2008/2009 Research, Development, and Activities

College of Engineering and Applied Sciences
Neurobiology Engineering Laboratory: Drs. Miller and Severance and graduate student Michael Ellinger have completed the setup of a now operational Neurobiology Engineering Laboratory in room A-211. That laboratory includes a bio-safety cabinet, incubator, and recently installed de-ionized water, vacuum, and compressed air lines. Inspired by work by other researchers, the overall objective of this laboratory is to study the computational characteristics of neuron cell cultures as grown on multi-electrode arrays (MEAs). The current focus is on developing the instrumentation, software, and culturing protocols to support that goal. Graduate student John Stahl is now testing a two channel system that he and undergraduate student Justin Andrews constructed for electrical stimulation and measurement of cell culture activity. His instrumentation is based on previous work by three senior design groups, including one group composed of Troy Caruso, Evan Dalek, and Eric Jones, to adapt an existing circuit found in the scientific literature. Undergraduate student Kyle Batzer is developing a digital signal processing system to provide stimulation waveforms and to analyze cell culture responses. Michael Ellinger is also working on software to interpret cell culture action potential sequences. Culturing on MEAs is contingent upon successful testing of these equipment and methods on “simpler” target biological systems, e.g. earthworm axons. The first pseudo-neural cells were successfully cultured in the summer of 2008 with the help of biological sciences graduate student, John-Mary Vianney, who also works in the ECE office. The lab has relied on help from Drs. Bazuin and Gesink, David Florida, Biological Sciences faculty Drs. Jellies and Spitsbergen, and Matt Stoop and Harold Hladky in Chemical Engineering. Funding support includes undergraduate (Batzer) and graduate (Ellinger) research fellowships from the NASA Michigan Space Grant Consortium, a WMU Faculty Research and Creative Activities Support Fund grant and a WMU grand student research fund grant. Dr. Abdel-Qader provided software for the target digital signal processor as supplied by a previous NSF grant. A summary of this work was presented in oral and poster sessions at the 2008 NASA Michigan Space Grant Consortium in Ann Arbor, MI.

A course sequence related to this research is being established: ECE 5730 Foundations of Neural Networks and ECE 6730 Advanced Neural Networks. ECE 5730 is being offered this semester with ECE 6730 following in summer I.
CEAS team's sensors to monitor Parkview Bridge health - For many who work at the Parkview Campus, replacing the Parkview Avenue bridge over US 131 meant an inconvenient detour for the past summer. However, for a CEAS research team, it was an opportunity to incorporate sensors inside the bridge to measure stresses in the concrete and to monitor the health of the bridge. Dr. Osama Abudayyeh, CEAS associate dean, is principal investigator of the Michigan Department of Transportation (MDOT) project "Health Monitoring and Evaluation of the Rapid Bridge Replacement Technique at Parkview Bridge in Kalamazoo, MI," which funded the placement of the sensors and the monitoring of the bridge. The sensors – vibrating wire gauges embedded in the concrete – can measure stresses and temperature inside the concrete deck. "The sensors are rugged and have been proven reliable," he said. "They have been used in other places in the world, but this is the first time this kind of monitoring has been used in Michigan."

The key members of the bridge-sensor project include faculty and graduate and undergraduate students from Departments of Civil and Construction Engineering (CCE) and Electrical and Computer Engineering (ECE): Dr. Hubo Cai, CCE assistant professor (Co-PI); CCE students Joe Barbera (MS), Brock Mellema (MS), and Mike Peake (BS); Dr. Ikhlas Abdel-Qader, ECE associate professor (Co-PI); and ECE student Eyad Almaita (ECE Ph.D.). Others involved in the initial phases of the project include Dr. Sherif Yehia, CCE associate professor (Co-PI) who is on leave of absence this year, and CEAS alumni Vijay Meganathan (ECE), Ammar Zalt (CCE), Mike Maurovich (CCE) Ashwin Vijayakumar (ECE), and Pramod Govind Lalji (ECE) according to Abudayyeh, current plans call for one year of monitoring, but the research team has recently requested an additional three years of study.

Nonlinear Circuits and Systems Laboratory: Undergraduate students David Kirklewski, James Truszkowski, and Dan Heilman and graduate student Donovan Squires continue to investigate the design of chaotic circuits in collaborative research with Prof. Giuseppe Grassi of the University of Salento. A journal paper describing a coupled Lorenz system proposed by Dr. Grassi and demonstrated by a senior design team (Christopher Bommarito, Paul Kokney, and Donovan Squires) under the supervision of Drs. Miller, Bazuin, and Severance is being prepared. (Miller)

Artificial Neural Networks: Former graduate student Emil Mashev continues to build upon work by graduate student Rodrigo Arguello in evolving artificial neural network structures in collaboration with Dr. Miller and Dr. Garrison Greenwood of Portland State University.

ECE Visting Professor - Dr. Ghassan Halasa, a Fulbright Scholar and Professor from the University of Jordan joined the ECE Department this year while on sabbatical. During his stay he has aided our department by teaching ECE 3610 Electromagnetic Fields and ECE 3300 Electrical Machines in both the Fall and Spring semesters. Dr. Halasa has also been performing research in the green energy area, solar and wind, and has submitted three papers for publication during his stay with us.
Rehabilitation Engineering - The major thrust of activity in these studies relates to veering of visually impaired individuals. Veering is the drift from one’s intended path of travel and it happens to most persons when position feedback is absent. One of the major efforts in these studies has been the development of a device to train blind individuals to better walk a straight path without veering in short missions such as crossing a street or walking across a parking lot. Such a device, an Anti Veering Training Device (see Photo), has been developed and is waiting field-testing. Other activity in this area focuses on the development of a Veer Analyzer, a device which, when coupled to a veering individual, will measure and record, in two dimensions, the trajectory of the individuals movement. The recorded trajectory is then analyzed in an effort to decompose the trajectory into a rotational and a translational component. If successful, the analysis will be useful in developing programs to reduce veering. Thus far, hardware has been developed to record the trajectory and progress is being made on analytical techniques to extract the rotational and translational components. John Gesink heads this effort and the National Institute of Disability Rehabilitation and Research funds it.

Dual-Use Ground Vehicle Condition-Based Maintenance – The U.S. Army is poised to introduce Condition Based Maintenance (CBM) across its land-based vehicle fleet. CBM is expected to increase the vehicles’ readiness and operational availability and reduce the soldiers’ maintenance burden. Within this research, our team is to develop an intelligent vehicle health management system for light tactical vehicles. Our focus is on vehicle systems as follows: engine, axles and wheels. We will also develop a secure vehicle identification method through RFID technology. The front-end of our vehicle health management system will have the following elements: data acquisition, data manipulation, condition monitoring, health assessment (diagnostics) and prognostics. The $345,000 project is funded by the U.S. Army Tank-Automotive Research, Development, and Engineering Center (TARDEC) through CAViDS. (ECE faculty involved in this project are Janos Grantner, CoPI; Bradley Bazuin, Liang Dong and Richard Hathaway and Claudia Fajardo of the MAE Dept.).

TS-Type Fuzzy Automaton for Software Agents – In this project our objective is to develop a new, Takagi-Sugeno type fuzzy automaton. Tracking the status of an event driven, large control system is a difficult problem. Those systems often encounter unexpected events in an uncertain environment. The use of fuzzy automata offers an effective approximation method to model continuous and discrete signals in a single theoretical framework. A Max-Min automaton can successfully model a cluster of relevant states when a decision is to be made on the next state of a goal path at the supervisory level. However, to provide analytical proof for stability and other key properties for inference performed by a fuzzy controller the Takagi-Sugeno model is preferred. This project is a continuation of a previous one referred to as Generic Encapsulated Fuzzy Automaton Software Agent. This project is overseen by Janos Grantner, ECE Professor and George Fodor, of ABB Automation Technologies, Sweden.

Changing of the guard in the CEAS Dean’s Office -
On Aug. 1, Dr. Tim Greene (left), who has served as CEAS dean since April 2005, assumed the position as WMU Provost and Vice President for Academic Affairs. Last week, WMU announced that Dr. Dan Litynski (right) – a professor in the Department of Electrical and Computer Engineering who has served as CEAS dean, WMU provost, and interim WMU president – will serve as CEAS dean for 11 months while a 15-member WMU team searches for a new CEAS dean.

Litynski was CEAS Dean from 1999-2002, a period of increased CEAS student enrollment, new programs and accreditations, conception and construction stages of the new 270-acre CEAS Parkview Campus, and the early development of the Business, Technology, and Research Park. He recently spent three years at the National Science Foundation as Program Director for Physics and Director of the Division of Undergraduate Education.
**Radio Frequency Identification (RFID)**

Drs. Atashbar and Bazuin (left) are currently collaborating with Dr. Margaret Joyce (director) and a large team of faculty, post-docs and students primarily from the Paper Engineering, Chemical Engineering, and Imaging (PCI) department. There are multiple contracts and proposals related to the printing of electrical functional materials to construct sensors, circuit elements, test devices, and Radio Frequency Identification (RFID) tags.

**ECE supporting Sunseeker 2008 CAN (Controller Area Network) Bus Developments**

The 2008-2009 activities include the development of a Controller Area Network (CAN) Test Bench and the design of a solar cell characterization system. Undergraduates participating in this research are Trevor Case, Kyle Hendricks and Robert Olsen. The CAN test bench is a mockup of the CAN related components used to drive, monitor, and provide displays and indicators for the vehicle. In addition, second generation PCBs for the light and telemetry boards are being generated with revised software. This work is funded by a grant from the Denso North America Foundation. Undergraduates involved in this research are Ruba Afaneh, Hang Guan Chean and Ishrak Mamum. The solar cell characterization system is intended to measure the current-voltage or I-V characteristics of individual solar cells, cell arrays, and an entire solar cell array assembly.

**Electronic Network and Real-Time Vehicle Simulation Test Bed Developments**

Three members of the department are collaborating with a multidisciplinary team to seek funding for two vehicle system related test beds: a CAN electronic network test bed modeled on the Sunseeker 2008 CAN network and a table-top sized real-time Selective Fidelity Vehicle Simulator Test Bed. The multidisciplinary team, consisting of John Kapenga (CS), Richard Hathaway (MAE), Claudia Fajardo (MAE), Mitchel Keil (IME), Janos Grantner (ECE), Liang Dong (ECE), and Bradley J. Bazuin (ECE), has submitted an initial capital equipment gift proposal. These test beds can provide tremendous opportunities for student demonstrations, course laboratory assignments, independent research projects, and industrial collaboration.

**Dr. Frank Severance**, a professor in the Department of Electrical and Computer Engineering (ECE), headed up a delegation of about 14 WMU faculty members and students who attended the 13th Annual Conference of the Michigan Space Grant Consortium (MSGC) held October 2008 in Ann Arbor. Severance, who serves as WMU’s MSGC program director, introduced seven of the 23 conference presentations, which were based on projects funded by last year’s MSGC grants. Faculty and undergraduate and graduate students shared both the results of work completed on last year’s projects and plans for new or continued projects and experiments. “This is an opportunity to see our peers’ proposals and to expand on the knowledge base of the projects that we currently have in the works,” he said.

**Michael Ellinger**, a WMU master’s student in electrical engineering (EE), presented “Computing with Neuron Cell Cultures,” based on his research in biological computation. He also submitted a poster on the project. Other posters included “Low Noise Instrumentation for Amplification of Electrode Voltages in Neuron Cell Cultures,” which was related to Ellinger’s work and done by John Stahl and Eric Jones, EE master’s and bachelor’s students respectively, and “Adaptive Control Algorithm in Heterogeneous Swarm Robotic Systems,” by Hanyi Dai, an EE Ph.D. student. Faculty and students from 10 other Michigan colleges and universities participated in this year’s presentations. MSGC fosters education and awareness of space-related science and technology in Michigan. It is a branch of the National Space Grant College and Fellowship program with a network of consortiums representing each of the 50 states, the District of Columbia, and Puerto Rico. Each individual state consortium is allocated funding, which is dispersed among qualifying individuals who submit an application form and a proposal.
Professor for the Day - On Wednesday, February 18th the IEEE student branch hosted an alumni Professor for the Day. This event was schedule to enhance the Engineering Week celebration with that dinner being held on Tuesday night. Invitations were sent out to several alumni to join us the next day and work with an ECE faculty to teach a segment of the class. Alumni’s Matt Johnson, Eaton Corporation and Carrie Sutton (right), Denso Corporation accepted the invitation and participated in the event, organized by Johnson Asumadu, faculty advisor for the IEEE Student Chapter.

Freshmen Orientation – In the summer of 2007 ECE held approximately 14 freshmen orientations. The orientations were set up with an overnight stay. On the first day they visited the main campus and a mixer was held for the parents and faculty. The next morning the students were brought to the engineering campus and the ECE students were greeted by ECE Student Ambassadors, upper level ECE students who provided tours of our campus and help guide the future freshmen from one area to the next as they registered for their fall courses. The ambassadors talked to the future students about their experiences here in the ECE Department and about the outside activities available. ECE Faculty provided one on one advising with the students and staff helped the students register for their courses.

Wireless Cooperative Localization and Communication
Positioning and communication networking are key technologies of many wireless applications inside buildings. The major difficulty imposed on these technologies lies on the harsh indoor radio propagation environment. A complicated multipath propagation link usually exists between the transmitter and the receiver that makes the network localization prone to error and the traditional cooperative communication unreliable. This research proposes schemes of implementing indoor localization with cooperative communication. They assist each other in achieving both precise node localization and power-efficient communication. A prototype testbed is developed with the IEEE 802.15.4 and ZigBee protocols for wireless personal area networks. Research is being overseen by ECE Professor Dr. Liang Dong and supported by NASA – Michigan Space Grant Consortium and WMU Faculty Research and Creative Activities Support Fund.

Meet & Greet - The ECE Department held a Meet & Greet this year in the fall semester scheduled around the beginning ECE courses ECE 2500 and ECE 2510 to encourage attendance of the ECE students. A continental breakfast was provided approximately 90 students attended giving faculty and staff the opportunity to visit and meet the students.

Tours – throughout the academic year have been provided to various groups of students. The ECE faculty have often provided lab experiences for the visiting students and are available to meet with the students and their families to answer questions about the programs and curriculum. The ECE faculty has provided many different formats and labs for the visitors.

Vehicular Ad-Hoc Network
Future smart vehicle systems rely on vehicle-to-vehicle and vehicle-to-roadside-infrastructure communications. The vehicular ad-hoc network (VANET) consists of vehicles as mobile nodes and roadside elements as anchor nodes. The range measurement of pair-wise communication links within the VANET can help determine the relative positions of each vehicle. This complements GPS navigation systems. Our research aims at the development of a VANET that can be incorporated with the GPS to provide reliable navigation services for cars in urban canyons. The VANET system will generate relative position information of multiple vehicles present in the urban area. This relative map will be incorporated with accurate GPS information provided by, for example, GPS receivers on vehicles at the edge of the downtown area who have good GPS reception, or a few GPS repeaters that are installed on buildings at major intersections of the downtown area. Researchers Liang Dong, ECE Professor with K. Ro and J. Oh. Supported by DENSO Foundation.
Dr. Bazuin recipient of DENSO Award - In a ceremony held last fall, DENSO North America Foundation presented CEAS Dean Dan Litynski with a $25,000 check. The check was presented by Karen Cooper-Boyer – General Manager for HR/Corporate Services and HR Systems Planning at DENSO Manufacturing Michigan, Inc. in Battle Creek, a trustee on the DENSO North America Foundation Board, and a WMU alum (BBA ’86, Mgmt.; MA ’88, Educational Leadership). According to Dr. Brad Bazuin, Dept. of Electrical and Computer Engineering professor, the funds will be used “to provide WMU’s Sunseeker solar car project with a Controller Area Network (CAN) test bench while also providing multiple opportunities for hands-on student-centered learning.” Bazuin said, “CAN compatibility is currently required for onboard diagnostic in US passenger cars and light trucks; is used in higher end vehicles for communications between intelligent electronic components, such as instrument panel displays, transmission, seats, door locks and trunk releases; and is moving us toward full drive-by-wire vehicles.” With the DENSO gift, Bazuin, an ECE senior project team, and members of the Sunseeker electrical team will build a mock-up of all the CAN electronic modules and CAN connections that are expected in future Sunseeker cars. The funds will be used to purchase test equipment, a mobile workbench, ICs, printed circuit cards, cables, connectors, and other material needed for the CAN test bench. Before you install electronics in a vehicle, a mock up of all available components should be built to allow proper testing and to insure correct operation. The test bench and related CAN work will result in a more robust system that should enhance safety and make WMU more competitive,” he said. “The DENSO North America Foundation has supported multiple CEAS projects. This is one more significant contribution to WMU students and CEAS student teams.”

Summer Institute - In August, Dr. Frank Severance, a professor in the Department of Electrical and Computer Engineering (ECE) and Dr. John Kapenga, a professor in the Department of Computer Science (CS), offered a weeklong Summer Institute that focused on computer engineering and provided the students with “an overview of a four-year computer engineering program in a week to see if they’re interested,” Severance said.

Three area high school students attended the workshop held at the CEAS Parkview Campus for five hours each day programming and interfacing directly with electronic gizmos. They used neither monitors nor keyboards. Severance explained that what made the institute experience unique was interfacing the computer with the outside world, including speakers and lights. They also studied circuitry and electronics. “That’s what computer engineers do,” Severance said. “They get programs to talk to the electronics, which talks to the world.” Because the class was small, the students benefited from the tutorial support in enhancing their understanding concepts that will benefit them in their future careers.

High school students who attend the institute were Eric Smith, a junior at Portage Central (PCHS) and at the Kalamazoo Area Math and Science Center (KAMSC); Jason Pearson, a PCHS sophomore; and Rebecca Farrer, a Hackettand KAMSC senior with career goals in either computer or electrical engineering. The professors credited several sources for supporting this year’s event. Texas Instruments donated parts, meals, and t-shirts. Funding was also provided by Provost Tim Greene, who was CEAS dean when the event was approved last April, and Nuts and Bolts donated magazines. This is the first of what the two professors plan to offer annually.
WMU DAY – More than 800 Bronco supporters came to Lansing on WMU Day to showcase the university for Michigan Lawmakers.

CEAS students, faculty, and administrators were among the roughly 800 who participated in the first WMU Day held in Lansing on the lawn of Michigan’s Capitol. All WMU colleges showcased projects on the lawn of Michigan’s Capitol in Lansing. Among the CEAS displays were a concrete canoe, a life-sized robot, a solar car, a Formula race car, a hydraulic bike and chair research.

EE Alumni inducted into the Alumni Excellence Academy - Kalamazoo's Park Club was the setting for the inauguration ceremony of five new members inducted into the 2007 Alumni Excellence Academy last month. WMU President John Dunn joined the CEAS Executive Committee and CEAS Dean Tim Greene in honoring the recipients, who have impressive credentials. Fred Lawrence (BS ’70, Electrical Engineering), a venture partner for Shepherd Ventures and California Capital, the chair of Silicon Systems and Ceyx Technologies, and the director for Avaax, is a member of the Board of Directors for the San Diego State University Business School and the Florida Council of 100. He started his career telecommunications at AT&T, where he worked while attending college. Lawrence has also served as CEO, Sprint's Florida Telephone Operations; president, Transmission Group of ADC Telecommunications; CEO, ComStream; and CEO, Adaptive Broadband Corp.

Tau Beta Pi (tbp.org) is a multi-disciplinary honor society dedicated to “integrity and excellence in engineering.” Membership is offered to the top junior and senior engineering students that exhibit “distinguished scholarship and exemplary character.” ECE student Gregory Vosters is the President of our Michigan Kappa chapter of Tau Beta Pi while Dr. Miller serves as the chief advisor. Member David Florida plays a key role in the initiation process. Our chapter actively serves the college and local community. The chapter advisory board as chaired by Dr. Miller consists of Dr. John Cameron (Chemical Engineering), Provost Greene, Dean Litynski, and Dr. Bob White (Industrial Engineering).
Department Changes - Sheryl Todd (left) was recruited from our department to take the position of office manager for the Computer Science Department. Although we are sad to see her leave, we are happy about her advancement and feel lucky, as she is literally in the next office so we still get to see her regularly. A new addition to the ECE Department is Mariann Cardenas (right) who joined us at the end of the Fall 2008 semester. Mariann is from Texas. She worked for the counseling center here WMU for the past two years. Mariann is also continuing with her education and is planning on obtaining a BA in secondary education within the next few years. Please join us in welcoming her to the ECE Department.

Network Localization and Velocity Estimation Enhancing Multi-UAV Navigation - Conventionally, the inertial navigation system (INS) of vehicles can be calibrated by the GPS to correct integration drift. The INS, on the other hand, can fill the GPS update gap for guidance and control of high dynamic vehicles such as aircrafts and missiles. In GPS-denied environment, alternative assistance is required for the INS to maintain accurate tracking. When a fleet of unmanned aerial vehicles (UAVs) fly in proximity within GPS-denied environment, the INS drifts could cause collisions. Since the multiple UAVs form an airborne wireless ad-hoc network, one can exploit this communication network for collective INS calibration. This can be accomplished if the network provides multiple UAVs with accurate estimations of their relative positions and velocities (speed and direction). This technique can also be employed in cases when GPS receivers are not available onboard every single UAV due to cost or damage during mission. Our research develops a cooperative and distributed algorithm for relative positions and velocities estimation based on unreliable range and Doppler measurements. These estimates are used for INS calibration and to assist automated flight control. ECE faculty, Dr. Liang Dong with ECE PhD students Ahmad Aljaafreh and Abdel Ilah Alsbatat having been working on this research.

Enabling Adaptive Wireless Ad-Hoc Networks with Directional Antennas - This research seeks design of randomly-deployed static or mobile wireless ad-hoc networks with directional antennas. This can be solution to the communications system over complex channels or obstructed environments, and to the unattended wireless sensor networks in environment monitoring, manufacturing, disaster mitigation, and homeland security. Parameterized on the realistic antenna components and complex channel characteristics, this work will enhance the analytical framework for the communication architecture of ad-hoc networks across physical, medium access control, and network layers. The tradeoff between energy efficiency and source-to-destination bandwidth will be investigated. (Liang Dong with W. Stark)

Powered by Lemons – Dr. Damon Miller was invited by St. Mary’s school in Paw Paw to conduct a science experiment based on various sources for the elementary school children. The student’s conducted an experiment to see how many lemon batteries are required to provide enough electric power to light up an LED. By inserting a piece of copper wire and a zinc plated screw lemons can be wired in series to provide the voltage needed. Turns out you need at least 2. Photo courtesy of Connie Cooley.

Transmission Matrix Modeling - Dr. Atashbar presented a three days short course for research scientist and engineer at NASA Langley Research center Hampton, Virginia from July 17-19 2007. The theme of workshop was centered on Transmission Matrix Modeling of acoustic wave based sensors. In this course, three different configurations of the surface acoustic wave (SAW) devices: delay line, one-port resonator, and two-port resonator were introduced. Both the equivalent circuit and transmission matrices modeling approach for the SAW devices will be presented. Creation and use of the extended transmission matrices method, for delay lines and resonators as well as S network parameters (S11, S12, S21, S22) will be discussed.
**Dr. Atashbar** was on sabbatical leave on academic year 2008-2009 at University of Michigan to support his research activities based on a proposal entitled “MEMS-based Energy Scavenging and Power Generation”. Since Fall 2008 Dr. Atashbar has been holding Visiting Research Professor position at the Department of Electrical Engineering and Computer Science, University of Michigan, Ann Arbor, MI to continue his research collaborations. As ultra-low-power circuits and microsystems developing conventional batteries used for these systems could be replaced with smaller-sized and longer-lifetime alternatives. In this sense, energy harvesters hold great advantages such as unlimited life-time, and no need for recharging or power cables. Mechanical energy harvesters are especially useful for environments that are exposed to external vibration and forces, like the wing of an insect. The goal of this research is to develop an efficient microscale power generator that harvests energy of >50µW within a volume of <0.01cc and a weight of <0.2g from live beetles as a part of the DARPA HI-MEMS (Hybrid Insect) Project. (Collaborating with Professor Khalil Najfi at the University of Michigan). This research resulted in several publications and presented at the Solid-State Sensors, Actuators, and Microsystems Workshop, • Hilton Head and IEEE Sensors conference.

**Dr. Atashbar** has successfully developed an Advanced Micro Electro Mechanical Systems course with University of Michigan collaboration at Western Michigan University with for the first time. This is a project-oriented laboratory course in integrated microsystem design, fabrication, and testing. As system integration levels have increased, more and more different devices are being integrated on a common substrate, creating interesting tradeoffs in system partitioning and technology. To understand these tradeoffs, this course addresses the development of a complete multi-chip microsystem containing sensors, signal processing, and an output interface. This allows us to explore not only a basic MOS device/circuit process, but also to explore processes such as wafer bonding and micromachining that are used for transducers. Microsystems will increasingly be portable devices, emphasizing very low power and making capacitive transducers particularly attractive and important. Students in this course has designed, fabricated and currently are testing their MEMS and ED-NMOS electronic readout chips. These projects include, Silicon-on-Glass based Accelerometer and Gyroscope.

**Hybrid Guided Shear Horizontal Surface Acoustic Wave Sensor Instrumentation System** - **Dr. Atashbar** is working on development of this system for the detection of serum protein biomarkers. The sensing devices as well as microfluidic chamber for these system is fabricated and in currently being tested evaluated. This research is resulted in several publication including M.Z. Atashbar, A. Z. Sadek, W. Wlodarski, S. Sriram, M. Bhaskaran, C. J. Cheng, R. B. Kaner, and K. Kalantar-zadeh “Layered SAW gas sensor based on CSA synthesized polyaniline nanofiber on AlN on 64º YX LiNbO₃ for H₂ sensing” Sensors and Actuators.