Spring 2005

# WIMS WORLD

University of Michigan  Michigan State University  Michigan Technological University

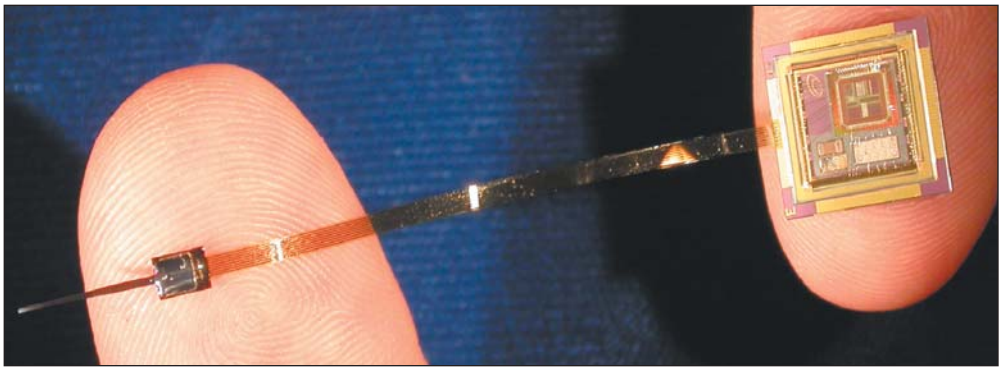
## Director's Message

As always, the past spring term was a very busy time, marked by the submission of our Annual NSF Report, the end of classes, and our annual Site Visit. These events are always important times to take stock of where we are and what we have accomplished, but they were especially so this year, which marks the half-way point in the life of the Center. It seems like only yesterday that we started the ERC, determined to put microsystems on the map and define a generic architecture for them that would work over a broad range of applications. The past five years have been a great adventure as we have pursued these goals.

In education, we have now presented over twenty-five pre-college short courses, using WIMS to illustrate the exciting opportunities that can come with an engineering career. The great majority of students from these courses have gone on to college careers in engineering, and I like to think that this occurred at least partly because of their exposure to WIMS. I think we have literally changed lives and hope we will change many more during the next five years of the Center. Our WIMS college courses now form an impressive microsystems curriculum and are being used by an increasing number of schools worldwide.

The May NSF Site Visit represented a special challenge for our testbeds in terms of pulling together prototypes of our environmental monitor and our implantable cochlear microsystem. System integration is challenging in that it requires everyone to set aside a little of what they are doing to work on the larger system and make sure their work meshes with what others are doing. Our cochlear implant is a great example. It consists of a high-density thin-film electrode array; an interface IC on the back of the array; a polymer interconnect cable; and a hermetically-sealed electronics package containing an embedded microcontroller and a bidirectional wireless chip that interfaces with the outside world. This microsystem is partially functional as of this writing and will be fully functional later this year. It is a great example of teamwork. The electrode, interface circuitry, and cable were developed by our Biomedical Sensors and Subsystems thrust, the wireless chip by our Wireless Interfaces thrust, the embedded microcontroller by our Micropower Circuits thrust, and the hermetically-sealed package by our Advanced Packaging thrust. In addition, the system software is being developed at the University of Puerto Rico at Mayaguez. This is an example of a microsystem that could never have been developed without some real teamwork in system integration. We hope it will unlock new possibilities in the treatment of hearing disorders.

In its fifth year, the WIMS ERC consists of 125 projects involving 168 graduate students, 113 undergraduates, 40 faculty, and 19 industrial partners. It remains one of the premier microsystem research organizations worldwide, and at this half-way point in the ERC, I want to thank all the faculty, students, staff, and industrial partners that have made the Center possible. We look forward to an exciting year ahead!



***Prototype of an implantable cochlear microsystem, featuring a high-density thin-film electrode array, polymeric cable, embedded WIMS microcontroller, and bidirectional wireless interface chip.***

*Ken D. Wise*

Director, Engineering Research Center for
Wireless Integrated MicroSystems

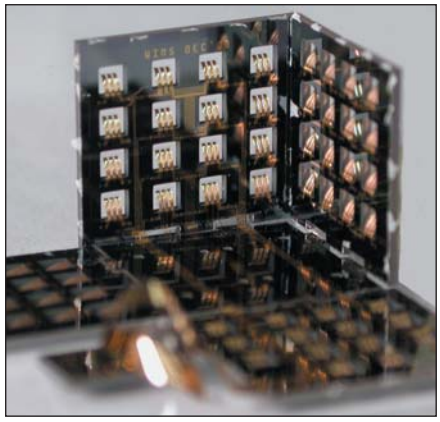
## Inside

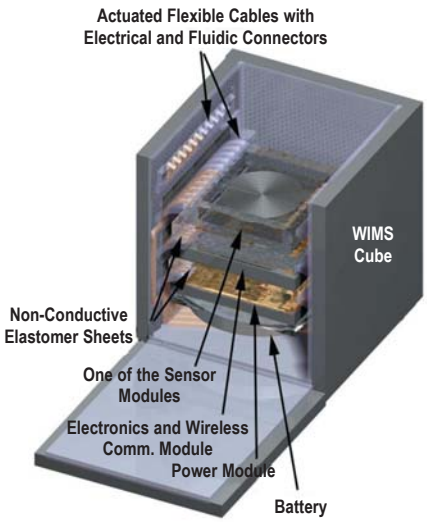
# Research Highlights

## Modular Assembly and Packaging of Multi-Substrate Microsystems: WIMS Cube

*Asli Burcu Ucok, Joseph Giachino, and Khalil Najafi*

A re-workable and modular packaging/assembly approach for Wireless Integrated MicroSystems (WIMS) consisting of multiple substrates containing circuits, sensors, and actuators has been developed. In this assembly approach, substrates of a microsystem, which are fabricated using different technologies, are "dropped" into a cube (WIMS cube) in sequence, automatically aligned through mechanical registration, and separated using non-conducting elastomer sheets. Signal transfer (electrical and fluidic) between these dice is achieved using rows of integrated flexible cables attached to the cube walls. Cables are actuated row-by-row during assembly to make pressure contacts to each die. Therefore, connections are not permanent. This allows the microsystem to be disassembled if one of the dice fails after assembly or if a different microsystem with a different set of sensors or actuators is needed for another application. This provides maximum flexibility and modularity, both of which are critical for microsystems and MEMS applications. The figures show a schematic of the WIMS cube and a fabricated WIMS cube with integrated flexible Parylene cables.

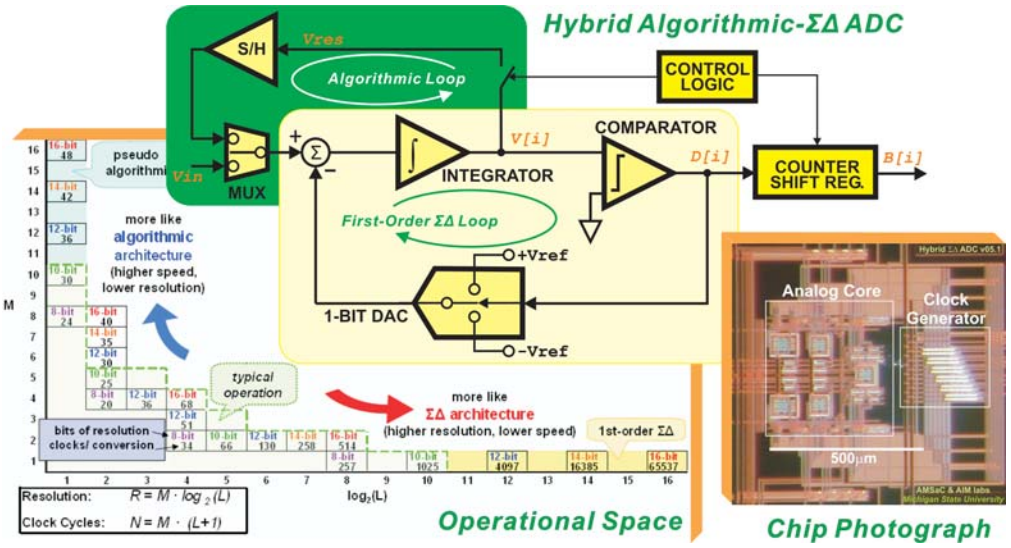





## Dynamic Reconfigurable A/D Converter for Sensor Applications

*Cheong Kun, Andrew Mason, and Shantanu Chakrabartty*

There is tremendous value to dynamically controlling the resolution and speed of A/D conversion in many sensor systems due to variable sensor characteristics, desire to quickly scan arrays before measuring a specific element with high resolution, and the opportunity to minimize power consumption during extended periods of inconsequential data. A hybrid algorithmic-ΣΔ A/D converter has been developed wherein the residual of a ΣΔ conversion is iteratively fed back and resampled to embed bit-weight information into the digital output sequence, as performed in an algorithmic conversion using the extended counting technique. By varying the number of sampling and feedback cycles, the A/D converter is capable of dynamic self-adjustment between a more ΣΔ-like architecture (with higher resolution and slower speed) and a more algorithmic-like architecture (with faster speed and lower resolution). For a nominal clocking frequency of 10MHz, the A/D converter can resolve 8 bits in 1.6$\mu$sec, 16 bits in 51.2$\mu$sec, or various configurations in between (see Operational Space plot). The hybrid algorithmic-ΣΔ A/D converter has been implemented in 0.5$\mu$m CMOS and occupies less than 0.4mm$^2$. This converter can significantly improve the performance characteristics of low-power integrated microsystems such as those being developed within the WIMS ERC.



## Multifunctional Flexible Parylene-Based Intracortical Microelectrodes

*David S. Pellinen, Taegyun Moon, Rachel Miriani, Rio J. Vetter, and Daryl R. Kipke*

A new polymer-based flexible microelectrode with drug delivery capability has been developed by the NEL (Neural Engineering Lab) at the University of Michigan. The probe was fabricated and tested for electrical and fluidic functionality in early stage design. It is a micro-fabricated, multi-channel polymer probe capable of selectively delivering chemicals at the cellular level, as well as electrically recording and stimulating neurons *in vivo*. The width and height of the fluidic channel are 9*µ*m and 50*µ*m, respectively. The electrical recording sites are located on the top side of the probe—designed to function for both electrical recording and stimulation (Fig. 1). The fluid enters the inlet port of the microprobe and flows through the microchannel inside of the probe until it comes out of the outlet ports of the microprobe as shown in Fig. 1. Fig. 2 shows a sequential process of a water bubble growing at the fluidic outlet port of the polymer microprobe. *In vivo* chronic recording experiments succeeded in demonstrating the *in vivo* reliability of the probe. Successful *in vivo* experiments confirm the suitability of the probes as implantable chronic recording devices with robust fluid delivery function.

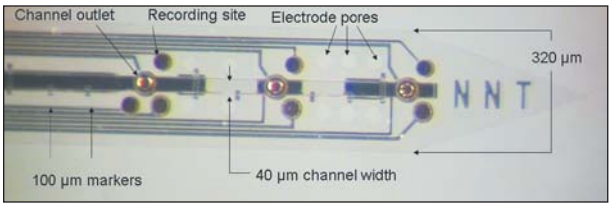



***Fig. 1 – Photograph view of the flexible parylene-based microfluidic electrode. The total thickness of the device is nominally 20µm, with a channel height of 5µm.***

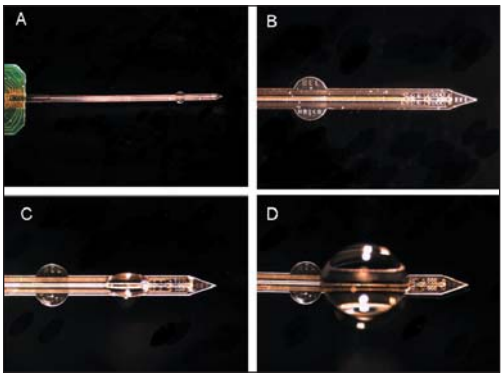



***Fig. 2 – Pumping through a microfluidic electrode. Fig. A shows the whole electrode, up to the bonding pads. The fluid connection (not shown) is to the far left of the probe. Fig. B shows the implant portion of the electrode prior to fluid delivery. Fig. C shows the initiation of flow, which quickly develops into a large bubble of fluid in Fig. D.***

## Wireless Implantable MicroSystem for Multi-Channel Neural Recording: The Spike Detector Module

*Amir M. Sodagar, Kensall D. Wise, and Khalil Najafi*

A wireless implantable microsystem for recording and processing the neural signals sensed and preconditioned by multi-channel active recording microprobes is being developed. This microsystem is powered and controlled through a wireless inductive RF link and transmits the preconditioned/processed neural activity to the outside world (Fig. 1). Such a system will be a critical element in both treating some of mankind's most debilitating disorders and studying the nervous system at the cellular level.

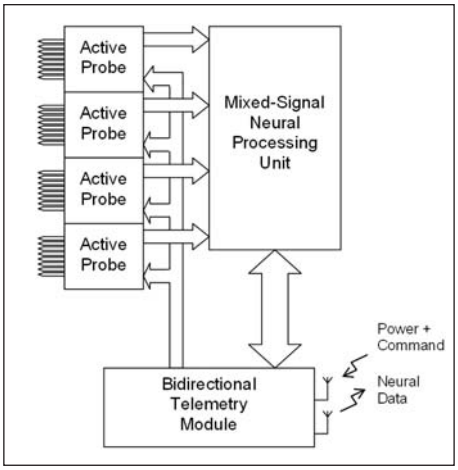



***Fig. 1 – General architecture of the system***

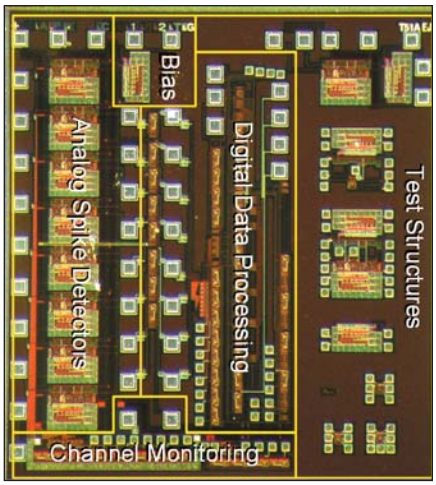


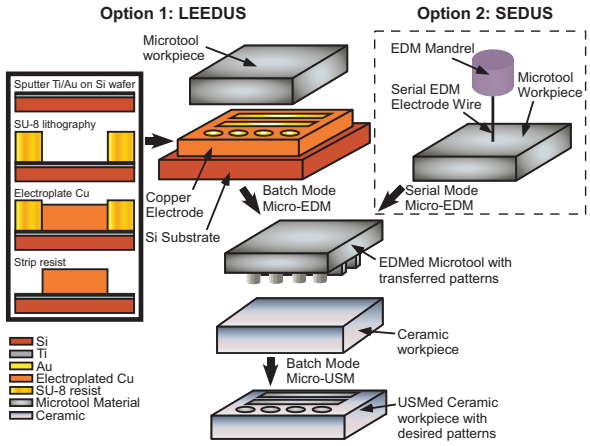

***Fig. 2 – Die photograph of the SD-8 chip***

Active microprobes obtain neural signals from a specific subset of the input sites (channels) and, after preconditioning, deliver them to the Neural Processing Unit (NPU), which is responsible for either spike detection on all the input channels received from the active probes (Scan Mode) or selecting a single-channel for high-precision neural recording (Monitor Mode). The bidirectional Telemetry Module retrieves the energy required for the operation of the whole system and also the data and clock needed to control the system, all from a signal received through an inductive link. There is also a back telemetry block on this module that is in charge of sending the neural information to the outside world.

The *Eight-Channel Spike Detector Test Module (SD-8)* (Fig. 2) is the first test chip that has been designed, fabricated, and tested for this system. It has been designed in such a way that it can be considered both as a smaller-scale test version of the NPU and as one of the modules that will be used in the full-version of the NPU.

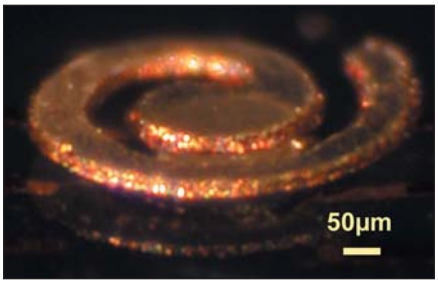
# A New Batch Mode Pattern Transfer Technology for Bulk Ceramics and Glasses

*Tao Li and Yogesh Gianchandani*




***The LEEDUS / SEDUS process flow, by combining Lithography, Electroplating, Batch/Serial Mode Micro Electro-Discharge Machining, and Batch Mode Micro UltraSonic Machining.***

Bulk ceramics (including PZT) are important materials for micromachined transducers and packages, but they are usually difficult to pattern lithographically. A new process named LEEDUS has been developed to provide die-scale planar pattern transfer capability from lithographic masks onto ceramics, glass or other hard, brittle, and non-conductive materials. A related process (SEDUS) uses serial $\mu$EDM and omits lithography. Feature sizes of 25$\mu$m have been micromachined on a glass-mica (Macor™) ceramic plate with a 4.5 x 4.5mm$^2$ die size, 34$\mu$m cutting depth, and 18$\mu$m/min machining rate. In-plane actuators with octagonal or circular spiral geometry were fabricated from a bulk PZT plate as a demonstration. The devices, with footprint of 450 x 420$\mu$m$^2$, can produce displacement of ~2$\mu$m at 40V, which is 6–7 times larger than the calculated $d_{31}$ transverse displacement from an equivalent straight beam actuator, demonstrating that practical devices can be made with this lithography-based enabling technology.




## Personnel Focus

**Professor Jerome (Jerry) Lynch** received his BE from Cooper Union before attending Stanford University for his graduate work. He received his PhD in 2002 from the Department of Civil and Environmental Engineering for his work in the field of wireless sensor networks, embedded data processing, and MEMS sensors. Professor Lynch also obtained an MS degree from the Department of Electrical Engineering while at Stanford. As a faculty member in the Department of Civil and Environmental Engineering and the Department of Electrical Engineering at the University of Michigan, Professor Lynch is currently working on the design of a low-power 802.15.4-compliant wireless sensor for the WIMS Center. In collaboration with Professor Michael Flynn within the Wireless Interfaces Thrust, the hardware design of the wireless node is complete, with testing to begin in early Fall 2005. Professor Lynch is also active in the deployment of wireless sensor networks in real civil structures (bridges and buildings) to monitor their response to ordinary, earthquake, and blast loadings.

## Recent Events

### Michigan Nanofabrication Facility Groundbreaking

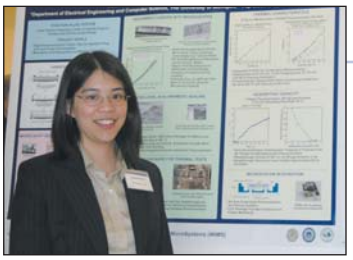
The expansion of the Michigan Nanofabrication Facility (MNF) was launched on April 15, 2005, with a groundbreaking ceremony attended by College of Engineering Dean Stephen Director, U of M President Mary Sue Coleman, and Anne Lurie who made a $15M donation toward the $31M cost of this project. The new expansion will be a four-story addition of 36,577 gross square feet. There will be 6,844 sq. ft. of new clean room or "fab" space, broken down into 4,018 sq. ft. of "bunny suit" work space and 2,826 sq. ft. in clean areas for equipment and clean services (chemical delivery, gas delivery, etc). The remaining area of the expansion will include all of the support systems for the clean space, including air purity, air handling, chemical waste disposal systems, chemical storage, and safety systems. The project will also include the renovation of approximately 4,376 sq. ft. of existing lab space to improve temperature and humidity control. A new wet chemistry laboratory to support bio- and nanotechnology research will be constructed in this renovated space. The new facility will include a high-visibility tour aisle to allow visitors to view the laboratory and its operations. The east entrance to the EECS building will be substantially changed and its appearance improved by the new project. Occupation and final interior renovations are scheduled to be completed by mid-2007.

***Neil Welch, Khalil Najafi, Anne Lurie, Stephen Director, Mary Sue Coleman, Jerry Levin, and Donald Graham***

## WIMS Hosted the NSF and IAB Site Visit Meeting

WIMS hosted its annual combined NSF Site Visit and Industrial Advisory Board Meeting May 25–26 on North Campus in Ann Arbor, where ERC faculty presented overviews of ongoing research and testbed development. WIMS graduate students had the opportunity to showcase posters displaying ongoing research projects in the Gallery at Pierpont Commons. Laboratory tours were provided for the visitors that included demonstrations. The Center would like to thank the IAB members for their direction and assistance in our research and the NSF representatives for their encouragement and advice.

*NSF team led by Dr. Bruce Kramer on lab tour*



*Graduate student Helena Chan manning her poster*

*Poster sessions in progress*

*NSF site team member Dr. Philip Loizou discussing poster with graduate student Pamela Bhatti*

*Graduate student Gayatri Perlin with advisor Dr. Ken Wise*

## Industrial Liaison's Report

During our recent Industrial Advisory Board and NSF Site Team meeting, we had the opportunity to meet with a broad cross section of engineers and discuss our research and efforts in commercializing our technology. Besides using spin-out companies, we are working with the Zell-Lurie Institute to develop a methodology to identify and shape the commercial potential of our research. The Program for Research Commercialization Potential (PRCP) is designed ultimately to identify new venture creation opportunities that benefit both the researchers and the MBA students alike. Second-year MBA students were involved in exploring the technologies being developed, identifying customer needs, and assessing business models for commercialization potential. The researchers had the opportunity to connect with business school students in conducting market research and assessing market potential.

Three research projects were reviewed during a six month period. The final deliverable was a recommendation on whether to advance a given system to the business planning stage.

Perhaps the best summary was offered by a researcher who said of the report on his system:

*"It seems like it is written from an investor's point of view rather than an entrepreneur's point of view. It seems that an investor looks for reasons to not invest."*

And a business student commented on the experience:

*"I came away with some good questions that I know to ask now when talking with technologists."*

The most important result of the PRCP is that we have established a dialogue between the business and technical communities so that commercial potential of new technology can be explored early. This should assist engineers in understanding what is needed in going forward with a business plan before that plan is prepared.

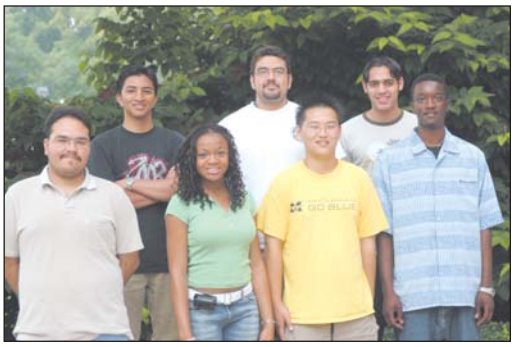
The Zell-Lurie Institute is planning to rollout PRCP to a larger audience, including the WIMS ERC, other research centers, universities, and private companies in the coming year.

As always, please visit the Center whenever you are in the Ann Arbor area.

Joseph M. Giachino
*Associate Director, Industry*

# Education Highlights

## WIMS Initiates New LSAMP Undergraduate Research Program



*WIMS LSAMP REU 2005 students*

On May 31, 2005, seven Louis Stokes Alliance for Minority Participation (LSAMP) undergraduate students arrived in Ann Arbor to begin a ten-week WIMS Research Experiences for Undergraduates (REU) research program. These students were from various universities across the USA. They came to work with our outstanding WIMS graduate students and receive first-hand knowledge of WIMS, while doing research that helped facilitate their graduate student mentor's research project. These students have come from the varied disciplines of computer engineering, biology, civil engineering, physics, biochemical and biophysical sciences, chemistry, and biochemistry. They worked on projects that interacted with their own backgrounds while exposing them to the state-of-the-art concepts of MEMS and microsystems.

Each student also received additional instruction on communication skills that helped him or her in preparing a final written and oral report of their completed project, including a PowerPoint presentation. They also attended workshops that focused on the professional ethics involved in working in their disciplines. In another workshop, encouragement was given to attend graduate school and highlighted the requirements and advantages of obtaining a higher degree. The REU students traveled to MSU for an afternoon of faculty presentations about graduate study, as well as met graduate students and toured labs. The LSAMP students also had opportunities to tour the EPA National Fuels and Emissions Laboratory, Michigan Nanofabrication Facility (MNF), and the Henry Ford Museum.

These students completed their WIMS experience on August 12, 2005, with a Closing Symposium where their efforts and accomplishments were presented.

## WIMS Hosted WISE GISE Summer Camp

***Participants Sachi Gianchandani and Sara Allen show the progress in creating their unique LEGO robot for the class competition.***

WIMS hosted fourteen girls from various middle schools in the Ann Arbor area as part of the University of Michigan's Women In Science and Engineering (WISE) Girls In Science and Engineering (GISE) Summer Camp. Each morning during the week of June 20–24, these girls received hands-on experiences with engineering concepts, while building and programming robots to perform specific tasks. With the help of the instructor, Nathan Usher, and other mentoring students from MSU, each team of two girls designed their own unique robot to meet the required challenges. A competition was held at the end of the week to see which team's robot could successfully complete the most challenges in two and one-half minutes.

# Faculty/Student Awards

- **Professor Edward T. Zellers** has been invited to be the first of four plenary speakers at *Eurosensors XIX* in Barcelona, Spain, September 11–14, 2005, to give a key lecture on "Au-Thiolate Nanoparticles as Interfacial Layers on Microsensor Arrays for Micro Gas Chromatography."
- Recently, the College of Engineering 2005 Student Leadership Recognition Dinner and Student Honors Brunch spotlighted students and organizations whose performances were nothing short of excellent. **David Lemmerhirt,** graduate student in electrical engineering, was the recipient of the Distinguished Achievement Award. Recipients of this award are chosen by department and program faculty that recognize academic and personal excellence.
- Graduate student **Fatih Kocer** and **Professor Michael P. Flynn's** paper, "A Long Range RFID IC with On-Chip ADC in 0.25$\mu$m CMOS," was selected as the third best student paper in the *RFIC 2004 Conference*.
- **Professor Dennis Sylvester**, EECS, has received a 2006 Henry Russell Award. This special honor is conferred by the University on junior faculty members in recognition of distinguished scholarship and conspicuous ability as a teacher. An excerpt from his nomination, which was submitted by a fellow faculty member, follows: "Professor Sylvester is an outstanding candidate for the prestigious Henry Russel Award. Despite the early stage of his academic career, Professor Sylvester has already established an extensive international reputation in his field. His research is widely cited and has made outstanding impact. In the area of teaching, his enthusiasm and energy have been an example for other junior faculty, and he has won several prestigious teaching awards. His service has made extensive contributions to the department and to the research community at large."

# Presentations and Publications

## Conference Presentations

***ACM/IEEE Great Lakes Symposium on VLSI, Chicago, Illinois, April 2005***

H. Kaul and D. Sylvester, "A Novel Buffer Circuit for Energy Efficient Signaling in Dual-Vdd Systems"

R. Bai, N. S. Kim, D. Sylvester, and T. Mudge, "Total Leakage Optimization Strategies for Multi-Level Caches"

J. Zhou and A. Mason, "Increasing Design Space of the Instruction Queue with Tag Coding"

***IEEE SoutheastCon 2005, Ft. Lauderdale, Florida, April 2005***

H. S. Savci, A. Sula, Z. Wang, N. S. Dogan, and E. Arvas, "MICS Transceivers: Regulatory Standards and Applications"

***IEEE International Symposium on Circuits and Systems (ISCAS), Kobe, Japan, May 2005***

D. Sylvester, H. Kaul, K. Agarwal, R. M. Rao, S. Nassif, and R. B. Brown, "Power-Aware Global Signaling Strategies"

E. Karl, D. Sylvester, and D. Blaauw, "Timing Error Correction Techniques for Voltage-Scalable On-Chip Memories"

***IEEE International Conference on Solid-State Sensors and Actuators (Transducers), Seoul, Korea, June 2005***

H. Kim and K. Najafi, "Characterization of Parylene-Assisted Wafer Bonding: Long-Term Stability and Influence of Process Chemicals"

R. T. Borno and M. M. Maharbiz, "Distributed Actuation Based on Young-Laplace Forces"

A. Basu and Y. B. Gianchandani, "Trapping and Manipulation of Particles and Droplets Using Micro-Toroidal Convection Currents"

S. W. Yoon, N. Yazdi, N. C. Perkins, and K. Najafi, "Novel Integrated Shock Protection for MEMS"

X. Zhu and D. M. Aslam, "Polycrystalline Diamond Thin Film Packaging Technology for WIMS"

D. F. Lemmerhirt, D. A. Fick, and K. D. Wise, "An Autonomous Microsystem for Environmental and Biological Data Gathering"

Y. Tang, D. M. Aslam, J. Wang, and K. D. Wise, "Technology and Integration of Poly-Crystalline Diamond Piezoresistive Position Sensors for a Cochlear Implant Probe"

***IEEE-EMBS International Conference on Microtechnologies in Medicine and Biology***

K. Oweiss, A. Mason, K. Thomson, J. Li, and Y. Suhail, "Augmenting Real-Time DSP in Implantable High-Density Neuro-Prosthetic Devices"

A. Mason, J. Li, K. Thomson, Y. Suhail, and K. Oweiss, "Design Optimization of Integer Lifting DWT Circuitry for Implantable Neuroprosthetics"

C. Hsin and M. Liu, "Partial Clustering: Maintaining Connectivity in a Low Duty-Cycled Dense Wireless Sensor Network," IEEE International Workshop on Algorithms for Wireless, Mobile, Ad Hoc, and Sensor Networks (WMAN), Denver, CO, April 2005.

F. Kocer and M. P. Flynn, "A Long Range RFID IC with On-Chip ADC in 0.25$\mu$m CMOS," IEEE Radio Frequency Integrated Circuits Conference (RFIC), Long Beach, CA, June 2005. (Third Best Paper Award)

X. Zhu and D. M. Aslam, "CVD Diamond Thin-Film Technology for MEMS Packaging," Applied Diamond Conference 2005, Argonne, IL, May 2005.

K. D. Wise, "Wireless Implantable Microsystems: Electronic Interface to the Cellular World," Int. Symposium on Bio Micro and Nanosystems, Seoul, Korea, June 2005.

## Publications

P. Mohseni and K. Najafi, "A 1.48-mW Low-Phase-Noise Analog Frequency Modulator for Wireless Biotelemetry," *IEEE Transactions on Biomedical Engineering*, 52, May 2005.

P. Mohseni, K. Najafi, S. J. Eliades, and X. Wang, "Wireless Multichannel Biopotential Recording Using an Integrated FM Telemetry Circuit," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, June 2005.

M. D. Johnson, K. J. Otto, and D. R. Kipke, "Repeated Voltage Biasing Improves Unit Recordings by Reducing Resistive Tissue Impedances," *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 13(2), pp. 160–165, June 2005.

# Doctoral Dissertations

*University of Michigan, 2005*

Mohamed Ahmed Abdelmoneum, "Novel Class of RF MEMS Resonators/Filters With Semi-Automatic Post Fabrication Trimming"
Postgraduate Position: Intel Corporation, Oregon
Advisor: Professor Clark T.-C. Nguyen

Masoud Agah, "Low-Power Temperature-Programmed Micro Gas Chromatography Columns"
Postgraduate Position: Assistant Professor, Virginia Tech, Blacksburg, VA
Advisor: Professor Kensall D. Wise

Mustafa U. Demirci, "Micromechanical Composite Array Resonators and Filters for Communications"
Postgraduate Position: Post-Doctoral Researcher, Toyota
Advisor: Professor Clark T.-C. Nguyen

Fatih Kocer, "A New Transponder Architecture for Long Range Telemetry Applications"
Postgraduate Position: Hittite Microwave, LTD, Istanbul Design Center, Istanbul, Turkey
Advisor: Professor Michael P. Flynn

Dongwoo Lee, "Analysis and Minimization of Leakage Current"
Postgraduate Position: Samsung, Korea
Advisor: Professor David Blaauw

David F. Lemmerhirt, "A Multi-Sensor Microsystem for Autonomous Data Gathering"
Postgraduate Position: Senior MEMS Engineer at Sonetics Ultrasound, Ann Arbor, MI
Advisor: Professor Kensall D. Wise

Enrique J. Duarte-Melo, "Field-Gathering Wireless Sensor Networks: Throughput Scaling Laws and Network Lifetime"
Postgraduate Position: Boston Consulting Group
Advisor: Professor Mingyan Liu

Pedram Mohseni, "Single-Chip Wireless Microsystems for Multichannel Neural Biopotential Recording"
Postgraduate Position: Assistant Professor of EECS, Case Western Reserve University, Cleveland, OH
Advisor: Professor Khalil Najafi

David Pellinen, "Multifunctional Flexible Polymer-Based Intracortical Neural Recording Microelectrodes"
Postgraduate Position: Engineering Scientist, NeuroNexus Technologies, Ann Arbor, MI
Advisor: Professor Daryl R. Kipke

# Seminar Series

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

*** April 5, 2005**
Arjun Selvakumar, PhD
Applied MEMS
"A MEMS Company Insight – Getting MEMS Technology to Market!"

*** April 12, 2005**
Professor Rashid Bashir
Purdue University
"BioMEMS and Bionano-technology: Interfacing Engineering and Life-Science at the Micro and Nanoscale"

*** April 19, 2005**
Professor Babak Ziaie
Purdue University
"Hydrogel-Based Micromachined Platforms for Physiological Sensing and Smart Flow Control"

*** May 3, 2005**
Marion Scott, PhD
Sandia National Laboratories
"Microsystems Research-to-Development-to-Applications at Sandia National Laboratories"

*** May 10, 2005**
Professor Kensall D. Wise
University of Michigan
"WIMS Overview"

*** May 17, 2005**
Bhaskar Mitra
University of Michigan
Graduate Student
"High Speed Chemical Sensing Using Microdischarges"

*** May 17, 2005**
Amar Basu
University of Michigan
Graduate Student
"High Speed Liquid Pumping, Mixing, and Particle Entrapment with Non-Contact Microscale Heat Sources"

**Available for viewing on website*

***Schedules of upcoming seminars, as well as a listing of publications, are available at http://wimserc.org***

# Member Companies

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**Corning, Inc.**
**Delphi Corporation**
**Dexter Research Center, Inc.**
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