ±25% of those from the reference method in the presence of up to 50 background VOCs. Temporal variations in TCE air concentrations in one house were monitored continuously for up to 48 hrs near the primary entry location for TCE contamination. In the second house, with no TCE VI, spatial profiles derived from the μGC prototype data revealed an intentionally hidden source of TCE within a closet, demonstrating the capability for locating non-VI sources. Results demonstrate that this type of μGC instrument could serve the need for routine TCE determinations in VI-related assessment and mitigation efforts. Postdoctoral Fellow Hungwei Chang designed and built the first SPIRON prototypes with help from doctoral student Sun Kyu Kim. Mr. Kim led the field study, with help from fellow student Jonathan Bryant-Genevier. This project was a collaboration with IST, Inc. and involved personnel from Hill Air Force base. It was funded by the Department of Defense, Environmental Security Technology Certification Program.

Mercury: A Palm-Size Gas Analyzer

Prof. Kensall D. Wise and Robert Gordenker

Other Contributors: Jeffrey Hayden, Dr. Sun Kyu Kim, Dr. Onnop Srivannavit, Prof. Ted Zellers



The complete three-board implementation of the Mercury analysis system. The circuit boards are 10cm x 4cm.

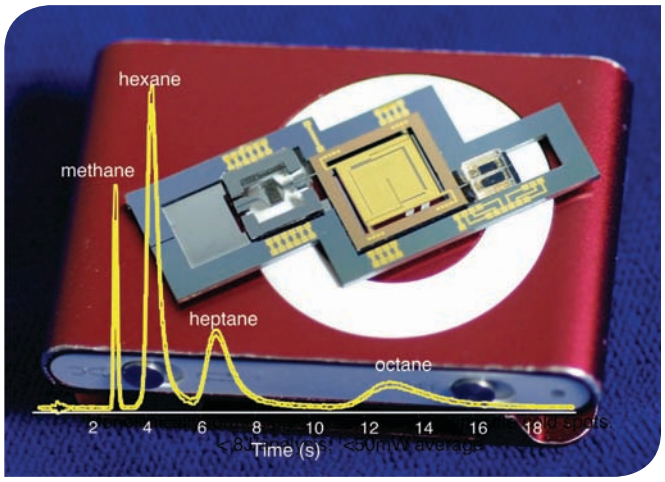
Mercury is a palm-size micro gas chromatography system developed by Robert Gordenker and Prof. Ken Wise. The device uses no consumables and is composed of a preconcentrator, a separation column, a chemiresistive detector and associated electronics. It has been designed for deployment on a robotic crawler to allow the detection of explosives and chemical warfare agents in field areas that are potentially unsafe for personnel. The system separates a wide variety of compounds in seconds to tens of seconds with many detection limits below 1ppb. System power levels are a few watts using bulk silicon fluidic components and less than one watt using thermally-isolated components. Still more advanced versions of this system could reduce power dissipation by another factor of five, permitting system realization, including the pump and power supply, in the size of a cell phone. The attached image shows a complete "Mercury" μGC system. The fluidic components are based on wafer-bonded silicon-glass MEMS technology and consist of a single-stage preconcentrator, a 50cm-long microcolumn, a multi-element detector, and an off-board commercial minipump. Physically the system works by using a single-stage preconcentrator/focuser to accumulate the sample, that injects a plug of gas into the column where the gas separates into components that are detected by a multi-element chemiresistor. The system is implemented on three 10cm x 4cm printed circuit boards, housing the fluidic analysis system, the power electronics, and embedded microprocessor-based control.

Orion: Pushing the Limits

Prof. Kensall D. Wise

Other Contributors: Robert Gordenker, Katharine Beach, Dr. Shaelah Reidy, Dr. Onnop Srivannavit, and Prof. Ted Zellers

Orion is a prototype gas analyzer that explores the limits of future μGC systems. Developed under the direction of Prof. Ken Wise, it consists of a carbon nanotube-loaded preconcentrator, a thermally-isolated microcolumn, a dual-element chemiresistive detector, and associated electronics. The fluidic portion of Orion is shown below in a micromachined alignment frame. The preconcentrator and detector chips plug directly into the column chip, eliminating bulky capillary interconnects and their associated band broadening. Experimental results from an alkane separation with a methane marker using the 25cm-long microcolumn are also shown. The three-chip fluidic system is sitting on a "Shuffle" MP3 player, representing the possible size for such a system with custom-integrated electronics for signal processing and communication. The small size of the microsystem also reduces power consumption and permits faster analysis using high-speed temperature programming. It should be pointed out that MEMS-based valves and pumps for such systems have already been prototyped; thus, such systems could soon become a reality for defense, homeland security, health care, food processing, environmental monitoring, and other applications. The system's purpose is to help us understand the tradeoffs involved in designing and constructing an extremely small μGC.



A CNT-loaded preconcentrator, 25cm column, and detector is shown on a "Shuffle" MP3 player, representing the possible size of an eventual μGC-based gas analyzer. The outer ring of the white circle is about the size of a U.S. quarter. An alkane separation from the column is superimposed.

Industrial Liaison Report

Dr. Andy Oliver

Industrial Liaison and Principal Staff Scientist

The last 12 months have seen more than a 50% growth in the number of both full and associate members in the WIMS² Center. While we are gratified with the support of both our new members as well as our continuing members, I'd like to take this space to discuss why many companies are part of WIMS². Companies often join WIMS² to transfer technology from the Center into their organizations. One of the mechanisms for full members of the Center to transfer technology from the Center is through preferential access to the Center's intellectual property. Full members of WIMS² are notified a year in advance of the general public of technologies that are beginning the patent and licensing process. This provides Center members a valuable opportunity to acquire exclusive or non-exclusive technology licenses without competing with non-Center members. While the Center offers both full and associate members assistance with the technology licensing process, full members are granted a one-year head start. Another way to transfer intellectual property from the Center is through royalty-free, internal-use licenses that are granted to all full-member companies. WIMS² also helps its members transfer technology through assistance with device fabrication. The Resident Engineer program provides prepaid access to the Lurie Nanofabrication facility, as well as office space to facilitate interactions with faculty, students, and staff. Stryker Corporation has used this program very successfully. Directed research projects where the faculty and staff of the Center participate in company research and development projects also give full center members opportunities to directly leverage WIMS² research and expertise.

An important way to transfer knowledge from the Center to industry is for companies to hire Center graduates. Many companies attempt to recruit students through crowded career fairs where it is challenging to screen through a large number of inappropriate applicants. In contrast, membership in a research center gives companies a chance to observe students over months or years, not just seconds or minutes and get to know them and their professors. At the same time, students are able to meet and screen potential employers. This long-term relationship leads to a better and more compatible match between employers and potential employees. To support our members, we have begun posting job openings on the Center's website. It could be argued that the most important product of the Center is not the research, but rather the students. If you have any questions about the benefits that WIMS² membership could give your company or want to get more out of your existing membership, I invite you to contact me at 734-615-2325 or ado@umich.edu. ■

Katsuo Kurabayashi, PhD

WIMS^2 Director of International Academic Partnerships
Associate Professor, Mechanical Engineering
College of Engineering

Katsuo Kurabayashi, is an Associate Professor of Mechanical Engineering with a courtesy appointment in the Electrical Engineering Department. Prof. Kurabayashi received the B.S. degree in precision engineering from the University of Tokyo, Japan, in 1992. He received the M.S. degree in Materials Science and Engineering from Stanford University, in 1994 and his Ph.D. from Stanford in the same field in 1998. He has been on the University of Michigan faculty since January 2000. Among his many honors, he received the Pi Tau Sigma Outstanding Professor Award in 2007, was awarded a visiting professorship at the Tokyo Institute of Technology from May through August of 2006, and obtained an NSF CAREER Award. In 2005, he received the Robert Caddell Memorial Award for significant joint graduate student/faculty research contributions from the University of Michigan.

One of his more recent prominent projects has been the development of MEMS-based thermal modulators for 2 Dimensional Gas Chromatography systems or GCxGC. GCxGC employs two separation columns (small channels) with different chemical coatings inside their inner walls. The complementary separation processes in these columns enable the system to attain the ability to detect a much larger number of compounds than conventional single column devices. In order to regulate the flow of gas, GCxGC systems require a thermal modulator. Existing modulators are extremely large, however, and must cycle between -40 degrees and 570 degrees Fahrenheit within just three to four seconds. To do so, they require coolant as well as 1,000 Watts of power.

Prof. Kurabayashi and his team are the first in the world to have designed, fabricated, and tested a MEMS-based thermal modulator for GCxGC. Their modulator, microfabricated in conjunction with the U-M Lurie Nanofabrication Facility, is comprised of two microchannels that cryogenically trap analytes in the sample from the first-dimension column and thermally deliver them to the second-dimension column in a rapid, predictable, and programmable way.

The device not only improves selectivity and sensitivity, it is capable of cycling between -40 and 570 degrees Fahrenheit within 100 milli--seconds. The rate of change is more than 6000 degrees Fahrenheit a second. The on-chip, solid-state micro-cooling unit does not require coolant, and the entire modulator requires just 10 watts of power, two orders of magnitude less than conventional thermal modulators.

The project builds off Prof. Kurabayashi's earlier work developing microsystems that analyze large numbers of chemical components in the atmosphere. His work on the microscale thermal modulator was initially funded by NASA. More recent support has been provided by Agilent Technologies, which has expressed interest in incorporating the technology into its future GCxGC gas chromatography products. ■

Dr. Xudong (Sherman) Fan

Associate Professor
Department of Biomedical Engineering

Dr. Xudong (Sherman) Fan obtained B.S. and M.S. degrees from Peking University in 1991 and 1994, respectively, and a Ph.D. degree in physics and optics from the University of Oregon in 2001. Between 2000 and 2004, he was a project leader at the 3M Research Lab. Then from 2004 to 2009, he was at the Biological Engineering Department at the University of Missouri. In January of 2010, he joined the Biomedical Engineering Department at the University of Michigan as an Associate Professor.

Dr. Fan's research includes photonic bio/chemical sensors, micro/nano-fluidics, and nano-photonics for analysis of biological and chemical molecules in the liquid and vapor phase. One of his efforts is focused on the development of smart and adaptive two-dimensional micro-gas chromatography, which may potentially lead to drastic improvement over current μGC performance. In this paradigm-changing design, an intelligent module that has the function of detection, decision-making, and flow routing is inserted between two conventional μGC columns to direct the vapor analytes to different downstream columns for further analysis. It is analogous to a telephone operator who connects incoming calls to different lines. This work was recently published at *Analytical Chemistry* (vol. 84, 4214 (2012)) and was highlighted at the College of Engineering website (http://www.engin.umich.edu/newscenter/feature/gas-sensor)

Dr. Fan is a recipient of 3M Non-Tenured Faculty Award (2004, 2005, and 2006), the Wallace H. Coulter Early Career Award (2006 and 2008), the National Science Foundation CAREER Award (2008), and NSF-China Outstanding Overseas Chinese Young Scholar (2011). Presently, he serves as Associate Editor for Optics Express, a flagship journal at the Optical Society of America, where he is responsible for optical biological/chemical sensors and optofluidics. ■

Hilton Head Conference

15th Biannual Hilton Head Solid State Sensors, Actuators, and Microsystems Workshop Conference was held from June 3 to June 7 on Hilton Head Island in South Carolina. The Hilton Head Conference alternates with the *Transducers* meeting and is the premier meeting for MEMS in North and South America. WIMS^2 has traditionally had a strong showing at this conference and this year was no exception with eleven papers including a plenary talk by our own Prof. Ken Wise. Prof. Wises' talk was entitled "Wireless Implantable Microsystems: Creating a Revolution in Health Care". The talk was well received and heavily referenced during succeeding talks at the conference. In addition to Prof. Wises' talk, there were 5 oral presentations and 5 poster presentations from WIMS^2 faculty and students. The total includes a joint paper between Prof. Gianchandani's group and Agilent, a WIMS^2 member company. WIMS^2 was a commercial sponsor of this event with both a booth and an open poster.

Prof. Ken Wise and some of his former graduate students at 'Wise Guys' Restaurant in Hilton Head, South Carolina.

ISSCC

On February 21, Prof. Mike Flynn organized and hosted a networking reception at the *59th ISSCC (International Solid State Circuits Conference)* in San Francisco. This is the fourth time the Michigan event was held at ISSCC. The event is sponsored by individual faculty members, the Electrical and Computer Engineering Department, and WIMS^2. The purpose of the event is to reunite faculty, students, colleagues and friends. "It was really great to see everyone," said Prof. Michael Flynn, the organizing host of the event. "We all feel it's a great opportunity to connect with people in a relaxing environment." ISSCC is the flagship conference of the Solid-State Circuits Society, and is the premier forum for the presentation of advances in solid-state circuits and systems-on-a-chip. There were nine University of Michigan authored papers at ISSCC this year. These includes a paper a bandpass sigma delta modulators and and a paper on a noise-shaping successive approximation ADC from Flynn's group. One of five ISSCC 2012 papers co-authored by Profs. Blaauw and Sylvester describes an ultra low power timer for wireless sensor node synchronization.

New WIMS^2 Strategic Advisory Board Member

Dr. Rajinder Khosla
NSF Program Director
(Retired)

The WIMS^2 Center is pleased to announce that Dr. Rajinder P. Khosla has joined our Strategic Advisory Board. Dr. Khosla had a distinguished career at the National Science Foundation from 1996 to 2012 as a Program Director, Acting Director, and Program Manager. Previously, he worked at Kodak from 1966 to 1996 and was the General Manager of Eastman Kodak's Microelectronics Technology Division from 1985–1996. He received a PhD in physics from Purdue University in 1966. Dr. Khosla is Fellow of the IEEE, APS, OSA, and the AAAS. He was awarded the 1990 IEEE Frederick Philips Award for "initiating and leading the development of a microelectronics program that led to his company's preeminence in high-density imaging sensors."

Fall
Industrial Advisory
Board Meeting

IAB '12

October 9, 2012

Lurie Engineering Center
North Campus,
University of Michigan

Seminar Series

March 14, 2012
Professor Koji Ikuta
Department of Information Physics and Computing
Graduate School of Information Science and Technology,
The University of Tokyo,
"Three Dimensional Polymer-based Micro/Nano Devices for Future Biomedicine"

March 22, 2012
Zhong He, PhD
Professor
Nuclear Engineering and Radiological Sciences Department, The University of Michigan,
"3-D Position-Sensitive Room-Temperature Semiconductor Gamma-Ray Imaging Spectrometers and Their Applications"

April 5, 2012
David D. Wentzloff, PhD
Assistant Professor
Department of Electrical Engineering and Computer Science,
The University of Michigan,
"Energy- and Volume-Constrained Wireless Communication"

Visit our website at http://wims2.org to find out more information about these seminars and to view them on streaming video.

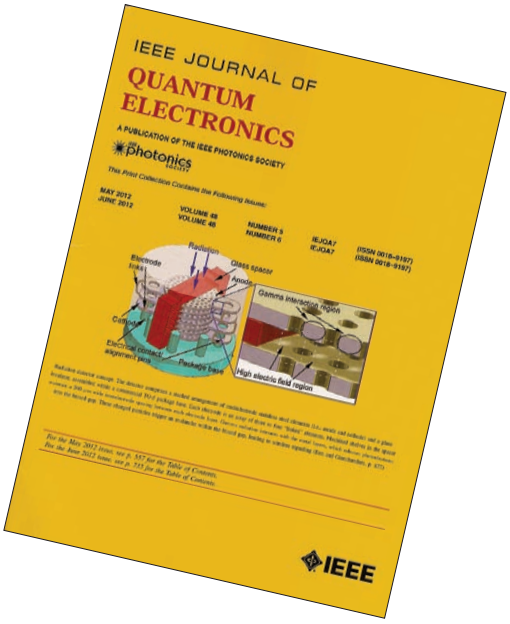
California Outreach Event

As part of a continuing efforts to broaden the Center's Industrial Program, WIMS^2 held an outreach event in Sunnyvale, CA on April 18. More than seventy people attended the event that consisted of research overviews, tutorials and an overview of the Center. The topics were wireless devices, low-power circuitry, MEMS, RF MEMS and microfabricated gas chromatographs, as well as a Center overview and a summary of Center benefits. These talks were given by Professors Gianchandani, Flynn, Rais-Zadeh, Sylvester, and Kurabayashi, as well as Dr. Oliver The purpose of the event was to raise the visibility of the Center's research program in Silicon Valley and to attract potential industrial collaborators and new Center members. We have generated one new associate membership from this meeting and have furthered several more relationships.

After the tutorials, there was a mixer and networking session. In total, the attendees represented more than 45 different companies ranging from small businesses to Fortune 500 firms. A large percentage of the people attending the event had no previous connections with WIMS^2 or with the University of Michigan. Mr. Roger Grace from the WIMS^2 Strategic Advisory Board was very instrumental in advising us on the marketing of this event. This event was partially supported by the College of Engineering as well as the Electrical Engineering and Computer Science Department.

Micro Discharge Sensor on Cover of *IEEE Quantum Electronics*

U-M grad and research fellow Dr. Christine Eun (BSE MSE PHD, EE '04 '06 '11) and Prof. Yogesh Gianchandani describe the diversity of applications possible for sensors based on microscale plasmas (or microdischarges) in the paper, "Microdischarge-Based Sensors and Actuators for Portable Microsystems: Selected Examples," published in the *IEEE Journal of Quantum Electronics*, vol. 48, no. 6, and featured on the cover of the May-June print issue. Microdischarges are attractive because they can provide relatively large signals even as the size of the device is reduced; they are also less sensitive to temperature than most of the conventional options. Some of the applications that are being explored for sensors involving microdischarges include the chemical sensing of gases and liquids for environmental monitoring, medical diagnostics, and space exploration; pressure sensing for oil exploration and subterranean mining; and radiation detection for homeland security.



Journal Articles (From January – June 2012)

M. G. Rezaie, X. Wang, B. Mishra, C. Collins, and N. Chronis, "Microfluidic Chips for In Vivo Imaging of Cellular Responses to Neural Injury in Drosophila Larvae," *PLoS ONE*, vol. 7, iss. 1, pp. e29869-1-8, January 2012.

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

Niloufar Ghafouri (May 2012)
"Bismuth Telluride Based Co-evaporated Thermoelectric Thin Films: Technology, Characterization and Optimization"
Co-chairs: Khalil Najafi and Rebecca L. Peterson

Jeff Gregory (June 2012)
"Characterization, Control, and Compensation of MEMS Rate and Rate-Integrating Gyroscopes"
Chair: Khalil Najafi

Sun Kyu Kim (January 2012)
"A Micro-Analytical System for Complex Vapor Mixtures– Development and Application to Indoor Air Contaminants"
Chair: Edward T. Zellers

Li Li (May 2012)
"Fully Integrated CMOS Phased-Array PLL Transmitters"
Chair: Michael P. Flynn

David Lin (March 2012)
"Flexible Digital-Intensive Wireless Receivers in Nanometer CMOS"
Chair: Michael P. Flynn

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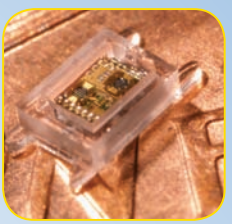
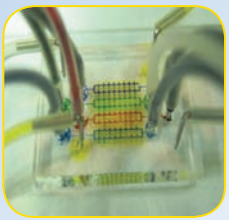
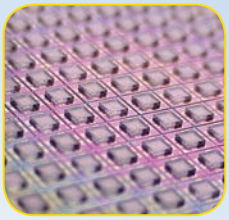
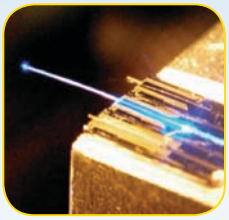
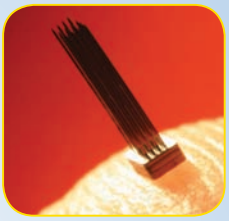
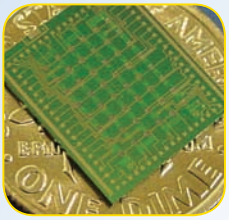
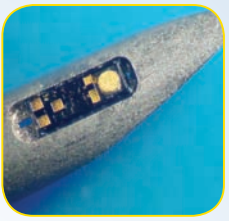
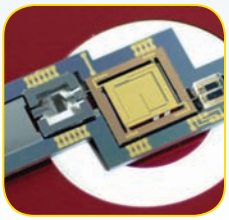

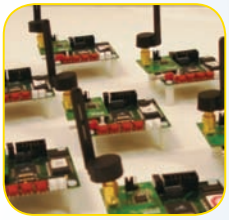

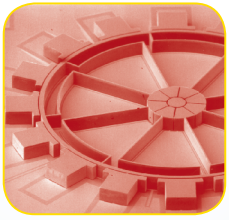
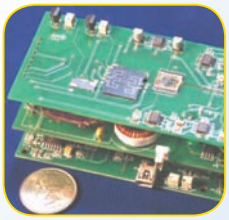

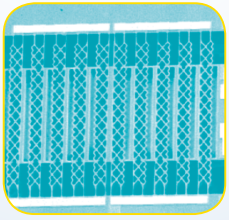

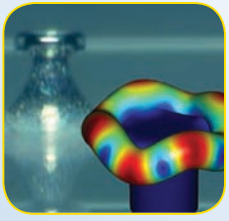
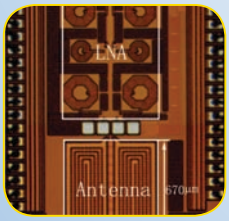
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