MichiganEngineering

WIMS WORLD

A quarterly update from the Engineering Research Center for Wireless Integrated MicroSystems www.wimserc.org Volume 1 No. 3 Fall 2001

MESSAGE FROM THE DIRECTOR

Last week someone asked me how big I thought the field known as "MEMS" will get. Will it, perhaps, grow to rival or even exceed microelectronics? I ventured that I doubted it would get that big and then had the temerity to suggest that it may even disappear completely. I hastened to explain what I meant. MEMS isn't so much a field unto itself but rather a way of doing things. It is truly a pervasive technology. Witness the proliferation of sub-fields in MEMS over the last five years or so. MEMS started with a focus on mechanical-MEMS but now we also have optical-MEMS, bio-MEMS, and rf-MEMS. MEMS is pervading all kinds of fields, and as it becomes accepted, it may just become part of those fields. It will just be the way things are done. And that will, ultimately, be the badge of its success and maturity.

While MEMS is far from mature today, we have nevertheless come a long way, even though it is sometimes hard to judge our progress. MEMS has broad applications and lacks the easily-tracked metrics of microelectronics: feature size, number of bits per chip, and so forth. Memory has been an especially powerful driver --- a single well-defined function with insatiable market pull demanding continuous improvements. The bits/chip metric provided a very visible benchmark on progress in this area and also hurled a challenge at the industry to keep up with Moore's Law. When we look at integrated sensors, however, one cannot help but ask what our drivers and metrics are? Do we have anything comparable to the DRAM? How much progress have we made? Where is our DRAM?

As we continue to evolve products based on MEMS, my guess is that some of the resulting microsystems will become our DRAMs --- common platforms customized for particular applications through stored-program intelligence. But they will be integrated systems and not just components. Probably the first integrated silicon sensor was the visible imager. Those devices today are finally challenging the resolution of film, but they are no longer just imagers. They are complete systems on a chip.

Pressure sensors are the oldest and most successful MEMS product to date. If we define a figure of merit, by dividing desirable features by parameters we want to minimize, we might put pressure sensitivity and dynamic range in the numerator and power dissipation, measurement speed, cost, and temperature sensitivity in the denominator. The first silicon-diaphragm piezoresistive pressure sensors, back in the 1960s, were fabricated by thinning the entire wafer and gluing the resulting chips onto headers. Yields were low and temperature coefficients were high. These early devices had a figure of merit of about 1. The appearance of anisotropic etchants and impurity-based etch-stops in the mid-1970s pushed yield up and reduced packaging problems, increasing the figure of merit to about 40. During the early 80s, the appearance of capacitive pressure sensors and on-chip circuitry improved the figure of merit to about 5000 with improved pressure sensitivity, decreased temperature sensitivity, and reduced power. Digital compensation now allows the use of thinner diaphragms over larger dynamic ranges and has pushed the figure of merit to 40,000 or more. So pressure sensors have seen substantial progress and are becoming integrated microsystems. One of our current ERC projects is even developing a complete vacuum-control system for use within the pressure reference cavity to ensure long-term accuracy.

As with microelectronics itself, visible imagers, and pressure sensors are maturing to become microsystems. Whether MEMS remains an identifiable field or disappears into its applications, helping components become microsystems will be a major activity for a long time to come. WIMS will endure because they are complete modules that solve complete problems. Driving this revolution forward is the focus of this Center, and we appreciate all those who are working with us in this quest. It's going to be an exciting decade ahead.

Ken D. Wise
Director
Engineering Research Center for Wireless Integrated Microsystems

University of Michigan
Michigan State University
Michigan Technological University

INDUSTRIAL LIAISON

The next Center meeting scheduled for May14-16, 2002 will be a combined NSF site visit and Industrial Advisory Board (IAB) meeting, thereby reducing the amount of travel required by IAB members. Details will be made available as the date approaches. The start of the school year brought our System Integrators to campus. With offices in the WIMS ERC, they are hard at work to insure that our testbeds are functional and hardware is on time. Read more about Cathy and Evan on pg. 5.

The tragedies in September interrupted plans to visit our members. If we have not contacted you, please contact me so that a visit to your facility can be arranged. One goal of the Center is to establish internships for our ERC students so that they can get to know our member companies better. If you are seeking interns, please contact me so that we can discuss how best to fill your needs. Updated student resumes are available in the Members Only section on our Web site http://www.wimserc.org. While there you might check out seminars you may have missed that are available via streaming video.

I encourage you to visit the Center whenever you can so that we can show you first hand the activities going on.

Joseph M. Giachino
Associate Director

TABLE OF CONTENTS

RECENT EVENTS

ERC STUDENTS TAKE BEST PAPER AWARDS

June 2-8 - C. J. Lu, EHS Ph.D. student doing work work closely related to the WIMS μGC, won Best Paper Award for his work, "Prototype design and Laboratory Performance Evaluation of a Novel Near-Real-Time Portable Analyzer for Indoor VOCs and SVOCs", at the American Industrial Hygiene Association Conference. EHS PhD(MDH) and MS (MH) students, M. D. Hsieh and M. Huang took both Best Student Poster award as well as 2nd place in the Best Overall Poster competition.

July 14-18 - Graduate student Reza Azadegan received 3rd place in the Best Paper contest at the 2001 IEEE Antennas and Propagation Symposium held in Boston, MA. Reza's paper entitled, "Design of miniaturized slot antennas" dealt with the development of an efficient miniaturized planar antenna apprpriate for a number of wireless applications. The smallest antenna built to date, it occupies about 0.05 lambda X 0.05 lambda (lambda is wavelength) and demonstrates a measured gain of about 0dBi. Future plans for the antenna include the incorporation of a miniaturized array of MEMS filters. ~ K. Sarabandi

M-PULSE SETS A BLISTERING PACE

July 25 - Racing from Chicago, IL, to Claremont, CA, along old Route 66, the dedicated team fought off 30 other teams from all over North Amercica for overall victory. Finishing in a total elapsed time of 56:10:46, the University of Michigan Solar Car Team was crowned 2001 champions of the American Solar Challenge.

Plagued with bad connections in the past, the College of Engineering provided use of a microwelder as well as staff member Brendan Casey's expertise in bonding the connections to the solar cells on the skin of the car.

As one of the Official sponsors of the team, the WIMS ERC would like to congratulate the team on all their hard work, especially after a disastrous crash during testing in June. Good luck in November at the World Solar Challenge in Australia. Go Blue! ~ LL

WIMS WEBSITE RELOCATES

September - Having finalized a domain name for the WIMS ERC Web site - now known as http://www.wimserc.org - we are running stronger than ever. Daily requests for "Members Only" access lets us know there is plenty of interest out there.

Be sure to check out our events section on a regular basis for an up-to-date listing of all WIMS-related events. For the most recent news, watch for News Flashes on our home page and in scrolling textboxes elsewhere on the site. For new IAB members, sign up to gain advance access to student papers, and to view resumes, project descriptions and more. For those interested in learning more about the industrial collaborations offered through the Center, visit our Web site at www.wimserc.org ~ LL

IAB CALLING

October 30-31 - The Industrial Advisory Board meeting will be held at the Crowne Plaza, near Briarwood Mall. For members that are unable to attend this year's meeting and would like a copy of the CD, contact our Administrative Director, Karen Richardson at: karenr@eecs.umich.edu. If you are not a part of the IAB and would like to find out how to partner with WIMS, log on to http://www.wimserc.org or contact our Industrial Liaison, Joseph Giachino at, giachino@eecs.umich.edu ~ LL

NEW COMPANY SETS UP SHOP

Dr. Clark Nguyen, a WIMS Research Thrust Leader, has founded, Discera, Inc. of Ann Arbor, a company that utilizes micromechanical vibrating resonators to improve the performance and reduce the size of wireless devices. These MEMS devices can easily be linked to existing systems and perform complex signal processing. The company's lead investor is Ardesta LLC, an IAB member. ~ JG

NEW DEGREE OFFERED IN INTEGRATED MICROSYSTEMS

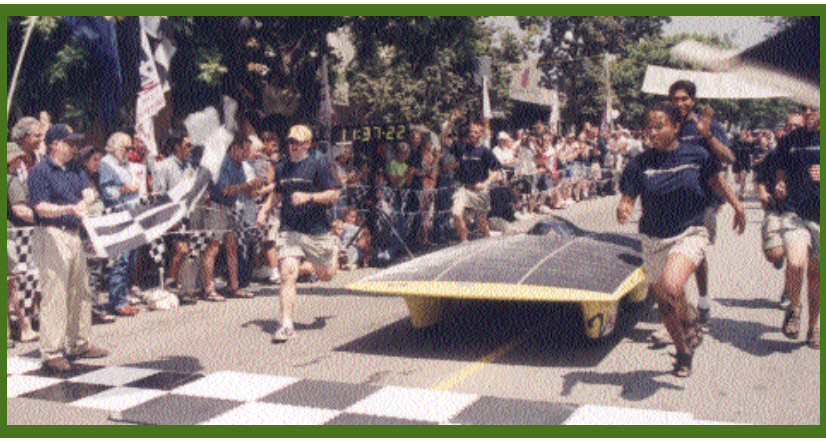
January 2002 - A 6th professional degree will be offered from the UM College of Engineering, focusing on Micro-ElectroMechanical Systems (MEMS).

The Master of Engineering Degree in Integrated Microsystems is geared towards professionals working on WIMS-related activities in the microelectronics industry. The program will give students the opportunity to gain a more in-depth understanding of the field while allowing them to expand their knowledge in complementary engineering disciplines as well as gaining valueable business skills for product and process development.

For more information see Education Highlights. ~ LL

JOINING HANDS WITH HANDS-ON

October - Members of the WIMS ERC faculty, staff and student leadership council met with the administrators of the Ann Arbor Hands-On Museum to discuss the possibility of an afternoon workshop for K-12 graders. Located in downtown Ann Arbor, the Museum has more than 250 fully-active exhibits and educational programs that feature chemistry, physics, geology, math, and music. The opportunity provided by the Museum for interaction between young minds and those of the graduate student researcher will open unique creative and educational possibilities for all parties involved. The ERC is also working with the Museum to establish a Hands-On MEMS exhibit. If you would like to know more about the museum and its activities, go to http://www.aahom.org. ~ JG



LEFT: *M-Pulse, UM's solar car entry in this year's American Solar Challenge Race, crossing the finish line in Claremont, California.* **Right:** *M-Pulse on the dragstrip going through prequalifying tests at Heartland Park in Topeka, KS. Good luck to the team at the World Solar Challenge, in Australia this November.*

EDUCATION HIGHLIGHTS

OVERVIEW

Over the summer nine students at UM were mentored or supported by graduate students and faculty under the following projects: simulation of the operation of MEMS structures, simulating MEMS for communication applications, characterizing micro acoustic ejectors, science experiments using microcontrollers, code generation and testing for microcontrollers, and an integrated microsystem with field connectable sensors. Two of the students are continuing their projects into the academic year.

Last year's trial programs at Okemos H.S. have progressed into experiential labs and demonstrations being designed for use in middle and elementary school classrooms in the Okemos area schools. This Fall, the first WIMS regular course is being piloted at Rennaissance H.S. in Detroit under the supervision and guidance of DAPCEP teacher, Miriam Turner.

We are also pleased to announce Ms. Peggy Henderson has accepted the Program Coordinator's position. Details in the next issue ~ L.C. McAfee

NEWEST INTERPRO DEGREE FOCUSES ON INTEGRATED MICROSYSTEMS

And then there were six...starting in January 2002, the College's five interdisciplinary professional degrees will be joined by one more: this one focusing on the burgeoning field of microelectromechanical systems (MEMS).

According to the program director, Professor Stella Pang of Electrical Engineering and Computer Science, the new Master of Engineering (MEng) degree in Integrated Microsystems will enable students to gain "a deeper understanding of MEMS while expanding the breadth of their knowledge in complementary engineering disciplines. This degree also incorporates courses in business management and manufacturing," she continued, "as well as an opportunity to participate on a team project within the microelectronics, MEMS, or biomedical industry."

Students who graduate from this program are expected to guide product and process development in the field with ease.

The MEng degree program is closely associated with the new Engineering Research Center for Wireless Integrated Microsystems, based at UM but also involving Michigan State University and Michigan Technological University. "That means our students will have access to the latest technologies being utilized in the Center, including fabrication, materials, sensors and actuators, sensing systems, power sources, and packaging," Pang said. It also means that students will have access to the latest research results. "That's consistent with the educational goals of the National Science Foundation, the Center's primary sponsor," explained Pang.

Students enrolling in the 30-hour MEng in Integrated Microsystems program must have an undergraduate degree in engineering, chemistry, physics, biology, or math. For more information about the program, contact the InterPro office at (734) 763-0480 or hek@engin.umich.edu. ~S. Pang

SCHOOL KIDS USE WIMS TO EXPLAIN FUNDAMENTAL SCIENCE

The goal of the pre-college program, "elementary school to Ph.D.", is to combine WIMS in educational laboratories - now operational at Michigan State, the University of Michigan and Okemos High School – with instruction provided by precollege, undergraduate, and graduate students. School children are involved in innovative WIMS projects designed to explain fundamental science concepts related to physics, chemistry and Biology.

All projects are built on the basic programming of WIMS robots and microcontrollers using commercially available components. Examples of projects completed so far include: WIMS environmental monitor (WEM) equipped with flow, pressure and temperature measurement, spring constant measurements and measurement of acceleration due to gravity. Projects being developed include: WIMS robot for demonstration of Newton's laws of motion, extension of WIMS environmental monitor to include O2 and CO2 sensors, WIMS bacteria monitor, and WIMS chemistry experiments using an on-chip spectrometer.

WIMS SPONSORED SHORT COURSE FOR MSU-DAPCEP

The Academic Intensive Summer Residential Program (AISRP) and the One-by-Four Programs (ObF) sponsored in part by the Detroit Area Pre-College Engineering Program (DAPCEP) and NSF's ERC for WIMS, with emphasis on the WIMS short course recently concluded its second year with a series of presentations and demonstrations for parents and administrators at Michigan State University. These "small tech" focused, residential programs were organized by MSU's Engineering Diversity Programs Office (DPO) and spearheaded by Dr. Aurles U. Wiggins, director.

In 1999, with generous contributions from the 3M Corporation, DAPCEP, technical experts from WIMS ERC, Michigan State's Dean Aslam and DPO, developed the nation's first pre-college WIMS short course curriculum. Due to increased interest and demand for WIMS education in the AISRP, an additional program called the One-by-Four Program: Introduction to Wireless Integrated Microsystems, was added to the curriculum. The new addition was designed to expose 8th and 9th graders to the cutting edge technology of WIMS. As a result, the number of underrepresented participants increased from thirty students in the summer of 2000 to 100 students in the summer of 2001. The WIMS short course consisted of lectures and lab experiments utilizing Lego Mindstorms in addition to microcontroller programming.

The objective of MSU's summer residential programs was to illustrate the real-life applications of math, physics, and chemistry, thereby, encouraging students to pursue careers in those areas as well as engineering. The courses involved, seminars, lectures and engineering experiments. Seminars were offered in class, on the Web, or via videoconferencing broadcast across the campuses of the University of Michigan, Michigan Technological University, and Michigan State University.

Lectures and apperances by Ken Wise, Khalil Najafi, and Dean Aslam highlighted the importance of pre-college education as outlined by the Education Thrust. Additionally, Craig Friedrich (MTU), provided a videoconference lecture, offering first-hand distance learning experience for the students. A lab tour organized by Dr. Wise provided an excellent learning opportunity for the students to see first hand what advances in technology the ERC is making.

In addition to the WIMS short course, AISRP participants learned trigonometry, Unigraphics, technical writing, Web design, and MS Office 2000 applications. Similarly, the one-week residential program participants received instructions in algebra, geometry, Web design, and MS Office applications. The programs were not only academically rigorous, but demanded adherence to strict rules and regulations that were designed to help students prepare for the professional world.

In the past year, 11 out of 13 high school seniors who previously participated in the AISRP at MSU were accepted into either the University of Michigan, or Michigan State University, with a few gaining acceptance to both universities. The majority of these seniors declared their majors in engineering or medicine. Over the long term AISRP is looking to increase the number of minorities and women "small tech" engineers by providing more opportunities a quality education partnering with the WIMS ERC. ~ D. Kim

RESEARCH HIGHLIGHTS

SENSORS

Micro-GC

We continue to make excellent progress toward a monolithic wireless microanalyzer for complex vapor mixtures (WIMS-μGC). Initial testing of the on-board calibrator prototypes has shown good agreement with theoretical predictions, and fabrication of the MEMS version is underway. Fabrication of a single-stage, high-aspect-ratio preconcentrator heater is also nearly complete. Separate testing has shown that the originally proposed three-stage preconcentrator will indeed have the capacity and desorption characteristics required for efficiently trapping and releasing complex organic-vapor mixtures spanning a 10,000-fold range in volatility. Etched-channel separation stages have been successfully sealed with anodically-bonded lids and the fluidic parameters are close to expectations from modeling. Uniform deposition of stationary-phase polymers will permit characterization of separation parameters and temperature programming. Novel approaches to low-power heating of the separation channels are showing promise.

More recent test results from the first array of chemiresistor sensors employing monolayer-encapsulated metal (MenM) nanoclusters as chemically sensitive interfaces have confirmed earlier preliminary data indicating that detection limits in the part-per-trillion concentration range can be achieved for the majority of target analytes in a sample volume of just 0.25 L. Fig. 1 shows a transmission electron micrograph (TEM) of one of these Au-thiolate structures, which has an average diameter of 6 nm. Continuing studies of electrode structures and scaling factors suggest that further improvements in sensitivity will be possible. Integrated 4-sensor arrays have been fabricated, along with micromachined housings, to create an ultra-low-dead-volume μGC detector cell.

New projects to be launched this year will be concerned with the design, fabrication, and testing of the baffled μGC inlet to prevent particulate entrainment, and latching valves for directing sample flow within the system. ~EZ

WIRELESS

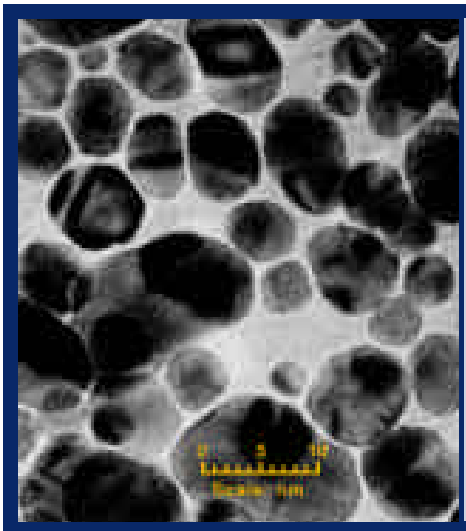
Researchers under the Wireless Interfaces Task have recently demonstrated the first-ever functional micromechanical resonators using CVD polycrystalline diamond as the structural material. Polycrystalline diamond has an advantage over silicon in that its acoustic velocity is higher. Since the resonance frequency of a mechanical resonator is generally directly proportional to the acoustic velocity of its structural material, polydiamond has great potential for more easily achieving the coveted UHF frequencies (0.3-3GHz) required for use in present and future wireless communication transceivers. In addition, due to the inherent stability of diamond material, for which very little diffusion can occur even at high temperatures, diamond can potentially offer better aging characteristics than polysilicon, which is extremely important for communication frequency reference applications. Finally, as has now been demonstrated by Wireless Task researchers, polydiamond can be machined nearly as easily as polysilicon, making it amenable to conventional surface micromachining, and with deposition temperatures around 540ºC, CVD polydiamond can be more easily integrated with highly conductive metal electrodes to allow lower losses and higher power handling at GHz frequencies.

The figure at right presents the scanning electron micrograph (SEM) of a 3MHz CVD polydiamond CC-beam micromechanical resonator fabricated via a surface micromachining process modified for diamond material. From the measured plot, this diamond resonator has a Q ~6,000, which is on par with that of polysilicon CC-beam resonators at similar frequencies.

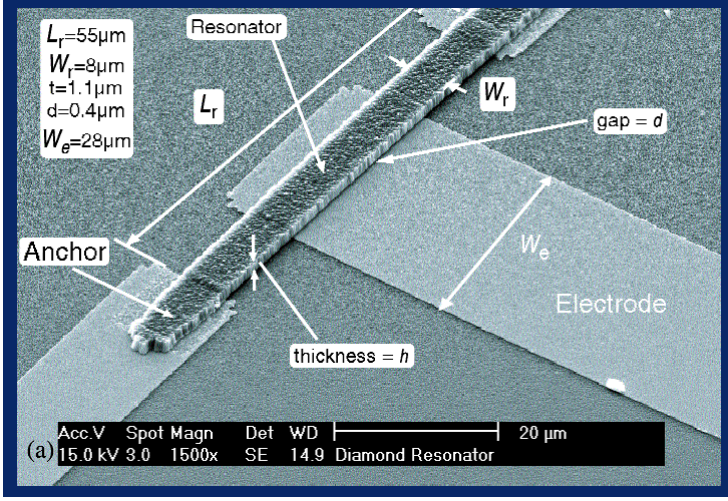
In related work, Wireless Task researchers have also very recently demonstrated polysilicon micromechanical resonators with temperature coefficients on par with that of quartz crystals using a combination of special materials and design techniques. ~CN

MICROPACKAGING

The micropackaging thrust has continued its research in several areas dealing with hermetic and vacuum packaging. Most importantly this thrust is developing several new technologies for vacuum packaging of MEMS using wafer-level approaches. Silicon-gold eutectic bonding is being utilized to develop a wafer-level approach to reliably package a variety of sensors in vacuum. While the silicon-gold eutectic approach has been utilized before, current research has focused on improving the reproducibility and reliability of this approach using a new technique for locally heating only the areas where the package is bonded to the substrate. Details of this approach cannot be presented here since the technology is being presented for a possible patent application. In addition, another technology is being developed for vacuum packaging of MEMS using metal packages fabricated in a batch process. It is anticipated that results from both of these approaches will be available in the next six months. In addition to vacuum packaging, we have continued our developed of a hermetic glass-silicon package and have now obtained further long-term tests results in both biological and salt-water solutions. Biological tests have shown full hermeticity and biocompatibility of the glass-silicon package for at least two years in animal models. This technology will be utilized in the implantable prostheses being developed at the Center. ~KN



Left: Transmission electron micrograph of one of the Au-thiolate nanoclusters used as chemically sensitive interface layers in the microGC chemiresistor-array detector. Average cluster size is ~7 nm (some agglomeration is apparent in this sample). **Below:** SEM of a 3MHz CVD polydiamond CC-beam μmechanical resonator with metal electrodes. The Q for this device is 6,000.



PERSONNEL

Khalil Najafi will receive a Faculty Recognition Award at the University Awards Ceremony in early October.

Nominated by students, faculty and staff, only five awards are granted each year to "distinguished faculty based on substantive contributions to the University through significant achievements in research and other scholarly activities, excellence as a teacher, advisor and mentor and distinguished participation in service activities of the University."

WIMS gladly welcomes two new Systems Integrators to the Center and would like to thank both Sandia National Laboratories and Ardesta, LLC, for their generous support.

Joining the WIMS ERC as System Integrator for the Cochlear/Neural Prosthesis testbed, **Cathy Morgan** of Sandia National Labs is very pleased to be on-site at the ERC for a two year appointment as Resident Engineer.

Having worked at TRW Systems, Inc, in Redondo Beach, primarily on radar and communications hardware development and systems analysis as well as on acoustic wave sensors, Cathy went on to received her PH.D. in Bioengineering from University of Washington, Seattle, in 1999. Her Ph.D. work towards developing an optoelectronic carbon dioxide sensor for transcutaneous monitoring of neonates incorporated MEMS structures and hybrid electronics and emphasized modeling of sensor performance and design strategies. In 1999, Cathy joined Sandia National Labs, Albuquerque, as a Postdoctoral Appointee in the Microsensor R&D Department, first working on a biosensor to discriminate bacteria based on their fatty acid signatures then moving on to instrumentation for a variety of vapor and liquid phase acoustic wave sensors applications. She recently joined the Integrated Microsystems Department at Sandia as Senior Member Technical Staff. Cathy's development interests include microsystems integration and sensor technologies.

Evan S. Gamble has nearly two decades of experience in researching, developing and assessing emerging technologies. His areas of expertise range from nanotechnology and MEMS to biotechnology and artificial intelligence. He is particularly adept at identifying synergies and integrating technologies from diverse fields.

His interest in nanotechnology and MEMS was cultivated while he was a Ph.D. student in molecular biology and biochemistry at the University of California Los Angeles. His research centered on engineering proteins with specific characteristics through the methods of directed evolution and phage display.

Most recently, he has been working with entrepreneurs and educational institutions around the world interested in developing and commercializing technologies related to MEMS and nanotechnology. Technologies that he has helped develop include: a micromolded fuel cell for cell phones and laptops with 20 times the energy density of existing batteries; optically-encoded microtaggants that are much more difficult to counterfeit than holograms; an innovative cooling system allowing future microprocessors of 10 GHz or more to be stacked directly on top of one another to maximize bandwidth; enzymatic synthesis of carbon nanotubes to yield uniform properties of diameter, chirality, and conduction bandgap; and both SPM-assembled and self-assembled molecular circuits to continue Moore's Law beyond the capabilities of conventional electronics.

Jaroslaw (Jarek) Drelich recently joined the ERC via Michigan Technological University where he has been teaching since 1997. He is currently working with Ted Zellers' group, using the laser-guidance deposition method to manufacture an array of sensors made of colloidal gold particles. Their overall goal is to develop a detector for the micro gas chromatograph that is capable of recognizing vapors and quantifying their concentrations at detection limits relevant to a range of environmental monitoring problems.

Once a Research Assistant Professor with the Department of Metallurgical Engineering at the University of Utah, Jarek has come a long way from his native Poland where he received his M.S. in Chemical Technology from the Technical University of Gdansk. Some of Jarek's current research activities include adsorption of surfactants at mineral and metal surfaces, fundamentals of wetting, spreading and adhesion phenomena, adhesion force measurements for fine particles using atomic force microscopy, and most recently fabrication of microscopic and sub-microscopic 2D structures using unconventional techniques.

Aside from teaching several courses at MTU, Jarek has published over 80 technical papers, holds 8 patents and has more than 30 conference presentations to his credit.

SLC REPORT

With the fall semester well under way, the Student Leadership Council has been busy scheduling several exciting and valuable activities for the Center.

The Ann Arbor Hands-on Museum has expressed interest in coordinating an afternoon electronics workshop for K-12 students. ERC volunteers would work with young people on an electronics project such as building 'laser-tag' devices using photo-detectors and flashlights. Look for more details on these activities later this fall.

We are continuing efforts to partner with local school districts for math and science tutoring as well as WIMS outreach demonstrations. The next round of science and engineering fairs is quickly approaching, so WIMS volunteers will be needed to serve as judges or mentors. Please contact David Lemmer-hirt (dlemmerh@umich.edu) if you have suggestions for education, outreach, or service activities the WIMS SLC might conduct or activities we could partner with you in any activities you are planning!

The SLC Industrial Committee is looking for more ways to improve interaction between industry and students within the ERC. An industrial expert committee, composed of volunteers from the various companies with different technology expertise, was briefly discussed at the last IAB meeting. Such a group of volunteers would provide a forum for students who have unresolved process or design issues to communicate with experienced industrial members who could provide valuable insight. In addition, we are looking into setting up guidelines for student internships with member companies. We hope to pursue both these issues further at the upcoming IAB meeting. If you would like to be a part of this committee or like to see it happen, please contact, John Clark (jrclark@umich.edu).

The SLC Social committee continues its efforts to encourage student team building through intramural sporting events such as volleyball, basketball, roller hockey team and tennis. Our most recent success came on the tennis courts where the ERC team (Manish Hamkar, T. J. Harpster, Sethu Palaniappan, and Sohin Chinoy) celebrated victory in the Graduate/Faculty/Staff league tournament after a 4-0 team win. For details or suggestions on other Social events contact T. Harpster (tharpste@eecs.umich.edu).

SEMINAR SERIES

After a summer hiatus, the Seminar Series is back in full swing. To find out what seminars are scheduled log onto our Web site: http://www.wimserc.org.

August 24, 2001

Paul Harmon
New Technology Section of the Advanced Research Lab in the InkJet Supplies Business of Hewlett Packard
InkJet Technology; History, Future, and Spinoffs

September 12, 2001

Prof. Tayfun Akin
Middle East Technical University
Low-Cost Uncooled Microbolometer Infrared Detector Arrays in Standard CMOS

September 18, 2001

Prof. Dean Aslam
Michigan State Universty
Poly-diamond/carbon Film Technology for Micro- and Nano-structures

October 4, 2001

Prof. Y.C. Lee
University of Colorado
MEMS Design and Packaging

October 9, 2001

Chang Liu
California Institute of Technology
Magnetic MEMS for RF Communication, Sensors and Microfluidics

For more information go to www.wimserc.org. To view archived material via MEonline contact:
Karen S. Richardson
WIMS Administrative Manager
karenr@eecs.umich.edu
(734) 647-1779

PUBLICATIONS

Contributed papers at the American Industrial Hygiene Assoc. Conference, New Orleans, LA.

M. D. Hsieh, E. T. Zellers
Personal Direct-Reading Instrument for Monitoring Exposures to Multiple Organic vapors

C. J. Lu, E. T. Zellers
Prototype Design and Laboratory Performance Evaluation of a Novel Near-Real-Time Portable Analyzer for Indoor VOCs and SVOCs
Best Paper Award Winner

Papers presented at the 2001 IEEE Antennas and Propagation Symposium, Boston, MA.

R Azadegan, K. Sarabandi
Design of miniaturized slot antennas
3rd place, Best Paper Contest

Invited presentation at the 3rd Annual Acoustic-Wave Sensors Workshop, Taos, NM.

E. T. Zellers, C. J. Lu, J. Grate, A. Hierlemann, A. Ricco
New perspectives on modeling responses from polymer-coated surface-acoustic-wave vapor sensors

Paper published in IEEE Trans. Biomed. Engr., pp. 911-920, August 2001

Q. Bai and K. D. Wise
Single-Unit Recording with Active Microelectrode Arrays

Paper presented at the 27th European Solid-State Circuits Conference, Villach, Austria, September 2001. The paper is published in the Technical Digest of conference.

K. K. Das and R. B. Brown,
Analysis of the Floating Voltage Transfer Characteristic and Comparison of Circuit Styles in Partially Depleted SOI-CMOS

Contributed papers at the 200th Electrochemical Society Meeting, San Francisco, CA.

Q. Y. Cai and E. T. Zellers
Chemiresistor vapor sensor array employing monolayer encapsulated metal nanoclusters

A. Hierlemann, E. T. Zellers, A. J. Ricco
Use of linear solvation energy relationships to model acoustic wave vapor sensor responses

C. J. Lu, E. T. Zellers
A dual-stage preconcentrator for a portable indoor-VOC microsensor system

J. J. Whiting, C. J. Lu, E. T. Zellers, R. D. Sacks
Toward a portable, high-speed, vacuum-outlet GC vapor analyzer employing air as carrier gas and surface acoustic wave detection

Q.-Y. Cai and E.T. Zellers
Chemiresistor vapor sensor array employing monolayer-encapsulated metal nanoclusters

Paper published in Sensors and Actuators, A, pp. 266-277, 2001.

K. L. Kraver, M. R. Guthaus, T. D. Strong, P. L. Bird, G. S. Cha, W. Hold, and R. B. Brown,
A Mixed-Signal Sensor Interface Microinstrument

2001 IEEE International SOI Conference, Durango, CO.

K. K. Das and R. B. Brown
Circuit Style Comparison based on the Variable Voltage Transfer Characteristic and Floating Ratio Concept of Partially Depleted SOI
To be published.

Paper submitted to the IEEE SSCS Workshop on Low-Power Circuits, Arlington, VA.

R. Brown
Low-Power Mixed-Signal Microcontrollers
To be published.

The following paper will be presented at the International IEEE Engineering in Medicine and Biology Conference (EMBC), Istanbul, Turkey.

H. Yu, and K. Najafi
Circuitry For A Wireless Microsystem For Neural Recording Microprobes

Paper presented at the International Sensor Conference - 2001, Korea.

K. Wise
The Coming Revolution in Wireless Integrated MicroSystems

COMPLETED DOCTORAL DISSERTATIONS 2001

Demetrios P. Papageorgiou
A Shuttered Probe with In-Line Flowmeters for Chronic In-Vivo Drug Delivery
The University of Michigan 2001
Advisor: Prof. Ken Wise

This thesis reports the development of drug-delivery probes incorporating integrated microfluidic cables, on-chip microchannels, in-line flowmeters, and outlet shutters. The flowmeters resolve dose to better than 5pL. Process-compatible valve and pump structures are also presented.

Ark-Chew Wong
VHF Microelectromechanical Mixer-Filters
The University of Michigan 2001
Advisor: Clark T.-C. Nguyen

This research reports microelectromechanical spring-coupled clamped-clamped beam resonators and filters operating from 10MHz to 70MHz. Localized annealing and voltage-based passband tuning are explored, and successful low-loss down-conversion and mixing of RF signals is described. The use of wafer bonding to combine the micromechanical elements with integrated BiCMOS circuits is also reported.

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Contact us:
WIMS World
University of Michigan
WIMS ERC
213 Engineering Programs Bldg.
2609 Draper
Ann Arbor, MI
48109-2101
Tel.: (734) 615-3098
Fax: (734) 647-2342
www.wimserc.org
Editor:
Luke Ling
email: lukeling@umich.edu

The Regents of the University of Michigan
David A. Brandon
Laurence B. Deitch
Daniel D. Horning
Olivia P. Maynard
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