University of Michigan

College of Engineering

Mechanical Engineering

ANNUAL REPORT 2006-2007

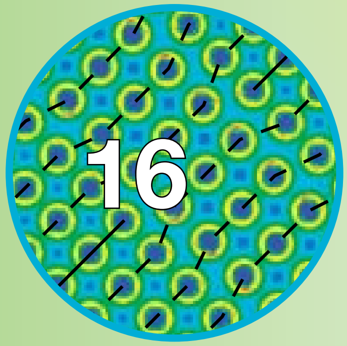
MichiganEngineering

Department of Mechanical Engineering

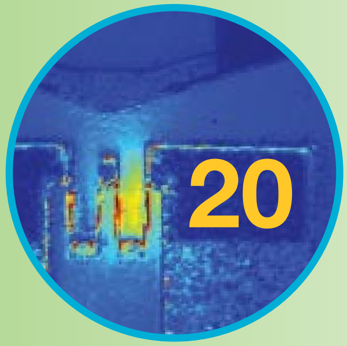
2006-07 Annual Report

Fresh Directions in Research

The ME Chair



The New Face of ME



Department Statistics

Honors, Awards & Activities

From the Interim Chair

A short fifteen years ago, in 1993, Mechanical Engineering at Michigan celebrated its 125th Anniversary. A brand new department chair had just started his duties, a youngish-looking fellow with a name whose pronunciation challenged all but the Greek scholars that Michigan is proud of. A special departmental annual report was produced that year, tracing the department's roots and outlining its evolution by dividing it into four eras: Laying the Foundation (1868–1900), Building National Prominence (1900–1940), Entering the Modern Era (1940–93), and Leadership in High Technology (1970–93). Thumbing through that report again this past year I was again struck by the intellectual power and the glorious achievements of our Michigan professors and students, now spanning three centuries and with no sign of letting up. In another short ten years, in 2018, the department will be celebrating its 150th anniversary. I wonder what we are going to call the 1993–2018 era.

Perhaps a clue for this can be found in this year's annual report where our main story is the new face of Mechanical Engineering, or the "new ME" for short. In many ways, the new ME is represented by our cohort of assistant professors, ten of them, who are rapidly redefining mechanical engineering. In the mid to late 20th century, mechanical engineering, nationally and internationally, had defined itself as a discipline by adhering to several *sine qua non* elements in its curricular and research portfolio: dynamics, fluid mechanics, heat transfer, materials, solid mechanics, thermodynamics — the building blocks of engineering science. Areas like manufacturing, design or automation would be seen as part of the engineering practice, necessary for a successful accreditation review. Much of that disciplinary self-definition still prevails today, but the game has changed. As it has become painfully obvious, the problems that increasingly preoccupy us are distinctly crossing the traditional boundaries of knowledge, not just for mechanical engineering, but also across all engineering department structures, and indeed outside engineering. While scientific knowledge turned into technology is what we strive for in our work, solutions based on that alone, without considering the social and human aspects of the problems, will be found wanting.

"I was again struck by the intellectual power and the glorious achievements of our Michigan professors and students."

The new ME at Michigan is broader than our young colleagues featured in this report. The whole department is actually the new ME. When I started my service as interim department chair in fall 2007, after a ten-year hiatus, one thing I learned quickly is how much everyone in the department had evolved. The traditional mechanical engineering ingenuity had found its way into addressing problems in biology, exotic energy sources, heath engineering, materials, molecular devices, and public policy — just to name a few. What an exciting time!

Looking back, I would like to thank Professor Dennis Assanis, who completed his department chair service in August 2007, for his sustained efforts to move the department forward into the new era. Looking forward, I would like to welcome Professor Kon-Well Wang, who assumed the department chair duties in June 2008, and wish him success in marshaling the department and all of its constituents into continuing the Michigan tradition of excellence.

I invite you all to join us in defining our era and in our journey right to our 150th date!

Panos Y. Papalambros
Interim Chair
Department of Mechanical Engineering

Meet Kon-Well Wang, New ME Department Chair

The Mechanical Engineering department welcomes Professor Kon-Well Wang as its new department chair, effective June 2008. A distinguished educator and researcher in the areas of structural dynamics and vibrations, Wang most recently served as the William E. Diefenderfer Chaired Professor in Mechanical Engineering and director of the Structural Dynamics and Controls Laboratory at the Pennsylvania

State University. He has also been an associate director of the Vertical Lift Research Center of Excellence and a group leader of the Center for Acoustics and Vibration at Penn State. He is a fellow of the American Society of Mechanical Engineers (ASME) and has received numerous recognitions for his accomplishments, including the ASME N.O. Myklestad Award, the ASME Adaptive Structures and Materials Systems Prize, the NASA Tech Brief Award, the Society of Automotive Engineers Ralph R. Teetor Award, the Penn State Engineering Society (PSES) Premier Research Award and the PSES Outstanding Teaching Award. Wang is currently the chief editor of the ASME *Journal of Vibration and Acoustics.*

Professor Wang says it was the "high energy level and potential of the department that inspired me and attracted me to the position. I was greatly impressed by the ME community when I visited U-M."

The U-M selection team, likewise, was impressed with Wang's qualifications. "He has just the right mix of characteristics," said Professor Panos Papalambros, interim chair and member of the search committee. "His experience as a mentor is well-suited to the strong growth in the department's junior faculty, and his attention to detail will help bring ME's building and expansion plans to fruition."

Wang adds, "I am excited and honored to have the opportunity to lead such a strong department, and I look forward to formulating future plans with the U-M ME community. Working together, I truly believe that we will be successful in our endeavors."

Wang earned his bachelor's degree in mechanical engineering from the National Taiwan University and his master's and doctoral degrees in mechanical engineering from the University of California, Berkeley.

Hats Off to Professor Dennis Assanis

Professor Dennis Assanis, Jon R. and Beverly S. Holt Professor of Engineering, recently stepped down from a five-year term as ME department chair. It was a productive and successful term, says Professor Panos Papalambros, who now serves as interim chair.

Papalambros, too, held the chairmanship — from 1992 to 1998. He hired Assanis into the department in 1994. "I had a very specific goal for him: to help us revitalize our automotive engineering education and research activity and generate a beehive of modern research activity in the Lay Automotive Laboratory. He has certainly done that," said Papalambros.

Assanis also played a critical role in the Automotive Research Center (ARC), the U.S. Army Center of Excellence in Ground Vehicle Systems, founded by Papalambros in 1993. Assanis became director of the ARC in 2000. "When we started looking for a new chair, he was one of the colleagues that naturally would fit in that role given the expansive role he was already playing in the department," Papalambros added.

Assanis also was a natural fit because of his "boundless optimism," said Papalambros, a defining characteristic that allows him to carry projects forward. "He was able to manage the department through many challenging times and still maintain his good humor and positive demeanor." Assanis also sparked serious discussions about new building and expansion plans for the department, which are moving forward.

Now that he has completed his term, Assanis continues his research in the area of alternative energy and propulsion. "He no doubt will

continue to play a leading role in the department, college and university," said Papalambros, "helping us attract new research projects and build new facilities."

The entire department thanks Assanis for his dedicated service as chair from 2002 to 2007.

Engineering Sustainable Systems Program

ESS

> "We are creating a new type of engineer."
>
> –Steven Skerlos

GLOBAL CLIMATE CHANGE, energy security, ecological degradation, environmental threats to human health and resource scarcity — these are a sampling of critical sustainability challenges for the future. And students who want to ensure that their work solving engineering problems is socially, environmentally and economically sustainable now have a new degree option: Engineering Sustainable Systems (ESS). The dual masters' degree program is offered by the College of Engineering and the School of Natural Resources and Environment (SNRE). ME Professor Steven Skerlos serves as ESS program coordinator along with Gregory Keoleian, associate professor in the SNRE.

Students pursuing the ESS program specialize in one of three tracks: sustainable design and manufacturing systems, sustainable energy systems or sustainable water resources. Skerlos expects that additional specializations, such as sustainable mobility systems, will be available soon.

Candidates complete all of the requirements for two degrees: a master of science in engineering and a master of science in natural resources and environment. The 54-credit-hour dual-degree program takes between 2 and 2.5 years to complete for most students.

"We are creating a new type of engineer," said Skerlos. "For instance while a typical mechanical or chemical engineer with a master's degree might consider a plug-in hybrid electric vehicle a sustainable technology because it uses much less gasoline, an ESS graduate would be capable of quantitatively studying other sustainability factors, such as the emissions of the electricity infrastructure and the likelihood plug-in vehicles could be accepted by the market in the foreseeable future." Graduates of the ESS program would do more than simply model the near-term benefits of, for example, biofuels and other renewable energy sources; they would examine the impacts and challenges associated with the new technologies.

The interdisciplinary, dual-degree ESS program is the first of its kind in the nation. The ME department, and field of mechanical engineering, have a central role to play in sustainability, said Skerlos. "ME is a true systems discipline: thermal fluid sciences, automotive, mechatronics, design, manufacturing, materials and beyond — considering how broad our department is, it's only natural for us to lead the field of sustainable technology and systems design."

For more information, visit http://www.ess.umich.edu.

New Ground Robotics Research Center

MECHANICAL ENGINEERING

Professor A. Galip Ulsoy has spearheaded a new Ground Robotics Research Center (GRRC) and now serves its founding director.

The GRRC will be supported with funding from the U.S. Army. The army has been consolidating its unmanned ground vehicle research, development and engineering efforts at The U.S. Army Tank-automotive and Armaments Command (TACOM) in Warren, Michigan, making the new U-M GRRC the ideal hub for coordinated, synergistic research, education and technology transfer activities. The GRRC will bring together collaborators from government, industry and other academic institutions, including Michigan State University, Wayne State University and others undertaking robotics work.

The GRRC will "immediately establish southeastern Michigan as a national, and international, center of activity in the rapidly developing area of unmanned ground vehicles (UGVs) and robotics," said Ulsoy. Given such rapid development, GRRC participants have identified five research thrust areas:

- UGV architecture for intelligence, vision and man-machine interface
- UGV energy, power and propulsion
- UGV dynamics and navigation, including ground and vehicle interface
- UGV reliability and manufacturing
- UGV integration and demonstration testbeds

The highly interdisciplinary research agenda calls for collaboration among participants in the areas of mechanical engineering, electrical engineering, computer science, aerospace and naval engineering. Several robotics projects are already funded and underway, and "the establishment of the GRRC is a way to create a real focus of research and commercialization activity," added Ulsoy.

The GRRC leadership is also in discussion with numerous private companies that design and manufacture autonomous vehicles, components and software. All have expressed strong interest in joining the center's activities; some of the firms now are considering opening offices in southeastern Michigan.

In conjunction with the launch of the GRRC, the College of Engineering will offer a new Master of Engineering degree program in Robotics and Autonomous Vehicles (RAV) in September 2008. Recruitment efforts to bring new faculty onboard are underway. Professor Huei Peng, who directs Interdisciplinary Professional Programs, serves as Education Thrust Leader.

The army has provided some $500,000 for the GRRC's initial research projects in 2007, which include: developing and evaluating techniques for spatial reasoning and mental imagery, learning and adaptation and tactics discovery; adjustable autonomy for safe, coordinated control; integrated power systems for improved mobility; safe operations via un-cooled far-infrared image sensors; a report on robotics reliability and manufacturing; and development of a personal dead reckoning system. Ongoing GRRC work for 2008 and beyond will require about $4 to $5 million annually.

In addition to Ulsoy's leadership as director, an industrial advisory board and representatives from the U.S. Army and academic partners guide research priorities and strategic planning efforts.

ME Faculty Receive Funding to Stimulate State's Economy

THREE MECHANICAL ENGINEERING faculty-led teams received nearly $4 million from the State of Michigan's 21st Century Jobs Fund, a state-level economic development program designed to diversify the state's economy and stimulate research, development and commercialization of competitive technologies. The program supports work in four areas: life sciences; alternative energy; advanced automotive, manufacturing and materials and national security and defense. Research and commercialization proposals were reviewed by a panel chosen by the American Association for the Advancement of Science.

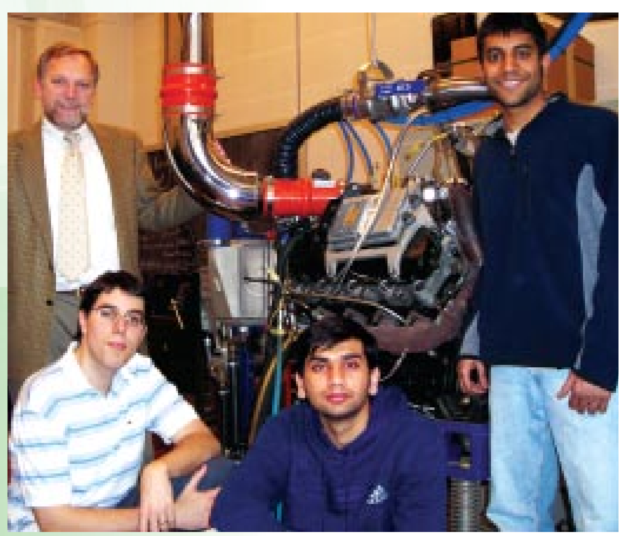
Cleaner diesel engines

A team led by Dennis Assanis, the Jon R. and Beverly S. Holt Professor of Engineering, is partnering with Eaton Corporation to develop a better understanding of the chemistry of nitrogen oxide traps and selective catalytic reduction for cleaner-burning diesel engines. Simulations done by Assanis' team at U-M will lead to improvements in these after-treatment technologies.

High efficiency hydraulic hybrid propulsion

Research Associate Professor Zoran Filipi is leading a research program on Integration and Demonstration of High-Efficiency Hydraulic Hybrid Technology for Trucks. The foundation for the $1.25 million award was laid by much basic research on hybrid propulsion for heavy vehicles, conducted in the U-M Automotive Research Center. Filipi's research group led efforts to develop simulation tools and methodologies for hybrid vehicle design and control. Early case studies indicated a strong potential for improved fuel economy using hydraulics for truck hybrid applications, due to their high power density and energy conversion efficiency.

The U-M group is partnering with Bosch Rexroth AG, which has developed a novel Digital Displacement™ hydraulic motor specifically for vehicle propulsion. In the system under development, a hydraulic unit provides transmission of torque, thus enabling full flexibility in controlling the engine operation. The opportunities for improving both efficiency and emissions will be maximized through integration of the



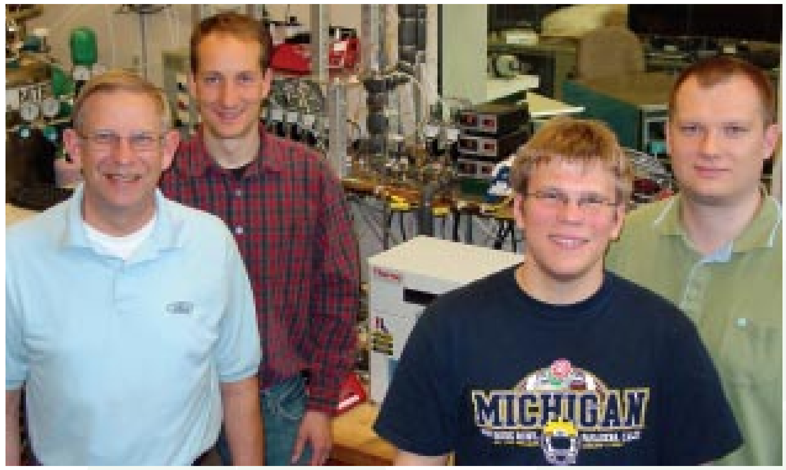
From left: Research Associate Professor Zoran Filipi with graduate students Fernando Tavares, Rajit Johri, and Ashwin Salvi in the U-M powertrain-in-the-loop facility.

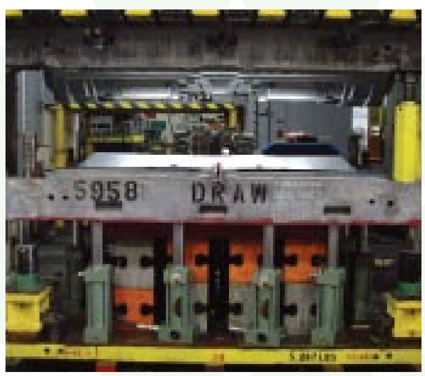
real engine and hydraulics with a virtual vehicle simulated on a computer in the U-M test facility. This will bring the advanced exhaust emission diagnostics into the vehicle design process. Simon Baseley, director of Bosch Rexroth Intelligent Hydraulic Drives, credits the 21st Century Fund for enabling a timely launch of the partnership and significantly accelerating R&D efforts. The team has already met many of its technical milestones, and Bosch Rexroth has created several new engineering jobs since the inception of the project.

Computer-aided metal stamping

A. Galip Ulsoy, the William Clay Ford Professor of Manufacturing, is heading a consortium to develop a computer-aided system for stamping sheet metals. Using sensors and control algorithms to individually operate hydraulic cylinders during each split-second stroke of a stamping press, the system reduces the tearing and wrinkling that can occur in conventional stamping processes. Current processes rely on press operators to visually inspect each stamped part and make subsequent adjustments to the press manually. The new system also allows for the stamping of hard-to-form materials, such as aluminum and magnesium alloys, which are attractive to car manufacturers because of their light weight.

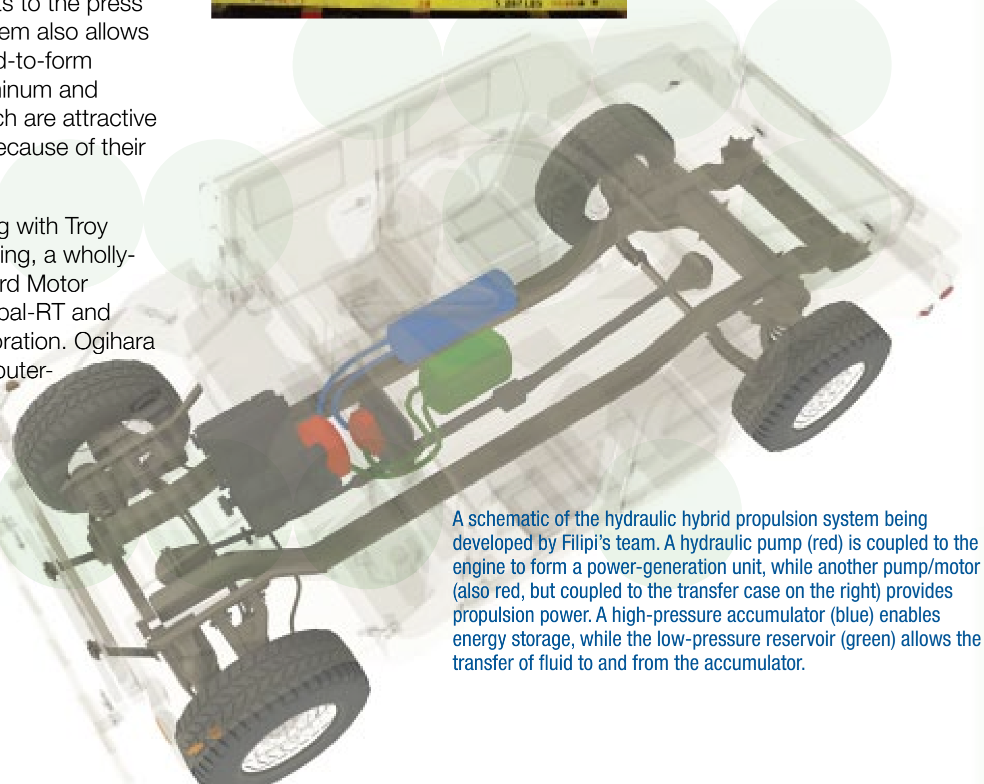
Ulsoy's group is working with Troy Design and Manufacturing, a wholly-owned subsidiary of Ford Motor Company, as well as Opal-RT and Ogihara America Corporation. Ogihara will be adding the computer-aided system to its production lines next year.





Above: Students and faculty involved in the development of the catalyst bench developed for the Eaton project (from left): John Hoard, Stani Bohac, Stefan Klinkert and Markus Schmitzberger.

Left: Force controlled hydraulic actuators used to control the blankholder forces in the stamping press at the Troy Design and Manufacturing facilities in Warren, Michigan.



A schematic of the hydraulic hybrid propulsion system being developed by Filipi's team. A hydraulic pump (red) is coupled to the engine to form a power-generation unit, while another pump/motor (also red, but coupled to the transfer case on the right) provides propulsion power. A high-pressure accumulator (blue) enables energy storage, while the low-pressure reservoir (green) allows the transfer of fluid to and from the accumulator.

Michigan Mechanical Engineers Around the World

INTERNATIONAL EXPERIENCE will become an integral component of engineering education, and the U-M College of Engineering has developed several new initiatives to help students study and work abroad. ME faculty have taken a lead in these efforts and are moving the college toward an important goal: to see at least half of its students graduate with international experience.

A group of CoE undergrads (several MEs included) who attended the International Engineering Summer School at TU Berlin in 2006.

ME Professor Volker Sick has long been active in international programs. He was recently appointed as chair of the college's International Programs Committee. In this role, he is responsible for promoting international programs to students and faculty, generating new study abroad partnerships and providing assistance to students seeking international internships. Sick spearheaded, and now serves as faculty advisor to, the newly established International Minor for Engineers, the College's first minor program. He also is an advisor to the Engineering Career Resources Center.

Europe

The International Engineering Summer School program, established by Sick and Professor Frank Behrendt of the Berlin University of Technology in 2006, recently expanded, thanks to a gift from IAV Automotive Engineering Inc., Ann Arbor. The program targets engineering undergraduates and offers students language training, cultural and engineering excursions and laboratory project work for which they earn U-M credit. The company's sponsorship will help lower costs to students and provide valuable follow-up internships for returning students.

Asia

ME Associate Professor Hong Im co-directs exchange programs with the Korea Advanced Institute of Science and Technology (KAIST). Geared toward graduate student and faculty exchange, Im and co-director Sangmin Choi, a KAIST professor, have led a series of successful workshops since 2001 with students and faculty from both universities to promote the exchange of ideas and talent and foster collaborative work.

ME Professor Jun Ni, who led the collaboration with Shanghai Jiao Tong University (SJTU), continues to expand U-M activities in China. Serving as the first dean of the U-M–SJTU Joint Institute, he dedicates a significant amount of his time to this project in Shanghai. The Joint Institute provides opportunities for U-M faculty to teach courses in Shanghai during the summer months. These classes are popular among College of Engineering students studying in China since they are taught in English and count toward their U-M degrees. The summer program at the institute continues to grow and flourish, combining internships at Chinese companies with language and cultural training.

Africa

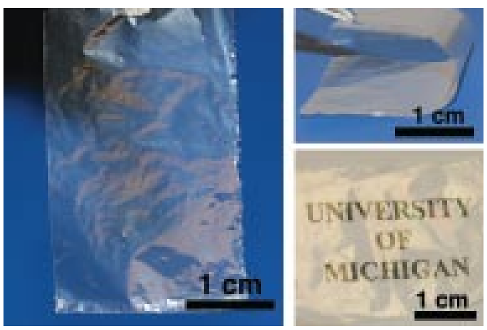
Professor Ni has also taken a leading role, along with Professor Elijah Kannatey-Asibu, in drafting a Memorandum of Understanding that is helping build a partnership with the University of Johannesburg in South Africa. Kannatey-Asibu also represented the college on a U-M delegation with President Mary Sue Coleman that visited Ghana and the Republic of South Africa.

ME Assistant Professor Kathleen Sienko was awarded a U-M grant to pursue a new summer program. Through the Global Intercultural Experience for Undergraduates, a group of U-M undergraduates will travel with Sienko to Ghana in summer 2008. The group will develop a maternal mortality prevention program focused on the generation of innovative technological interventions as well as educational outreach. Students will investigate best practices in the U.S. and other developing nations; they will observe clinicians; conceptualize medical, technological and infrastructural interventions; and develop and implement a basic outreach program for women of child-bearing age.

Professor Bill Schultz with the ME 235 class in Shanghai.

New Strong, Transparent Composite

WORKING WITH COLLABORATORS throughout the College of Engineering, Professor Ellen Arruda has helped develop a composite material that looks similar to ordinary plastic wrap but has nearly the strength and stiffness of steel. Mimicking the brick and mortar molecular structure of mother-of-pearl, or nacre, the research team fabricated the material from layers of clay nanosheets and a water-soluble polymer akin to white glue. The resulting paper, "Ultrastrong and Stiff Layered Polymer Nanocomposites," was published in the journal *Science*.

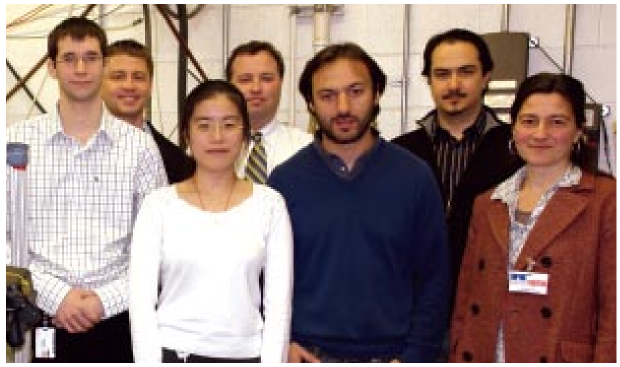


Free-standing, 300-bilayer PVA/MTM composite film showing high flexibility and transparency. The lower image was taken at an angle to show diffraction colors. Images courtesy of Associate Professor Nick Kotov, U-M Department of Chemical Engineering.

The work sheds light on a problem scientists working at the nanoscale struggle with: how to transfer the exceptional mechanical properties of these tiny materials to macroscale materials. To solve the problem, the team used a layer-by-layer (LBL) assembly process — and a machine it developed specifically for this purpose — that dipped a glass substrate into, alternately, a polymer solution and a solution of negatively charged clay nanoplatelets. The final product was comprised of 300 layers but no thicker than a sheet of plastic wrap.

Further development of the composite material could lead to lighter, stronger armor for police and soldiers as well as for their vehicles. It also has application in microelectromechanical, or MEMS, devices; microfluidics; biomedical sensors and valves and unmanned aircraft.

Arruda's laboratory assisted with the modeling and computer simulation of the composite's nanomechanical behavior. The interdisciplinary team is now working to design an even tougher version.



Professor Anna Stefanopoulou and her research team

Optimizing Flex-Fuel Vehicles

PROFESSOR ANNA STEFANOPOULOU AND HER RESEARCH TEAM have received funding from the U.S. Department of Energy (DOE) to develop an engine management system for flex fuel vehicles (FFVs). The system will be capable of running on any blend of ethanol from 0 to 85 percent with minimal or no penalty in usable vehicle range.

The Stefanopoulou group is collaborating with Robert Bosch LLC and Ricardo, Inc. The project was one of 11 selected by the DOE in a highly competitive review process and received a $1.8 million award from the DOE and $1.8 million in matched funds from Robert Bosch LLC and Ricardo.

Over the course of the three-year endeavor, the Stefanopoulou lab will develop the control intelligence for an optimized flex-fuel vehicle. Using models and sensor fusion techniques developed by her team, the methodology will estimate the ethanol content in the vehicle tank and optimize engine combustion accordingly by altering critical degrees of freedom in the engine control unit. The approach "relies heavily on software-based estimation and adaptation striving for minimal modifications to the gasoline-optimized engine hardware system," she said.

"Biofuels impose formidable challenges and offer exciting opportunities for internal combustion engine systems. This effort will contribute to the technological leap required in establishing a carbon-stable and sustainable automobile," Stefanopoulou added.

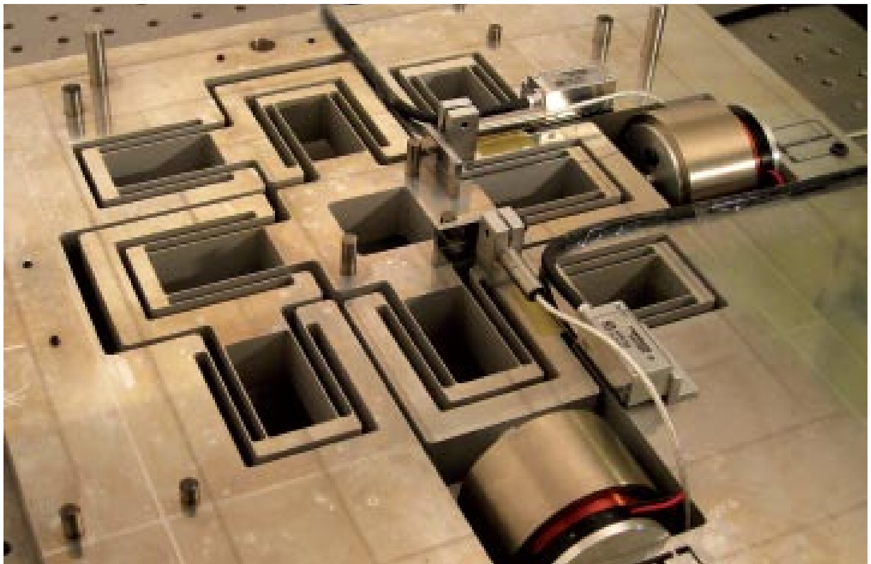
Meet Shorya Awtar

In addition to his research duties, Assistant Professor Shorya Awtar teaches mechanisms and mechatronics; a typical project is the two-wheel balancing scooter built by his Fall 2007 ME552 class, and showcased at the U-M Design Expo. Awtar also collaborates frequently with the Ann Arbor Hands-On Museum to develop new exhibits.

Assistant Professor Shorya Awtar joined the ME faculty in 2007. He designs high-performance motion systems for macro-, micro- and nano-scale applications. Research disciplines pursued in his group include precision engineering and mechatronics, with emphasis on kinematics, mechanics, dynamics and controls.

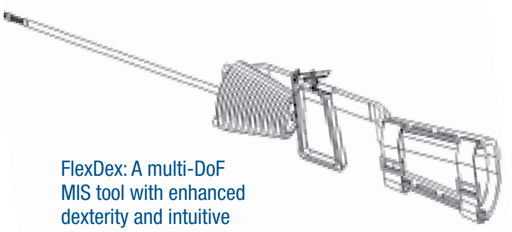
One of the main thrust areas in Awtar's research group is nanopositioning systems. To realize the potential of nanotechnology, engineers need machines that are macro-scale in size but that can provide nanometric precision and resolution. Scaling nine orders of magnitude — from one meter in size to one nanometer in precision — remains a major challenge in machine design and is being tackled by Awtar and his students. They are currently developing next-generation multi-axis nanopositioning systems that provide high precision, high speed and large motion range, for applications in scanning probe microscopy and nanolithography.

Awtar also works in the area of flexure mechanism design. Flexure mechanisms rely on elastic deformations for motion, which eliminates friction, backlash and the need for assembly and maintenance. This enables sub-nanometric precision at low cost, and makes these mechanisms indispensible in MEMS devices, high-precision positioning and alignment stages, harsh-environment applications and consumer products. Awtar is developing a new synthesis and analysis methodology based on 'elastic averaging,' which greatly enhances performance robustness despite local defects, a paradigm commonly found in nature. His group also studies the non-linear dynamics and controls of these flexible structures to achieve high-system bandwidth, along with noise and disturbance rejection.



Large-range high-precision high-bandwidth XY nanopositioner developed by Awtar.

In another project, Awtar's group is developing a family of novel and low-cost minimally invasive surgical (MIS) tools with enhanced dexterity, intuitive control and hand-tremor reduction. Existing MIS tools either have limited functionality or are prohibitively expensive. Awtar collaborates with colleagues in the surgery department at the U-M Medical School, and his team plans to license and commercialize this technology in the near future.



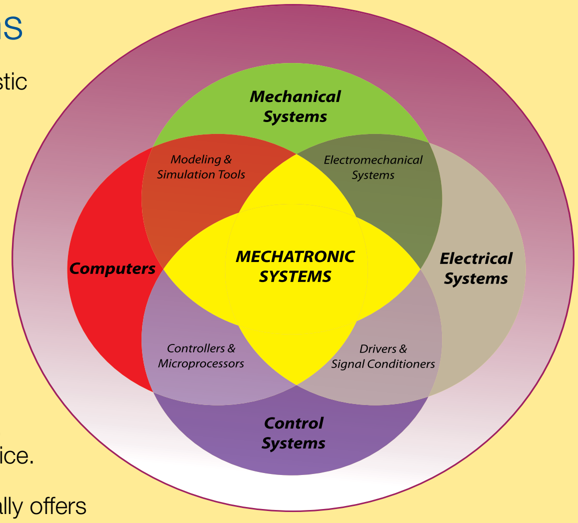
FlexDex: A multi-DoF MIS tool with enhanced dexterity and intuitive control.

Awtar is developing research collaborations with scientists at the National Institute of Standards and Technologies and the University of Illinois at Urbana-Champaign, as well as with colleagues in the electrical engineering, aerospace engineering and materials science departments at U-M.

Awtar teaches mechanisms and mechatronics at the undergraduate and graduate levels. He also teaches professional courses on "Flexure Mechanism Design" at annual conferences organized by the American Society of Mechanical Engineers and the American Society for Precision Engineering. He and his students actively work with the Ann Arbor Hands-On Museum to develop new engineering and technology exhibits.

After earning his doctorate at the Massachusetts Institute of Technology, Awtar worked with the General Electric Global Research Center in Niskayuna, New York, where he developed advanced sealing technologies for power-generation turbines and aircraft engines. He has generated more than two dozen inventions that are patented, pending approval or being prepared for filing.

Mechatronic System Designs



Mechatronics, the synergistic integration of mechanical disciplines, controls, electronics and computers, has become a critical component of design education in ME. Most high-tech systems and consumer products today are mechatronic in nature, and it is imperative that engineering students learn this multi-disciplinary, model-based design practice.

The ME department annually offers a graduate course in Mechatronic Systems Design (ME552). In fall 2007, Awtar taught the class and challenged student teams to build two-wheel balancing scooters from scratch — in eight weeks and with a $1,750 budget — for their class project. By the end of the term, all teams successfully built their own full-size, fully functional balancing scooters, which were showcased at the U-M Design Expo.

ME552 course learning objectives include hardware skills related to machine elements and assembly, sensors, actuators, drivers, signal conditioning, circuits and microprocessors, coupled with the underlying engineering fundamentals of design, multi-domain modeling, controls theory and electronics. Throughout the course, emphasis is placed on system integration — bringing together knowledge from various fields and using it in a systematic fashion to design, build and test a complex engineering system. The course follows a studio-style instructional format with emphasis on periodic design reviews, teamwork and self- and peer-learning.

Awtar is also working with his colleagues to add mechatronics components to the undergraduate design and manufacturing course sequence — ME250, ME350 and ME450.

Meet Nikos Chronis

Nikos Chronis came to U-M in 2006 after earning his doctorate. Attracted to Michigan because of the fit with his own interdisciplinary style, his research focuses on applying mechanical engineering concepts to the design, analysis and micro- and nanomanufacturing of devices to address biological problems.

A fundamental problem in neuroscience is the lack of understanding of how neural circuits operate. Assistant Professor Nikos Chronis envisions the development of novel micro- and nanoscale devices that can probe neural circuits *in vivo.*

Designing the probes and optimizing how they interact with biological samples are critical issues that Chronis' highly interdisciplinary bio-MEMS research program addresses. Such technology has the potential to revolutionize the field of neuroscience and lead to the detailed understanding of neuronal disorders and processes such as neuronal aging and regeneration.

Chronis' research applies mechanical engineering concepts to the design, analysis and micro- and nanomanufacturing of devices to address biological problems. The clinical applications are many, including lab-on-chip devices for point-of-care diagnostics, such as the MEMS biochip for HIV diagnosis and monitoring in developing countries that his research group is pursuing.

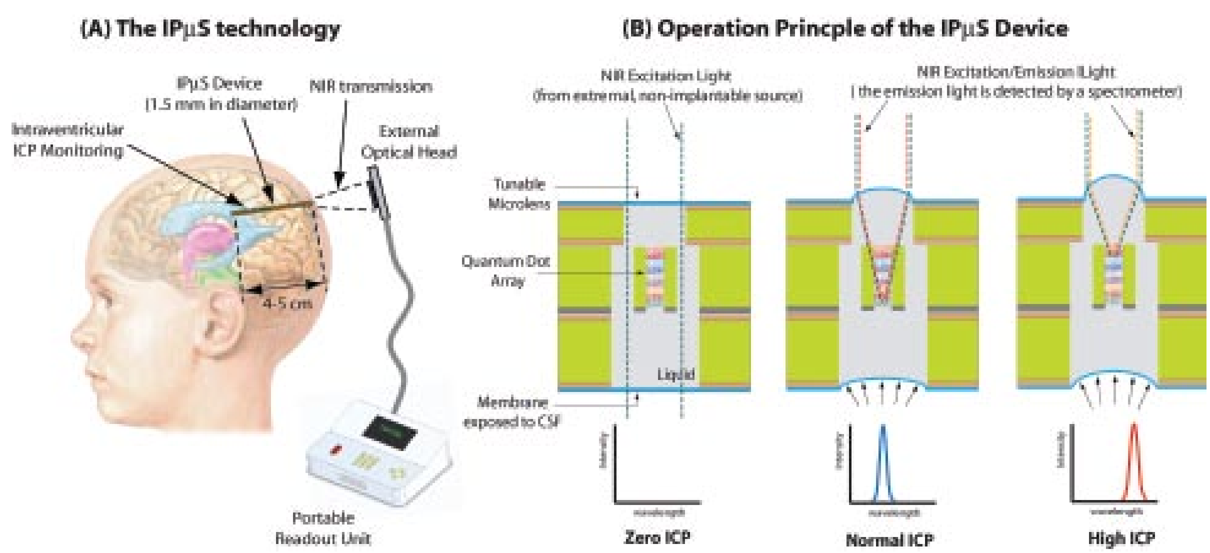
Given the interdisciplinary nature of Chronis' work, he was drawn to U-M by its highly rated departments of mechanical engineering, bioengineering, biology, and its medical school as well as its excellent micro- and nanofabrication facilities. He joined the faculty in fall 2006, after earning a doctoral degree from the University of California, Berkeley. He conducted postdoctoral research, supported by the Howard Hughes Medical Institute, at Rockefeller University. His undergraduate work was completed at Aristotle University in Thessaloniki, Greece.

Chronis was the first to demonstrate the manipulation of single cells in solution using novel polymer micromachined actuators he designed and fabricated. The 'amphibious' microgrippers can operate in both air and physiological media, such as cell cultures and blood. He has also developed a total internal reflection (TIR)-based biochip for a micro-optical system with single-fluorescent-molecule detection capabilities. His biochip design utilizes silicon micromirrors and polymer-filled cavities integrated on top of microfluidics. The design allows for the construction of an inexpensive, portable excitation-detection system. Hundreds of TIR detection sites can be incorporated to achieve ultra-sensitive, high-throughout screening in a variety of applications.

To understand how information is processed in complex neural circuitry at the sensory, interneuron and motor neuron levels, Chronis fabricated a novel microfluidic ‘worm trap and fluidic delivery’ chip. The chip enables the recording of activity from interneurons if the worm *C.elegans*. The findings have provided detailed information about the role of specific neurons in the olfactory circuit. Further research includes developing a high-throughput laser nano-surgery platform for axon regeneration and degeneration studies in *C.elegans in vivo*. His laboratory is devising imaging techniques to study how neural circuits generate locomotory patterns in *C.elegans*. Resulting images will be essential to one day restoring mobility in humans after spinal cord and brain injuries.

For patients with severe traumatic brain injury, the Chronis group is inventing a new class of implantable intracranial pressure (ICP) monitoring devices. Monitoring ICP is an important diagnostic tool for assessing the condition of individuals who have experienced traumatic brain injuries. The monitoring device consists of a 1.5 mm implantable, MEMS chip that converts changes in pressure into changes in light wavelength as well as a tunable, liquid-filled microlens with a quantum dot array.

Chronis’ students are exposed to principles and techniques that span the disciplines of molecular biology, genetic engineering, micro- and nanofabrication, design and optimization, microfluidics and micro-optics. He is planning to design a bio-MEMS course at the graduate level to introduce students to the applications of micro- and nanotechnology to biology and medicine; for undergraduates, he is planning a course on the fundamentals of MEMS.



Intracranial Pressure MicroStick technology for monitoring intracranial pressure. It consists of an implantable, MEMS-based device that converts ICP changes to wavelength changes. It integrates a tunable, liquid-filled microlens with a quantum dot array.

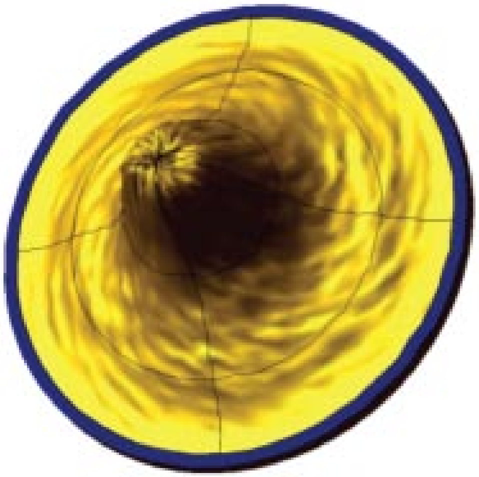
Meet Samantha Daly

Samantha Daly's team is using a combination of small-scale and macroscopic techniques to probe the interactions between length scales. By helping us understand the nature of materials, Daly's research will result in improved production of biomedical devices and MEMs devices.

Assistant Professor Samantha Daly joined the U-M faculty in January 2008. Her research activities focus on the application of multi-scale experimental mechanics to materials science in order to characterize, design and develop new materials.

Daly is particularly interested in the behavior of and interaction between material features on different length scales, which play a large role in important processes like fatigue and failure. Understanding the complex relationship between the nano- and micro-scale behavior of a material and its macroscopic properties is a critical aspect of the development of new materials and the accurate prediction of their behavior in practical applications.

The Daly research group uses a number of methods to investigate the characteristics of materials from the nano- to continuum length scale. One example of a small-scale technique is pole plots, which are diffraction maps that define the texture, that is, the orientation distribution of crystalline grains, in a polycrystalline metal (see top image on page 15). Each plot shows the intensity of a specific crystallographic orientation plotted

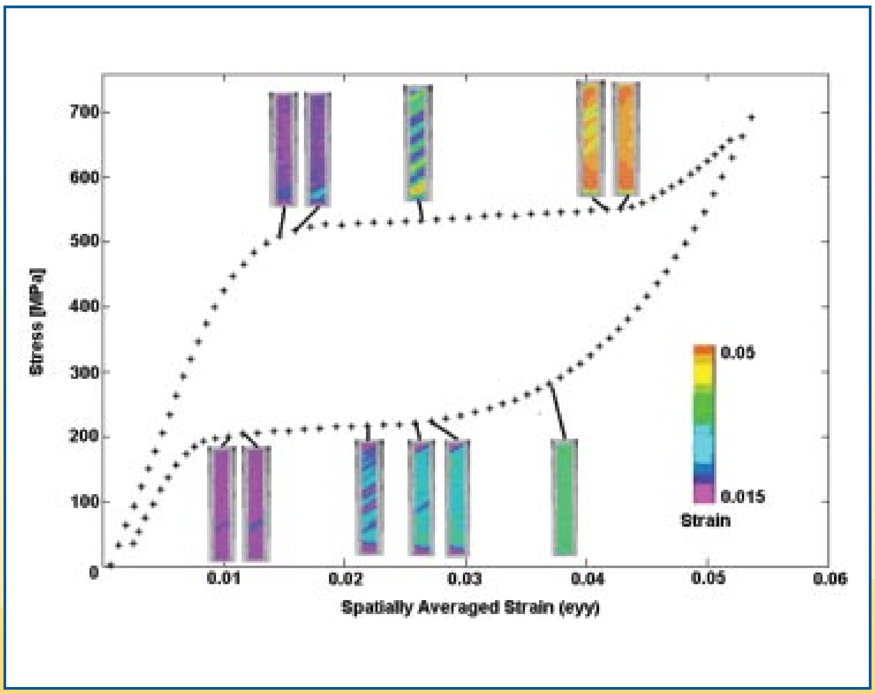


One technique used to look at texture is the orientation distribution of crystalline grains in a polycrystalline metal. The pole plot shows the intensity of a specific crystallographic orientation (the “height” of the graph), plotted in polar coordinates against the amount you have tilted (r) and rotated (Œ∏) the sample.

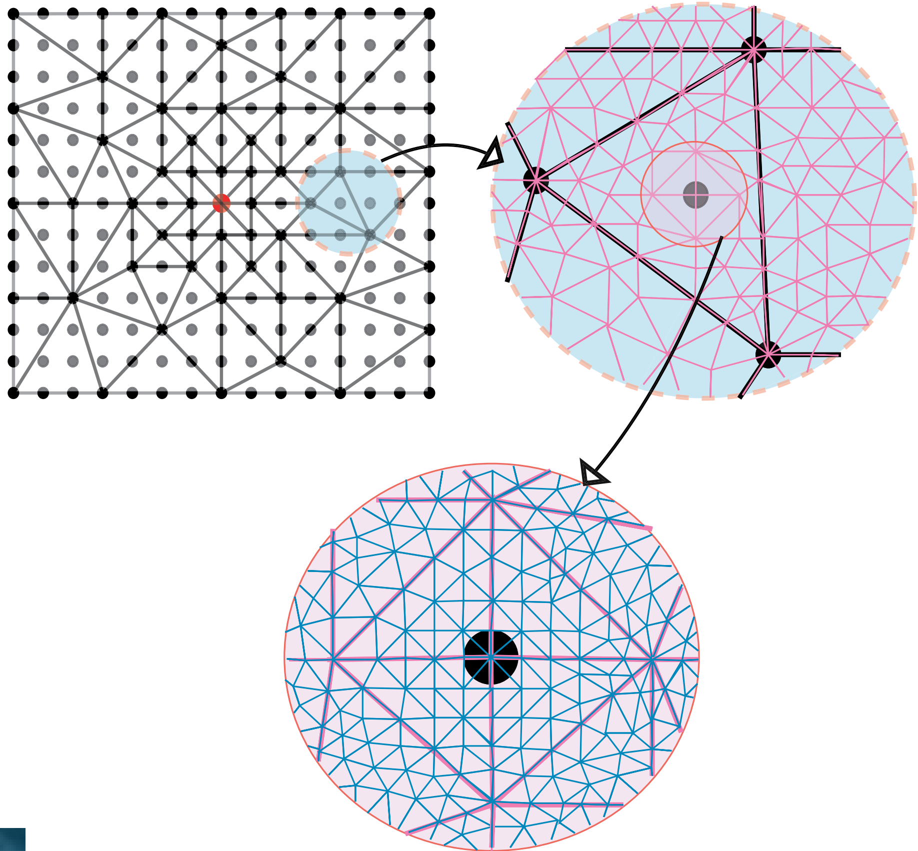
against the amount the sample is tilted (r) and rotated in-plane (Ø). The Daly group uses these and other diffraction techniques to determine the crystal structure of a material in the context of its macroscopic properties. Other techniques employed by the group to visualize small-scale material structure include scanning electron microscopy (SEM), which images a sample surface using a high-energy beam of electrons. The background image on page 14 shows an example of an SEM micrograph, recently taken by the Daly group as part of a research project examining fracture surfaces of metals under various loading conditions. The Daly group is working to combine these types of small-scale techniques in novel ways with macroscopic techniques in order to probe the fundamental interactions between length scales.

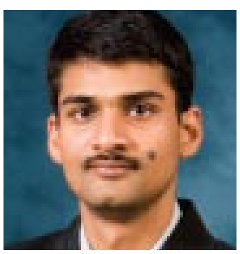
To visualize full-field continuum deformation, the Daly group uses a variety of methods, including Digital Image Correlation (DIC). DIC is a non-intrusive *in situ* technique that measures displacement on a surface by tracking a random pattern on that surface. By tracking this pattern, researchers can visualize a full-field map of the deformation. An example of this technique is the banded localization of deformation that occurs in thin strips of the binary alloy nickel-titanium (Nitinol) under tension. This alloy’s unique pseudoelastic and shape memory properties make it well-suited to applications ranging from biomedical devices — stents, vena-cava filters, septal defect occlusion devices, for example — to MEMs devices. Daly studied the kinematics of the phase transformation from a cubic to monoclinic crystal structure that makes these properties possible, and the heterogeneous nature of the deformation and failure of shape memory alloys. She and colleagues were the first to report the quantitative visualization of strain fields within these localized bands, contributing several new insights concerning the nature of deformation and phase transformation in Nitinol. Daly combines the experimental findings from these and other novel multi-scale techniques with finite element analysis and theory to develop a comprehensive, full-scale understanding of the mechanics of various materials.

Daly earned her doctoral degree in mechanical engineering from the California Institute of Technology, where her thesis work focused on the heterogeneous nature of the deformation and failure of shape memory alloys. While at Caltech, she assisted in teaching a range of courses, including solid mechanics, heat transfer, thermodynamics and fluid mechanics. For her doctoral research and as recognition for her speaking and teaching ability, she earned the 2007 Everhart Award and the Charles D. Babcock Award. She received her bachelor of arts and bachelor of engineering degrees in mechanical engineering from Dartmouth College.



One can look at a center crack propagating through a metal by using an infrared camera to image the heat (energy) this process releases.





Meet Vikram Gavini

Vikram Gavini's research couldn't be more timely: His group is investigating the "embrittlement" of metals subjected to radiation, which could help build safer and stronger nuclear reactors. In addition to his research and teaching duties, the Caltech graduate is working on developing a core curriculum for ME students interested in nanoscience.

Assistant Professor Vikram Gavini, who joined the U-M faculty in fall 2007, is building a research program with a broad goal: to develop computational techniques informed by quantum mechanics to predict materials behavior. The predictive science of materials behavior enables development of new materials with specific functional properties, for example, lightweight materials with improved strength and fracture toughness.

In order for a theory to be predictive, it must include fundamental physics with as little empiricism as possible. Currently available electronic structure theories describe materials properties from a quantum-mechanical perspective, but their complexity makes computations restrictive and often applicable only to small systems with a few hundred atoms. Since most materials properties are strongly influenced by defects, vacancies, dopants, dislocations and cracks, an accurate understanding of such defects must include both the electronic structure of the defect core as well as the elastic and electrostatic effects on the macro-scale. One of the key challenges in materials science is to bridge length scales from quantum mechanics to mechanics in a seamless way.

Gavini's research group is developing mathematical and computational techniques to perform electronic structure calculations at macroscopic scales, thereby bridging the quantum mechanical and mechanics descriptions of materials behavior and yielding fundamental, predictive and transferable theories. The group's work combines real-space formulation of electronic

Schematic of the hierarchy of triangulations which forms the basis of a new method (called QC-OFDFT) for conducting electronic structure calculations at continuum scales. This method probes the quantum mechanical nature of defects where necessary, while seamlessly capturing long-ranged continuum fields.

structure theories, finite-element discretization of the field equations and coarse-graining using adaptive numerical techniques. This unique combination enables multi-million atom electronic structure calculations and makes an accurate quantum-mechanical description of defects possible for the first time.

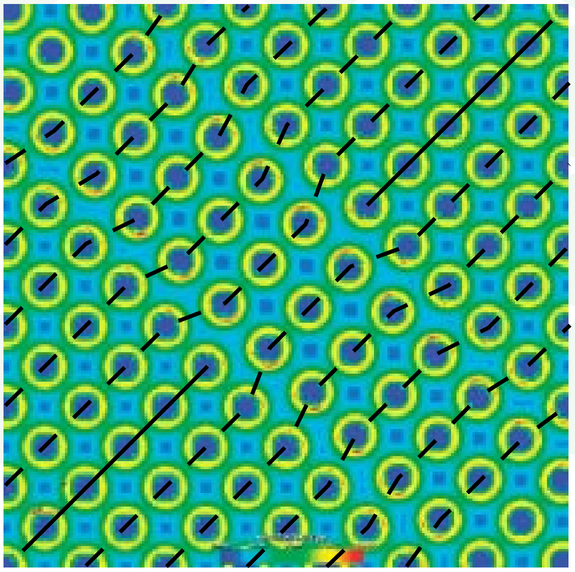
Currently the group is working to further refine these techniques and study various phenomena that arise from defect interactions. The team is investigating the effect of radiation on metals; the embrittlement that results in metals subjected to radiation is significant in many practical applications, including in nuclear reactors. Gavini's group is using electronic structure theories to probe the nucleation mechanism of prismatic dislocation loops, which are widely believed to be responsible for the loss of fracture toughness in irradiated metals.

Recent results from Gavini's laboratory show that vacancy clustering is a possible mechanism for the formation of prismatic loops, and loops as small as those formed from seven vacancies are stable, shedding light on the nucleation size of these defects, which was heretofore unknown. The group is now working toward quantifying the influence of prismatic loops on the fracture toughness in materials.

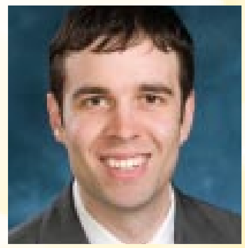
Experimental results show that the yield strength of a surface dominated structure increases by a factor of 50 to 100 in structures that are a few nanometers thick. Gavini's group also works to better understand the phenomenon of interaction between surfaces and dislocations using electronic structure theories. In the future, the work will focus on describing the macroscopic response of the nanostructure that result from these interactions.

Gavini has developed a new and rigorous graduate course in materials physics, which introduces engineering students to the fundamentals of quantum mechanics and how to systematically derive the condensed matter theories that form the basis of the discipline. The highly interdisciplinary course bridges ideas from physics, materials science, mechanics and applied mathematics and provides a foundation for students working in materials at small scales. He is also working with Assistant Professor Pramod Sangi Reddy on a core curriculum for ME students interested in nanoscience.

Gavini earned a bachelor's degree in mechanical engineering from the Indian Institute of Technology Madras in 2003. He earned a master's degree in applied mechanics and a doctoral degree in mechanical engineering from the California Institute of Technology. His thesis work on "Electronic Structure Calculations at Macroscopic Scales" brought together fundamental concepts at the intersection of mechanics, applied mathematics and materials physics. In 2007 he received the Robert J. Melosh Medal for best student paper in the field of computational mechanics, awarded by Duke University, ETH Zurich and the International Association for Computational Mechanics. Other recognitions include the Silver Medal from the Indian Institute of Technology Madras and the Allan Acosta Endowed Fellowship from the California Institute of Technology in 2003.

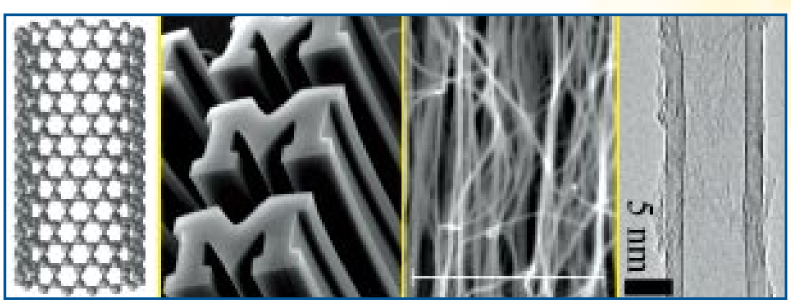


Electron-density contours around a prismatic loop formed from the collapse of a hepta-vacancy hexagonal cluster.



Meet John Hart

MIT alum John Hart teaches courses in design and manufacturing. His research involves carbon nanotube structures that are found, among other places, on the edges of samurai swords. Hart's ME background has stood him in good stead, preparing him for the interdisciplinarity of nanotech research.



From left: a schematic of a single-wall carbon nanotube (CNT); "M"icrostructured forests of vertically aligned CNTs; scanning electron micrograph showing alignment of CNTs within a forest; and transmission electron micrograph of an individual multi-wall CNT.

After completing graduate studies at MIT, John Hart returned to his alma mater in 2007 to join the ME department. His teaching focus is on design and manufacturing, including a new course he's created on manufacturing of nanoscale and nanostructured materials.

Hart's research deals with the manufacturing and applications of nanostructured materials. Specifically, his group creates ways to make and assemble nanostructures in massive quantities, so that large-scale materials can have the extraordinary properties that nanostructures exhibit at tiny scales. Likewise, these materials can make small-scale devices achieve new capabilities in sensing, energy storage, communication and computation.

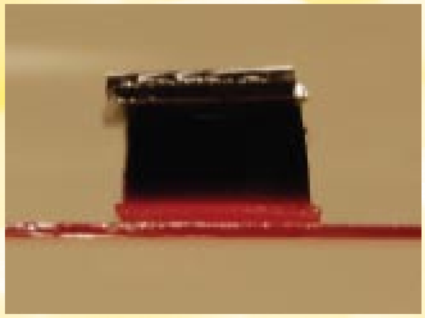
During the past five years, Hart has worked with carbon nanotubes (CNTs). These hollow cylinders of carbon atoms have five times the stiffness and at least twenty times the strength of steel, at only one-fourth the density. CNTs conduct heat ten times more effectively than copper, and, based on slight differences in their atomic structure, can take the form of metallic wires or semiconductors that transport electrons far more quickly than silicon. Like many elements of nanotechnology, CNTs are not new — they were used (unknowingly) as lamp filaments by British scientists in the 1880s and are found in the sharp steel edges of samurai swords. However, investigators are just now learning how to control the properties of these tiny building blocks, and how to engineer them to realize a new age of materials.

Starting with Hart's doctoral studies at MIT, and now with his research group at U-M, he has created highly ordered CNT structures called "forests" (http://www.mechanosynthesis.com). These grow from catalyst "seeds" on a silicon wafer, which is placed in a high-temperature furnace containing a carbon gas. The CNTs, which are only nanometers in diameter and number in the billions per square centimeter, arrange like a standing wheat field and grow at a speed equivalent to a one-foot diameter tree thrusting upward at over five hundred miles per hour.

By printing the catalyst and creating machines and methods for controlling the chemical reaction, his group has discovered how to rapidly and efficiently grow highly pure CNTs, with precise control over their alignment, diameter and length. While others have grown CNT powders, which resemble tangled spaghetti, they contain high levels of impurities, have wide variations in diameter, are difficult to mix with other materials and do not efficiently transport load, heat and electricity to one another. By aligning and densely packing the CNTs during growth, Hart's team creates solid materials with the mechanical strength and stiffness as well as thermal and electrical conductivity approaching that of individual CNTs. He can grow "monoliths" of CNTs to several millimeters in height using a small desktop reactor, mechanically mold CNT structures into three-dimensional shapes and infiltrate the CNTs with polymers and ceramics to produce new composite materials.

Atmospheric pressure tube furnace for nanotube and nanowire growth.

Along the way, Hart has captured the balance between order and disorder in self-assembly of CNTs in breathtaking images from electron microscopes. His images, which can be seen at http://www.nanobliss.com, have been published widely and serve to



4mm high CNT forest, photographed during growth on a resistively heated platform.

educate broader audiences about nanotechnologies and new materials.

Now Hart and his group are building a machine, which continuously produces CNT forests in large areas, and they are discovering how to grow CNTs to indefinite lengths to make super-strong cables. His forests improve the interlaminar toughness of carbon fiber composites by 300%, and this could significantly reduce the weight and fuel consumption of next-generation commercial aircraft. The ability to precisely control the diameter of CNTs shows promise in the making of new desalination membranes, which could significantly reduce the cost of clean water. Further, the team is making small ribbons of ultra-dense CNTs as next-generation microelectronic interconnects; existing materials are limiting the speed of microprocessors today.

This year, Hart's lab has received grants from the National Science Foundation and Defense Advanced Research Projects Agency, and is also supported by several industrial partners. He collaborates with colleagues in several other departments at U-M as well as with groups at MIT, the Technical University of Eindhoven, Oklahoma State University and the University of Cambridge. Lab members also regularly travel to the Cornell High Energy Synchrotron Source to perform x-ray scattering experiments on CNT materials.

Hart teaches courses in design and manufacturing. This year he taught Design and Manufacturing I (ME 250), the sophomore-level introductory design and manufacturing course, and he has created a new graduate course on manufacturing of nanoscale and nanostructured materials. In this course he addresses the properties of and interactions among nanostructures such as nanotubes, nanowires and nanoparticles and how to manipulate and order nanostructures using chemical, mechanical and electrical means.

Hart's research involves chemistry, materials science and physics, and he feels right at home in such an interdisciplinary research area thanks to his background in mechanical engineering. Mechanical engineering training has given him a strong knowledge of fundamental subjects, convolved with an eye for creative, elegant, cross-cutting solutions that identify and address key scientific questions — and, ultimately, commercial applications — that have the power to make life better for people worldwide.

Numerous honors and awards have been bestowed upon Hart, including the 2008 Young Faculty Award by the Defense Advanced Research Projects Agency and the 2006 MIT Senturia Prize for Best Doctoral Thesis in Micro/Nano-technology. He also received a Fannie and John Hertz Foundation Graduate Fellowship from 2002 to 2006, a National Science Foundation Graduate Research Fellowship from 2000 to 2002, the MIT Martin Fellowship for Graduate Study and the U-M Mechanical Engineering Distinguished Undergraduate Achievement Award in 2000.

Meet Kenn Oldham

Kenn Oldham divides his time between research and teaching. As an undergrad at Carnegie Mellon, he worked on a project testing impact damage on turbine blades, and began to realize the importance of interdisciplinary work. An NSF grant later enabled him to participate in a middle- and high-school outreach program in California building electric cars and hot air balloons.

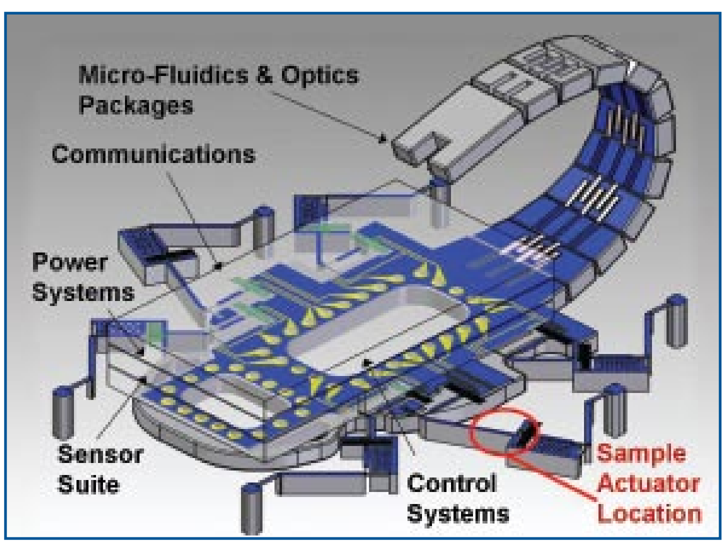
Assistant Professor Kenn Oldham studies applications of control systems at the microscale and heads the microsystems thrust area of the Vibration and Acoustics Laboratory.

Oldham, who joined the ME faculty in fall 2007, is leading efforts to design fast, maneuverable, microscale robotic systems that move like insects, a project he began during post-doctoral work at the U.S. Army Research Laboratory. The endeavor draws researchers from a wide range of engineering disciplines, from materials development in micro-manufacturing to computation methods that provide autonomy to individual and multiple micro-robots.

Oldham's contributions span MEMS mechanism design and ultra-low power control systems. In the lab Oldham and his students are devising fabrication methods for incorporating thin-film piezoelectric materials into silicon or polymer robotic legs, control strategies for low-power operation and design optimization strategies for insect-like robotic gaits. He recently fabricated and tested thin-film lead-zirconium titanate (PZT) microactuators with extended lateral stroke and exceptional force-displacement results. Now he is working to integrate high-aspect-ratio microstructures with the actuators, which will lead to prototype walking micro-robots.

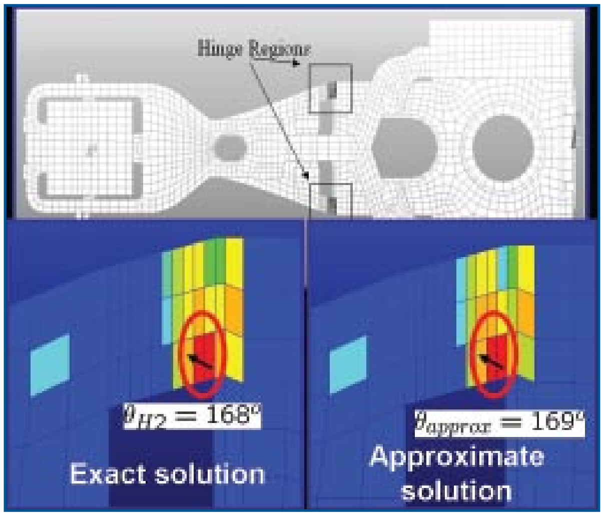
Oldham is concurrently addressing the power constraints on these micro-robots, which are limited by the amount of power generated by onboard batteries. He is exploring how to limit power consumption of servo systems to meet these exacting constraints and maximize overall efficiency. By aggressively regulating usage of sensors and actuators, and incorporating power electronics design into the servo system, he and his students expect to dramatically reduce power losses in highly mobile robotic systems. For instance, on-off control, the simple algorithm used by many thermostats, is not typically used in robotic systems, but — if properly designed — can be an effective tool in the energy-starved environment of a micro-robot.

Once the challenges of power generation and utilization are overcome, and the design optimized, the micro-robotic system should have wide application in other engineering systems, providing a variety of technical and educational opportunities.
In addition to graduate student participation in the micro-robotics work, undergraduates have the chance to contribute through the Michigan Undergraduate Research Opportunities Program, for which Oldham serves as a faculty mentor, while seniors participate through the mechanical engineering independent study course, ME490.



Conceptual view of a bio-inspired, insect-like micro-robot based on thin-film piezoelectric actuation

Conservation and sustainability are becoming an increasingly important consideration for Oldham, and he expects that although the strategies and devices under development are employed at the microscale, many will be adaptable to larger systems to conserve power and other resources. In 2000 he served as a volunteer with the GRATIS Foundation, a Ghanaian nonprofit that develops capital equipment for small businesses. There he experimented with an automatic control system for highly energy-efficient small industrial food dryer. He hopes to be able to apply his work on control systems at U-M to reduce resource consumption. He is a member of Engineers Without Borders and Engineers for a Sustainable World.



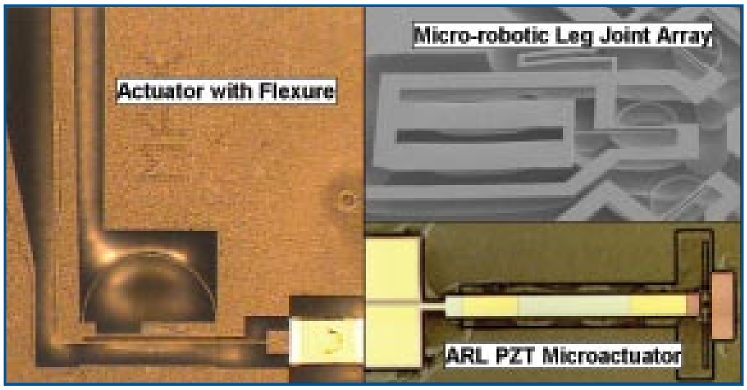
Optimal locations for micro-scale strain sensors in a computer hard disk drive servo arm.

While earning his doctorate at the University of California, Berkeley, Oldham developed methods for building and installing MEMS devices into computer hard disk drives to increase disk drive data density. He and his colleagues successfully built and flew a dual-stage disk drive servo arm, the first successful in-drive operation of such a servo system by an academic team. (For proper operation, the read-write head of a disk drive must be supported above the disk by a fast-moving cushion of air, 'flying' over the disk surface to maintain proper distance between the head and magnetic data bits.)

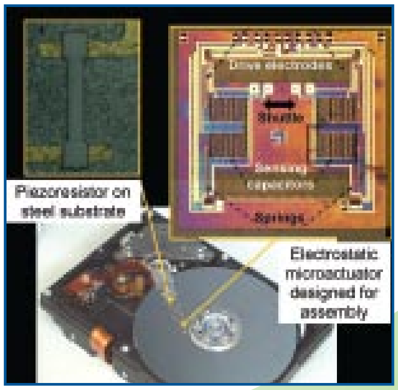
This work was Oldham's first opportunity to couple design and fabrication methods at the microscale with modern control system design, and he successfully developed such methods for making microscale sensors. In conjunction he developed efficient optimization methods for vibration sensor placement on disk drive suspensions for purposes of closed-loop control, and demonstrated micro-machined vibration sensor installation on steel disk drive components. This enables a host of innovative, new disk drive servo control strategies.

Oldham's appetite for research was whetted while earning his bachelor's degree at Carnegie Mellon University, where he worked on a project testing impact damage on turbine blades and later on controls engineering problems. He began learning more about MEMS and saw how the field required working across disciplines, which fit with his own style of research. The yen to teach evolved from a National Science Foundation middle and high school outreach program he participated in while at the University of California. Oldham and an eighth-grade science teacher had students build electric cars, spring-launching catapults and hot air balloons. Since arriving at U-M he has taught courses on dynamic systems and digital control.

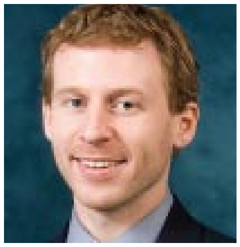
Oldham has earned numerous awards, including the U.S. Army Research Office STEP Grant in 2007, the 2008 Defense Advanced Research Projects Agency Young Faculty Award, the Berkeley ADEPT Fellowship in 2005 and an NSF Graduate Fellowship.



Individual piezoelectric actuator, actuator with MEMS flexure, and full joint assembly for a MEMS micro-robot.



An electrostatic microactuator and silicon strain gages for use in vibration suppression in computer hard disk drive.

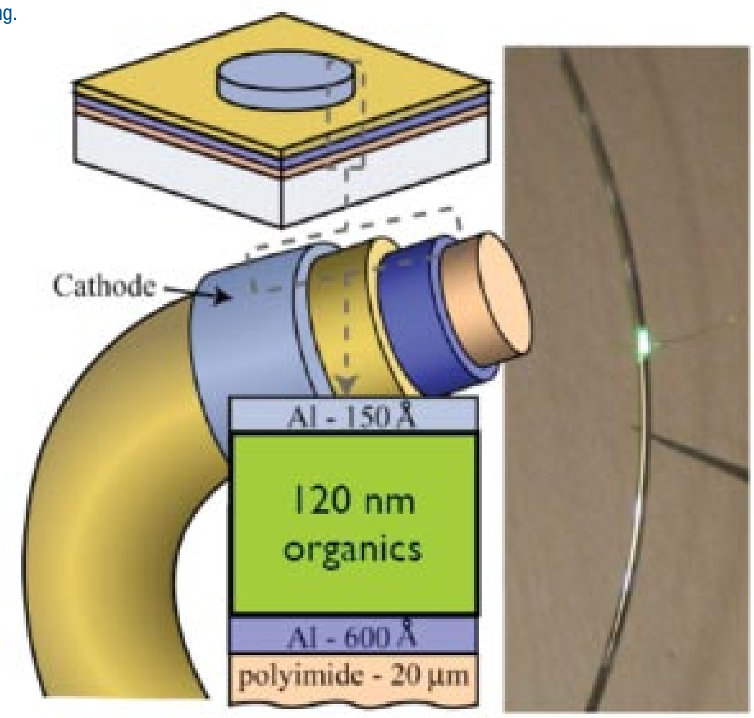


Assistant Professor Kevin Pipe joined the ME department in 2004, after completing doctoral studies at MIT. He has joint appointments in EECS and Applied Physics, and focuses his research efforts on energy transport in nanostructured systems.

Meet Kevin Pipe

Assistant Professor Kevin Pipe works in the area of energy transport in nanostructured systems, including heat transfer in electronic devices such as high-power lasers, energy conversion in nanostructured photovoltaic cells and thermoelectric materials, and energy transfer over nanoscale distances to and from active scanning probes. The common thread is engineering materials and devices at the nanoscale in order to make them more efficient.

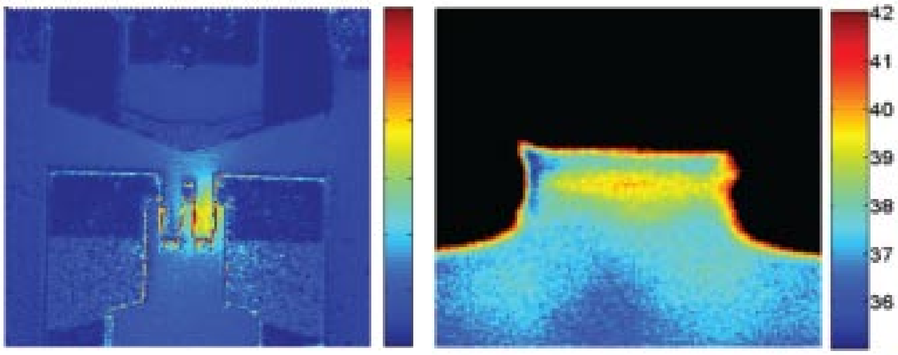
An organic LED deposited on a fiber, with applications in solid state lighting.



Pipe joined the ME department in 2004, after completing both undergraduate and doctoral studies in electrical engineering at the Massachusetts Institute of Technology. As an undergraduate he conducted research on wearable computers at the MIT Media Laboratory; as a graduate student, he worked on x-ray lithography and thermoelectric effects in semiconductor lasers in the MIT Research Laboratory of Electronics. This work led him to explore microscale heat transfer, an emerging area in the field of mechanical engineering.

Since arriving at Michigan Pipe has undertaken several important research projects and multidisciplinary collaborations in addition to teaching Thermodynamics I (ME 235), Heat Transfer (ME 335), Laboratory II (ME 495) and Statistical Thermodynamics (ME 631). His work centers on three focus areas: micro and nanoscale thermal physics; energy conversion materials and devices, and new scanning probe microscopy techniques.

In the area of heat transfer Pipe is the principal investigator of a recent $6.8 million Multidisciplinary University Research Initiative grant from the Air Force Office of Scientific Research (AFOSR) to study the fundamental mechanisms of heat transfer at interfaces between dissimilar materials. With collaborators at U-M, Brown University and the University



High-resolution thermal measurements of (a) Current collapse at high bias in a two-finger SiGe-based heterojunction bipolar transistor and (b) Active region heating at the facet of a high-power InGaAsP/InP laser.

of California, Santa Cruz, this work explores the engineering of interface nanostructure and chemistry to control thermal transport. Applications include thermoelectric energy conversion, thermal barrier coatings and electronics packaging.

In separate heat transfer projects Pipe has worked with ME Professor Albert Shih to develop next-generation nanofluid-based coolants for fuel cell vehicles through a General Motors Discovery grant. The two are also working on carbon foam heat sinks for automotive power electronics, with support from a U.S. Department of Energy grant from Oak Ridge National Laboratory.

Pipe has several ongoing projects specifically related to microscale heat transfer in electronic and optoelectronic devices. He is the principal investigator of a project sponsored by the Defense Advanced Research Projects Agency in collaboration with Professor Pallab Bhattacharya of the U-M Electrical Engineering and Computer Science department and Professor Jack Ma of the University of Wisconsin. The team is working to fabricate reliable room-temperature quantum dot lasers on silicon in a CMOS-compatible process, with applications in optical interconnects. In separate projects with the nLight Corporation and MIT Lincoln Laboratory, Pipe explores heat transfer and thermal management in high-power semiconductor lasers, with applications in telecommunications and military systems.

In the area of energy conversion, Pipe investigates nanostructured thermoelectric materials with high thermal-to-electrical conversion efficiency. Through a National Science Foundation (NSF) project, he has worked with Professor Rachel Goldman of the U-M Materials Science and Engineering (MSE) department to study the thermoelectric performance of quantum dot superlattice materials. Through a U.S. Army Research Office project, he is working with EPIR Technologies, Inc., to fabricate microscale HgCdTe-based superlattice thermoelectric coolers that have applications in infrared detectors.

Pipe co-founded the Laboratory for Nanostructured Energy Conversion Devices with MSE Assistant Professor Max Shtein. Together they are developing fiber-shaped thermoelectric and photovoltaic devices that can be woven into energy-harvesting carbon fiber composites for aerospace applications, allowing the conversion of thermal and solar energy to power on board aircraft devices. They are also developing equipment designed for the high-volume production of fiber-based energy harvesting devices. Other collaborators include Professor Tony Waas of aerospace engineering at U-M and Assistant Professor Peter Peumans of Stanford University. The work is funded by AFOSR.

Pipe and Shtein are developing a new scheme for intrachip communications for integrated circuits. The basis of the scheme is plasmonic waveguides, which offer small size and high bit rate. The signals in these waveguides degrade quickly, however. In order to create signal gain, Pipe and Shtein are using novel structures based on organic semiconductor heterostructures. This work is funded by the NSF.

Pipe and Stein also are exploring new scanning probe techniques to measure energy transport mechanisms with nanoscale resolution. This includes the monolithic integration of nanoscale organic LEDs and photodetectors with atomic force microscopy cantilevers, creating new sensing and imaging technologies with high spatial resolution. The team is pursuing applications of these new forms of near-field microscopy in biological research, where they have several practical advantages over conventional microscopy techniques, such as the ability to reliably perform simultaneous topographical and fluorescence microscopy of cellular transport mechanisms. The Office of Naval Research, NSF and the U-M Office of Technology Transfer have funded this work.

Pipe has joint appointments in the U-M EECS department and the Applied Physics program. He is a member of the Michigan Nanotechnology Institute for Medicine and Biological Sciences.

Meet Pramod Sangi Reddy

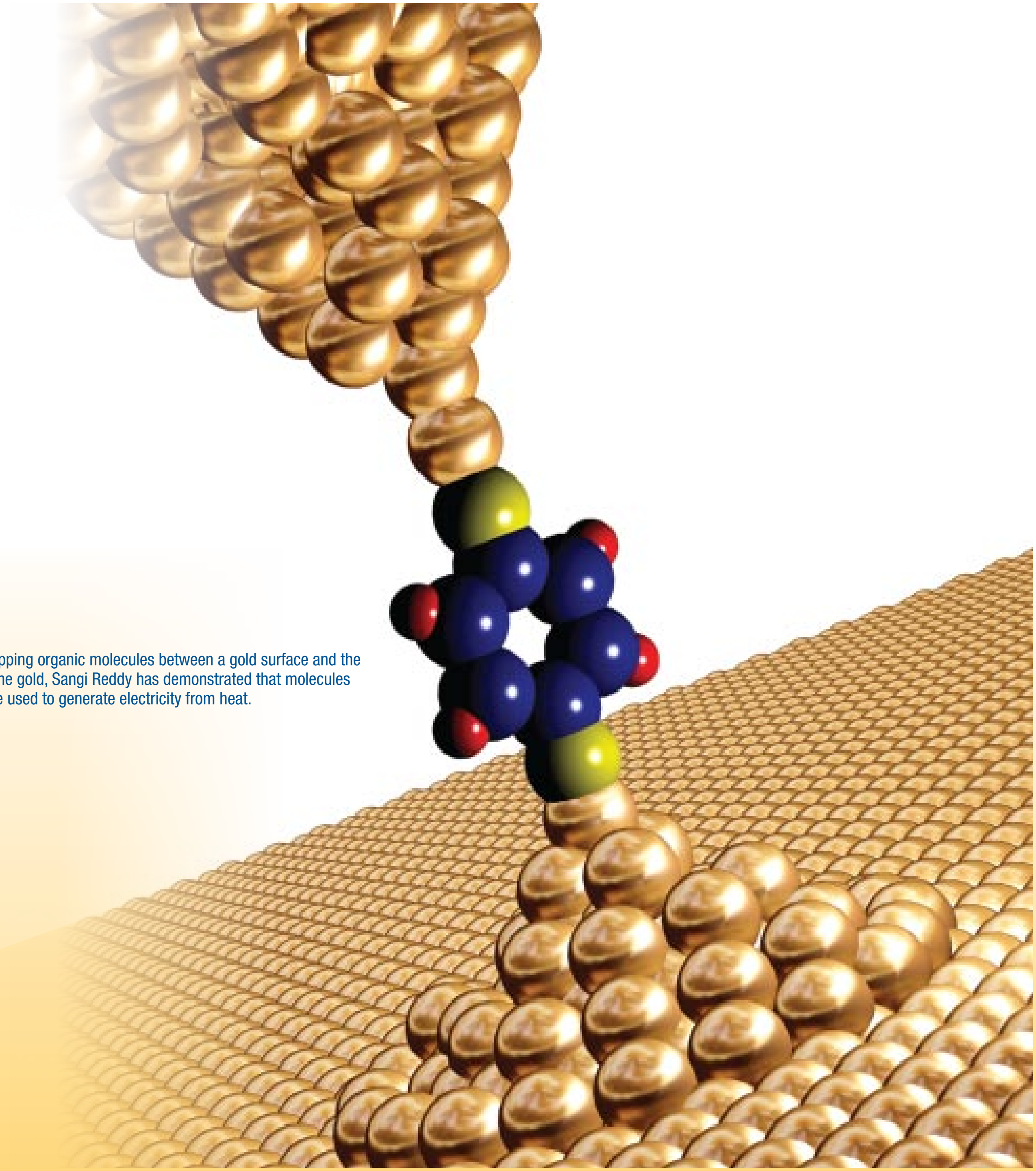
New and improved energy sources are critical in the 21st century. So Pramod Sangi Reddy's work on energy conversion efficiencies is more important than ever. His research, begun while a PhD candidate at UC-Berkeley, has already led to new ways to convert waste heat into electricity inexpensively.

Pramod Sangi Reddy joined the ME department in fall 2007 as an assistant professor. He teaches both undergraduate and graduate courses and is an experimentalist pursuing research on novel thermoelectric devices. His work focuses on heat and electron transport in nanostructured materials in order to improve energy conversion efficiencies.

Efficient conversion of heat into work forms is a significant challenge today, and one of the major areas of research in mechanical engineering. While traditional mechanical engineering focuses on improved designs of engines and turbines to achieve gains in energy conversion efficiency, the advent of nanotechnology offers new possibilities to address the problem.

Sangi Reddy's research on heat and electron transport in nanoscale materials aims to obtain a clear picture of how transport of heat and electricity at the nanoscale differs from that in macroscopic objects. This understanding could one day lead to the development of better thermoelectric devices that can be used to convert waste heat from exhaust gases and furnaces into useful electrical energy, for instance. His research also has the potential to help build better photovoltaic cells and novel energy storage devices. His work has already led to the development of new ways to convert waste heat into electricity; previous research done while at the University of California, Berkeley, led to insights on how to use organic materials to make inexpensive thermoelectric devices that can convert waste heat into electricity. He and colleagues trapped organic molecules between two gold electrodes of different temperatures; the difference in temperature led to the flow of an electrical current, demonstrating that thermoelectric devices can be built using organic materials that are much cheaper than inorganic materials. This makes it possible to develop cost efficient thermoelectric materials.

Sangi Reddy earned his bachelor's degree in mechanical engineering and a master's degree in computer aided design from the Indian Institute of Technology Bombay in 2002. After undergraduate studies in India, he earned a PhD in applied science and technology at the University of California, Berkeley.



By trapping organic molecules between a gold surface and the ultrafine gold, Sangi Reddy has demonstrated that molecules can be used to generate electricity from heat.

Meet Kathleen Sienko

Kathleen Sienko's research on balance disorders and artificial gravity comes naturally from her interest in space flight. She is now working on a version of the vestibular device she helped develop at the Massachusetts Eye & Ear Infirmary to test in the elderly, a population with significant balance problems. Also on tap for Sienko: a summer 2008 trip to Ghana as a teaching fellow with the Global Intercultural Experience for Undergraduates (GIEU) Program.

Being able to balance is something most of us take for granted. But an estimated 30% of Americans experience dizziness or balance-related challenges at least once in their lifetime. Assistant Professor Kathleen Sienko, who joined the ME faculty in January 2007, is developing a research program focused on the design, development and evaluation of medical devices to address balance problems.

A long-time fascination with and passion for space flight led Sienko to spend summers during high school and college (the University of Kentucky) working with NASA and on other space-related projects. While pursuing her master's and doctoral degrees at the Massachusetts Institute of Technology, she also worked with the Russian and Japanese space programs. Much of her research explored the effects of artificial gravity as a long duration space flight countermeasure on the vestibular system; that work soon led to investigating vestibular problems among the general population.

The vestibular system is composed of sensors located near the cochlea that measure head rotation and linear motion. Disorders of the system are among many that can lead to postural imbalance; vestibulopathic patients have difficulty walking and maintaining postural stability due to compromised function of the motion sensing apparatus within the inner ear or failure to properly integrate information provided by the sensors within the central nervous system. Existing therapies include pharmacological treatments, balance rehabilitation and balance aids such as canes and walkers.

While a graduate research assistant at the Massachusetts Eye & Ear Infirmary, Sienko contributed to the development of a device that replaces faulty or missing vestibular information by providing cues of body motion that can be mapped to the torso. Electronic sensors placed on the body accurately measure direction and degree of body tilt. The output of the sensors is processed and then expressed on the patient's torso in the form of small vibrations by vibrotactile elements called tactors. The tactors, similar to pager motors in a cell phone, convey information by buzzing when the patient tilts too far in one direction. Vibrations cease when the individual moves in the opposite direction and returns to the upright position. To date the device has been successfully tested in a research laboratory on patients with poorly functioning vestibular systems. These patients, typically incapable of standing without falling if their eyes are closed or in a dark environment, are able to train with the device and use the vibrotactile feedback to better balance.

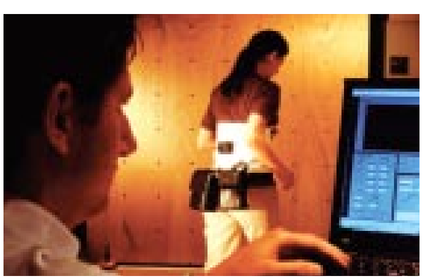
Presently Sienko is evaluating efficacy of the device on balance rehabilitation outcomes at the University of Michigan Vestibular Center with funding from the Michigan Institute for Clinical and Health Research Pilot and Collaborative Grant Program for Translational and Clinical Research. She is also developing a version of the device to test in the elderly. Funded by the University of Michigan Geriatrics Center Pilot Program, the study will assess the effectiveness of vibrotactile balance aid on community-dwelling elderly who report losses of balance.

Sienko is seeking funding to study balance deficits in patients with peripheral neuropathies and military personnel with mild traumatic brain injuries. As many as 65% of all traumatic brain injury patients' difficulty with balance stems from direct damage to the vestibular organs.

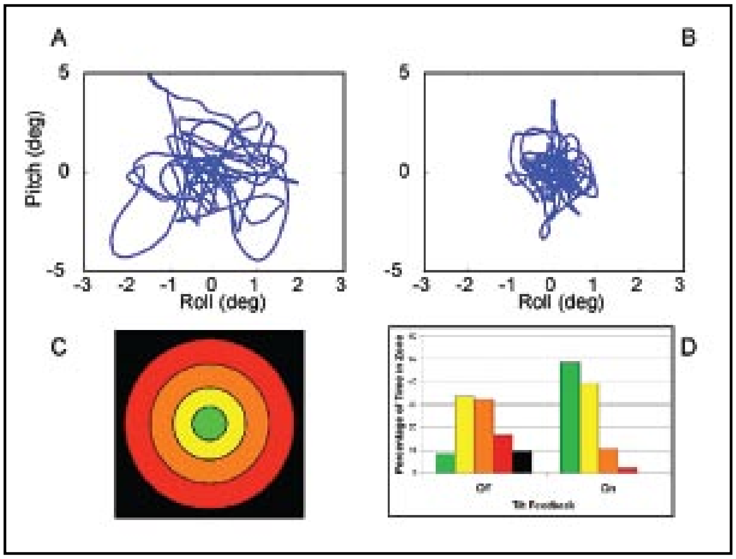
If this research is successful, she hopes the technology could be available for commercial use within five years.

A strong interest in entrepreneurship complements Sienko's work. In 2005 she won the MIT $50K Entrepreneurship Competition. At U-M, she works to promote that spirit in her lab and at the college level. She recently served as a judge for the college's Business Idea Competition and was a member of the Michigan Entrepreneurship Team.

Another research area of great importance to Sienko is global health



Sienko's balance prosthesis device consists of a motion-sensing system mounted on the lower back of the subject, a vibrotactile display and a laptop computer (or wearable watch) with analog and digital interfaces. Image courtesy of Draper Laboratory.



Trunk tilt responses from a vestibulopathic subject standing eyes closed on a two-axis moving platform. A) Trunk roll vs. pitch with no vibrotactile feedback. B) Trunk roll vs. pitch with directional feedback provided through 8 columns of tactors. Tilt magnitude displayed in 4 levels: dead zone of 1 degree of tilt, lowest tactor row of 1–3 degrees of tilt, middle tactor row of 3–5 degrees of tilt and top tactor row of over 5 degrees of tilt. C) "Zones" that correspond with the level of tactor display: center (green) = dead zone, etc. D) Distribution histogram of percentage of time the subject spends in each of the zones shown in C with tilt feedback "Off" and "On".

design. She completed a clinical preceptorship in India in 2006, where a 'typical' day might have included seeing pulmonary and extra-pulmonary tuberculosis and tropical diseases such as malaria and typhoid, followed by observing experimental robotic surgery or seeing patients with diseases common in more prosperous countries, such as heart disease and diabetes.

Sienko also recently presented on the topic of "Educating Technologists for Global Health" at the American Association for the Advancement of Science in Boston. She is collaborating with Professor Steven Skerlos of mechanical engineering and Dr. Aileen Huang-Saad, a lecturer in biomedical engineering at U-M on the design and implementation of a new minor in multidisciplinary design for engineering students who want to address global health challenges. The Global Health Design specialization would emphasize field experience, cultural sensitivity and exposure to global health issues in addition to medical device design.

As a Global Intercultural Experience for Undergraduates Faculty Teaching Fellow, Sienko is leading a group of twelve U-M undergraduates to Ghana in summer 2008 to work on a student-driven maternal mortality prevention program. Maternal mortality is the global health indicator with the greatest disparity between developed and developing countries and remains unnecessarily high in many countries. One maternal death occurs per minute; over 560,000 each year globally. The focus of the program in Ghana is on the generation of technological interventions as well as to provide educational outreach in order to reduce maternal mortality.

Collaborators include Frank Anderson, MD, from the obstetrics and gynecology department at U-M, and Dr. Kwabena Danso of Kwame Nkrumah University of Science and Technology School of Medical Sciences in Ghana. Sienko expects that the program will build upon and further strengthen ongoing collaborative efforts between the two universities.

Sienko has a joint appointment in the Department of Biomedical Engineering.

Meet Angela Violi

In her two years at ME, Assistant Professor Angela Violi has already established a strong program in energy processes. She collaborates on biodiesel research with groups at several universities, including Stanford. With joint appointments in chemical engineering and biomedical engineering, Violi also serves as faculty mentor in the Undergraduate Research Opportunities Program (UROP).

Assistant Professor Angela Violi joined the ME faculty in January 2006 and has already established a strong program in energy processes (http://www.umich.edu/~avioli/).

The goal of her research is to study energy processes for novel fuels and to characterize the formation of nanoparticles and emissions as well as their growth and fate in the environment. Toward that end she has created an innovative multiscale computer simulation approach.

Violi has been working on biodiesel fuels, developing the reaction mechanisms for different fuels in order to predict the amount and the type of emissions using various combustibles. She collaborates with experimental research groups at several universities, including Stanford University, to generate a deep understanding of biodiesels.

Violi uses multiscale methods, such as the kinetic Monte Carlo technique combined with molecular dynamics simulations, to follow the formation of nanoparticles and their growth in a chemically specific way from combustion sources. This approach provides a connection between the various time scales that govern the growth and self-assembly of nanoparticles as well as an unprecedented opportunity to understand the atomistic interactions underlying the structures and growth of nanoparticles.

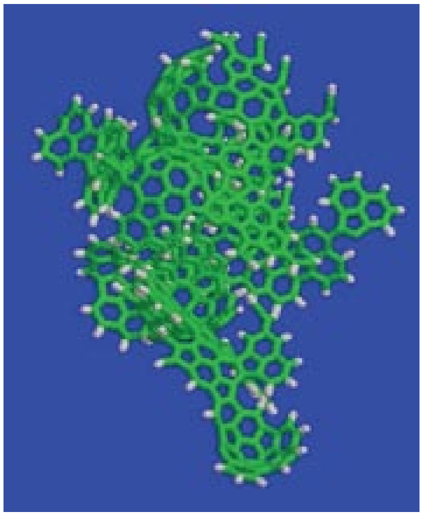
Different combustion environments, for example, flame or engine, produce nanoparticles of different morphologies and chemical compositions. The goal of this work is to develop a model for the formation of pollutants such as greenhouse gases and particles from novel fuels.

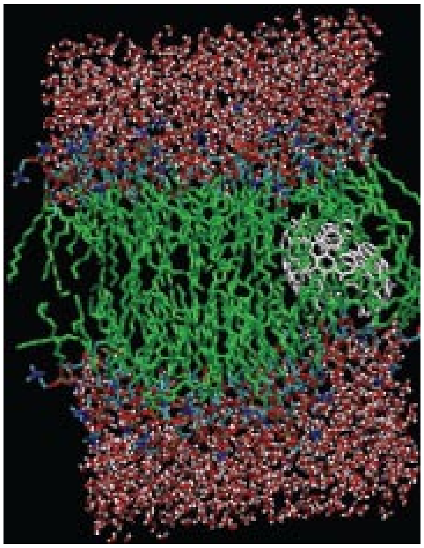
In a project funded by the National Science Foundation (NSF), Violi is investigating the formation of nanoparticles in high temperature systems, a challenging multiscale problem involving both molecular science and the statistical mechanics of nonequilibrium self-assembly and nucleation over two disparate length and time scales. Violi is developing new computational methodologies based on novel coarse-graining molecular dynamics techniques. This approach bridges the length and time scales in the area of nanocluster self-assembly.

Violi's work also investigates the biomedical impact of nanoparticles by gaining a detailed biophysical understanding of long-term interactions of these particles with self-assembled biological structures, such as cell membranes. Violi was selected by the NSF to receive a Faculty Early Career Development Award through the NSF CAREER program for work in this area. Her project focuses on the "Uptake, Fate and Transport of Environmental Nanoparticles: From Atomistic Simulation to Membrane Diagnostics" (see story on page 32).

Through the highly interdisciplinary research taking place in her laboratory, which draws on the fields of chemical engineering, physical chemistry, biomedical engineering and mechanical engineering, Violi aims to develop a theoretical multi-scale, computational nanoscience with methods and models to study the formation and fate of nanoparticles in the environment. The ultimate goal of this work is to identify the effects and impact of particulate emissions on human health and climate change. Learning how nanoparticles penetrate and modify the dynamic, structural, thermodynamic and mechanical properties of these biomolecular systems will yield insights into their potentially harmful effects — and methods for their remediation.

Violi has a diverse research group, in terms of background, ethnicity and gender. Several undergraduates work in her lab, and she serves as a faculty mentor through the Undergraduate Research Opportunities Program. She holds joint appointments in the Departments of Chemical Engineering and Biomedical Engineering.



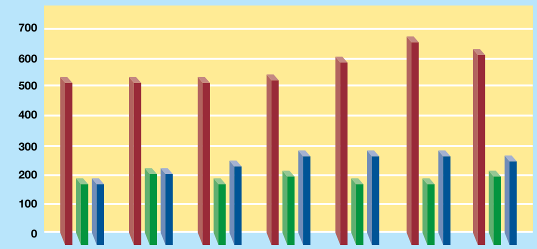


Top:
An example of carbonaceous nanoparticles produced through the proprietary Atomistic Model for Particle Inception (AMPI) code.

Bottom:
A snapshot from a molecular dynamics simulation of a carbonaceous nanoparticle interacting with a lipid bilayer.

Department Statistics and Trends

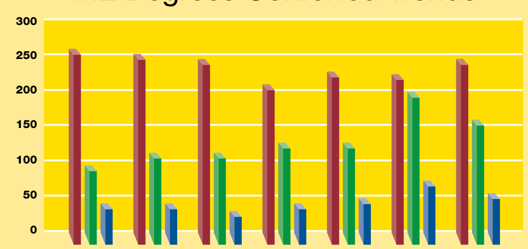
ME Enrollment Trends



	2001	2002	2003	2004	2005	2006	2007
BSE	538	536	531	548	604	680*	630
MSE	193	235	194	211	190	193	217
PhD	192	232	256	289	295	289	262

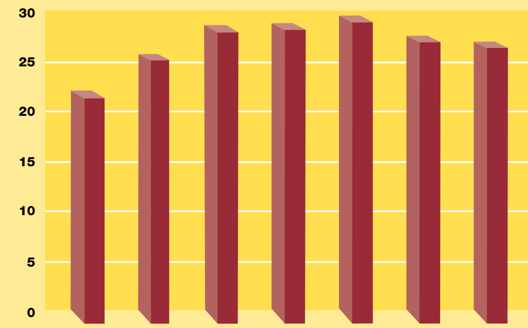
** Does not include all dual and joint degree students; only those whose primary unit is ME.*

ME Degrees Conferred Trends



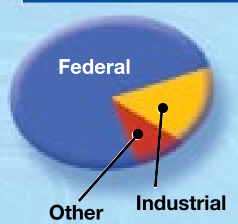
	00–01	01–02	02–03	03–04	04–05	05–06	06–07
BSE	258	250	242	209	229	221	239
MSE	92	115	116	127	125	198	155
PhD	39	39	27	36	47	60	54

ME Research Expenditure Trends



FY	00–01	01–02	02–03	03–04	04–05	05–06	06–07
$ in Millions	21.8	25.6	28.1	28.9	29.0	27.0	26.5

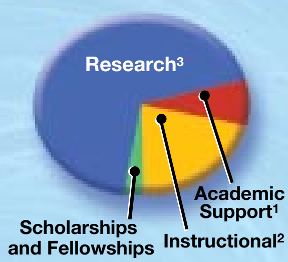
ME Research Expenditures



Distribution by Source
July 1, 2006 – June 30, 2007

	%	$
Federal	64.67%	17,163,694
Industrial	26.17%	6,945,108
Other	9.17%	2,432,684
	100.00%	26,541,487

ME Departmental Expenditures



July 1, 2006 – June 30, 2007

	%	$
Academic Support[1]	6.69%	2,554,835
Instructional[2]	21.24%	8,108,396
Scholarships and Fellowships	2.56%	976,300
Research[3]	69.51%	26,541,487
	100.00%	38,181,018

1 Funds used to support the academic mission of the department (infrastructure).

2 Funds used to support teaching and classroom activities.

3 Funds from external (federal and industrial) and internal sources used for research support and generation. Includes external sponsored activity such as training grants, public service and financial aid.

Donors

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Defense, Department of–Army
Defense, Department of–Defense Advanced Research Projects Agency
Defense, Department of–National Geospatial-Intelligence Agency
Defense, Department of–Navy
Defense, Department of–Other
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ETAS, Inc.
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Korean Automotive Technology Institute (KATECH)
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TRW, Inc.
Visteon
Whirlpool Corporation


ASHTON-MILLER


VIOLI

Dr. James A. Ashton-Miller
Named Albert Schultz Collegiate Research Professor

Distinguished Research Scientist James Ashton-Miller has been named Albert Schultz Collegiate Research Professor. This honor recognizes the contributions of both Ashton-Miller and his mentor, Emeritus Professor Albert B. Schultz, to the field of biomechanics.

Schultz and Ashton-Miller, close collaborators at the University of Illinois, came to the University of Michigan in 1983. Schultz founded the Biomechanics Research Laboratory (BRL) in the College of Engineering, where he mentored Ashton-Miller until 1999. The two were among the first biomechanicians to investigate mobility problems among the elderly. Schultz and Ashton-Miller initiated collaborative relationships with departments in the Medical School, the schools of Public Health, Nursing and Dentistry as well as with the Division of Kinesiology and the Institute of Gerontology. They conducted pioneering work on the spine, balance and the physical and cognitive causes of falls in the elderly. In a landmark experiment they showed that although age affects neural reaction time, it is the age-related slowing in muscle contraction rate that can limit the safe arrest of a fall, an effect that can be ameliorated by the right exercises.

Ashton-Miller now directs the BRL, and he has become an internationally renowned leader in biomechanics, particularly in falls and mobility problems of older adults, birth-related injuries in women and anterior cruciate knee injuries. He and a colleague rediscovered and characterized the functional significance of the Hofmann ligaments, forgotten for nearly a century and, prior to rediscovery, misidentified by spine surgeons as 'adhesions.'

Ashton-Miller has invented devices to measure pelvic floor muscle strength and methods to quantify and treat stress incontinence. Working with colleagues in gynecology and Radiology, he and his students developed the first three-dimensional computer model of the pelvic floor and used it to explain one of the main causes of birth-related injuries.

Many of Ashton-Miller's former doctoral students now hold academic positions; two of his students chair departments. He has graduated 18 doctoral students, more than any other research faculty in the College of Engineering. He also has provided sustained service to the department and university, including membership on the Mechanical Engineering Advisory and Biomedical Engineering Executive committees, the Medical School's Biomedical Research Council and he chairs the university's Conflict of Interest Committee. His vision helped lead to the new Bone and Joint Injury Prevention and Rehabilitation Center involving kinesiology, engineering, public health, imaging and sports medicine.

Angela Violi receives NSF CAREER Award

Angela Violi, assistant professor of mechanical engineering, chemical engineering and biomedical engineering, was selected by the National Science Foundation (NSF) to receive the prestigious Faculty Early Career Development Award through the NSF CAREER program. Her project focuses on the "Uptake, Fate and Transport of Environmental Nanoparticles: From Atomistic Simulation to Membrane Diagnostics."

"The intellectual merit of this project," according to the NSF, "revolves around a novel theoretical effort to explore the interaction of man-made carbon-based nanoparticles with biological structures such as membranes. Knowledge on the basic and critical issues of how such anthropogenic particles 'fit in' and modify biological assemblies, whether they be in plant or animal, is still very limited ... This project is therefore devoted to providing some of this critically important environmental information through a highly synergistic scientific approach."

Through the highly interdisciplinary research agenda of her laboratory, Violi aims to develop a theoretical multi-scale, computational nanoscience with methods and models to study the formation and fate of nanoparticles in the environment. The use of multi-scale methods, such as the Kinetic Monte Carlo technique combined with molecular dynamics, makes it possible to follow the transformations that occur during nanoparticle formation and their interactions with other systems in a chemically specific way. This approach provides information on both the chemical structure and the configuration of the system, ultimately helping to identify the effects and impact of particulate emissions on human health and climate change.

Faculty Awards and Honors

Ellen Arruda

College of Engineering David E. Liddle Research Excellence Award, 2006

James Ashton-Miller

Albert Schultz Collegiate Research Professorship, 2007

Excellence in Research Award, American Orthopedic Society of Sports Medicine, 2006

Dennis Assanis

Fellow, American Society of Mechanical Engineers, 2007

Arvind Atreya

Distinguished Best Paper Award, The Combustion Institute

James Barber

American Society of Mechanical Engineers Best Reviewer Award for the *Journal of Tribology*, 2007

Visiting Chair Professorship, National Taiwan University of Science and Technology, 2007

David Dowling

Student Council Mentoring Award, Acoustical Society of America , 2007

Deba Dutta

Scholar-in-Residence at the National Academy of Engineering Center for the Advancement of Scholarship on Engineering Education

Bogdan Epureanu

College of Engineering 1938E Award, for outstanding teaching, mentoring and scholarly integrity, 2007

Vikram Gavini

Robert J. Melosh Medal, bestowed by a consortium including Duke University, ETH Zurich, Elsevier and the International Association for Computational Mechanics, 2007

S. Jack Hu

Conference co-chair, 35th Annual North American Manufacturing Research Conference, 2007

Gregory Hulbert

Department of Mechanical Engineering Outstanding Achievement Award, 2006

Hong Im

U.S. Department of Energy Innovative and Novel Computational Impact on Theory and Experiment (INCITE) Award, 2007

Elijah Kannatey-Asibu

Conference co-chair, 35th Annual North American Manufacturing Research Conference, 2007

Katsuo Kurabayashi

Pi Tau Sigma Outstanding Professor Award, 2007

Wei Lu

Air Force Summer Faculty Fellow at Wright-Patterson Air Force Base, 2007

Jyoti Mazumder

Adams Memorial Membership Award, American Welding Society, 2007

Fellow, American Society of Mechanical Engineers, 2007

Jun Ni

College of Engineering John F. Ullrich Education Excellence Award, 2006

Jwo Pan

Society of Automotive Engineers Forest R. McFarland Award, 2007

Panos Papalambros

American Society of Mechanical Engineers Ruth and Joel Spira Outstanding Design Educator Award, 2007

Noel Perkins

General Motors Technical Education Program Outstanding Distance Learning Faculty Award, 2007

Kazuhiro Saitou

Senior Member, Institute of Electrical and Electronics Engineers (IEEE), 2007

Organizing chairperson, IEEE International Symposium on Assembly and Manufacturing, 2007

Department of Mechanical Engineering Outstanding Achievement Award, 2006

Ann Marie Sastry

Gustus L. Larson Memorial Award, Pi Tau Sigma and the American Society of Mechanical Engineers, 2007

William Schultz

College of Engineering Herbert Kopf Service Excellence Award

Jan Shi

Fellow, American Society of Mechanical Engineers, 2007

Albert Shih

Fellow, American Society of Mechanical Engineers, 2007

Outstanding Paper Award, North American Manufacturing Research Institution/Society of Manufacturing Engineering, 2007

International adjunct professor, National Cheng Kung University, 2006

Volker Sick

College of Engineering Service Excellence Award, 2007

Michigan Leadership Advisor of the Year Award, 2007

Society of Automotive Engineers International Faculty Advisor of the Year Award, 2007

Distinguished Best Paper Award, The Combustion Institute, with ME doctoral candidate Claudia Fajardo, 2006

Faculty of the term, Pi Tau Sigma, Michigan Pi Rho Chapter, 2006

Harold C. Simmons Award with James D. Smith, Institute for Liquid Atomization and Spray Systems, 2006

Steven Skerlos

Conference co-chair, 35th Annual North American Manufacturing Research Conference, 2007

Society of Manufacturing Engineers Kuo K. Wang Outstanding Young Manufacturing Engineer Award, 2007

Anna Stefanopoulou

Fellow, American Society of Mechanical Engineers, 2007

Michael Thouless

Fellow, American Society of Mechanical Engineers, 2006

A. Galip Ulsoy

Organizer and moderator, National Science Foundation workshop, "5XME," to address competitiveness in mechanical engineering education, 2007

Reviewer, National Academy of Engineering report, "Benchmarking the Competitiveness of the United States in Mechanical Engineering Basic Research"

Angela Violi

National Science Foundation Faculty Early Career Development (CAREER) Award, 2007

Margaret Wooldridge

Fellow, American Society of Mechanical Engineers, 2007

SAE J. Cordell Breed Award for Women Leaders, 2007

Faculty Promotions

Effective Fall 2007

- Bogdan Epureanu, to Associate Professor with tenure.
- Richard (Brent) Gillespie, to Associate Professor with tenure.
- Wei Lu, to Associate Professor with tenure.
- Edgar Meyhofer, to Professor with tenure.
- Dawn Tilbury, to Professor with tenure.
- Margaret Wooldridge, to Professor with tenure.

External Advisory Board Welcomes New Member

Simon Pitts, who directs University Alliances and the Ford–MIT Alliance at Ford Motor Company, has joined the Mechanical Engineering External Advisory Board (EAB). Comprised of distinguished alumni and friends of the department, the EAB convenes twice annually and serves as an advisory body to the department chair.

Pitts was born in London and graduated from the Loughborough University with a degree in automotive engineering and design. He joined Ford Motor Company in 1976, where he worked for the Research and Development Centre in the United Kingdom. His early work was on advanced powertrain development and research. This was followed by assignments in engineering and launching methanol, ethanol and compressed natural gas alternative fuel vehicles prior to his appointment as chief engineer of powertrain systems engineering. In addition to his work at Ford in Great Britain, Germany and the United States, Pitts pursued executive education in France at the international business school INSEAD.

Pitts held the positions of global vehicle line director of C class vehicles (Focus and Escort model lines), North American director of manufacturing operations and director of worldwide powertrain planning. He also served as director of product development operations for the Ford Motor Company, Jaguar, Land Rover and Volvo brands.

Richard Heglin wins Alumni Society Merit Award

Alumnus Richard (Dick) Heglin was recognized by the College of Engineering with a 2007 Alumni Society Merit Award.

Heglin earned a bachelor of science degree in mechanical engineering from U-M in 1959. He joined General Electric's Major Appliance division and also consulted on mechanical design projects for Michigan hospitals and extended care facilities. In 1970 he joined the Tecumseh Product Company. He held several positions there, each with increasing scope and responsibility. Heglin has also worked for American Standard Company, Amcast Industrial Corporation, Leybold Vacuum Products, Inc. and Balzers and Leybold Taiwan.

Heglin has served the Department of Mechanical Engineering and the College of Engineering for many years, including membership on the ME External Advisory Board since 1995. He served on the college's Alumni Society board from 1990 to 1996, as chairman from 1994 to 1996. As chair he also served as a representative to the Dean's National Advisory Committee.

Heglin has been a member of the U-M Club of Detroit since 1960. He also remains active as the president of R.T. Heglin, PE, LLC, a management consultancy.

Paul J. Kern Elected to National Academy of Engineering

Alumnus and General (retired) Paul J. Kern (MS ME, MS CE, '73) has been elected to the National Academy of Engineering (NAE).

Kern was selected for bringing modern digitization technology to bear on military effectiveness, training and procurement. During a distinguished career spanning more than four decades he worked to digitize and transform war fighting capabilities. He earned wide respect for improving supply chain and weapons systems readiness while controlling costs, and he led initiatives to consolidate major munitions production operations, employ radio frequency identification, manage supplies of rebuilt equipment for front lines and implement Lean Six Sigma. He has earned Defense and Army Distinguished Service Medals, several Silver and Bronze Star medals and three Purple Hearts.

Since retirement Kern has served as chair for Advanced Technology at West Point, an adjunct professor at University of Southern California and as a director of several corporations. He received a Society of Automotive Engineers Teetor Award and an Alumni Society Medal from U-M. He has served on the ME External Advisory Board since 2001.

Graduate Student Honors & Awards

RACKHAM

2007 Distinguished Dissertation Award
Ruan Xiulin

2006 International Student Fellowship
Yun Ju Lee

2006/07 Predoctoral Award
Xiulin Ruan

REA Fellowship
Michael Alexander
Serge Li Hoi Foo-Gregory
Scott Moura
Diane Peters
Karl Zelik

Susan Lipschutz, Margaret Ayers Host, and Anna Olcott Smith Award
Erin MacDonald
Christine Vehar

COLLEGE

Alexander Azarkhin Award
Woo Kyun Kim
Paul Teini

Corlett Fellowship
Ryan McCaffrey

Deans/Named Fellowship
Vinod Anandarajah
Saurabh Gupta
Steven Hoffenson
Ankur Kapoor
Jinjin Ma
Laura Manofsky
Eric Meshot
Devin O'Connor
Daniel Opila
John Rebula
Andrew Sloboda
Yifeng Tang

Distinguished Achievement Award
Guarav Bansasl
Songtao Tang

Distinguished Leadership Award
April Bryan
Kiran Dsouza
Kristen Mills
John Redmond

Regents Fellowship
Preeti Abraham
Joel Forman
Adam Frischkencht
Haicheng Guo
Joshua Lacey
Jong Girl Ok
Benjamin Pence
Brent Utter

William Mirsky Award
Gaurav Bansal
Ya-Ni Chen
Saurabh Gupta
Arjun Krishnan
Evan Pineda
Yifeng Tang
Monica Cristina Toma

EXTERNAL

31st International Symposium on Combustion, Heidelberg, Germany Distinguished Paper Award
Claudia Fajardo

Homeland Security Fellowship
Robert Littrell
Gregory Sommer
Steven Truxal

National Consortium for Graduate Degrees for Minorities in Engineering & Science (GEM) PhD Fellowship
Michael Alexander

National Defense Science & Engineering Fellowship
Daniel Opila

National Science Foundation (NSF)
Rachael Bis

Taiwan Merit Scholarship
Kuang Chuan Lin

Vietnam Education Foundation Fellowship
Phuoc Nguyen Huu
Daniel Opila

DEPARTMENT

Department Fellowship
Anastasios Amoratis
Harish Iyer
Zhenzhong Jia
Sung Jin Kim
Girish Krishnan
Chiao-Ting Li
Jingjing Li
Sha Li
Shifang Li
Zhengyu Li
Yi Liao
Jiajia Luo
Deepak Sharma
Dong Hoon Song
Huarui Sun
Sameh Tawfick
Paul Teini
Anurag Tripathy
Vivek Vichare
Karthik Visvanathan

Ivor K. McIvor Award
Adam Hendricks

Medtronics Foundation Fellowship
Ani Siyahian

Research Fellowship
Deniz Akcabay
Rachel Collino
Kari Danek

Tulga Ersal
Claudia Fajardo
Stephanie Frangakis
Mark Gordon
Arjun Krishan
Jaewon Lee
Youngseok Oh
Jungkap Park
Abhishek Yadav
Zhouzhou Zhao

Robert M. Caddell Memorial Award
Amit Kaushik
Paul Podsiadlo

Training Grant
Mark Gordon

ENGINEERING GRADUATE STUDENT SYMPOSIUM AWARDS

BIOMATERIALS, NANOMATERIALS & RHEOLOGY
Poster Session – 2nd place
Joong Bahng

DESIGN
Oral Session – 1st place
James Allison

Oral Session – 2nd place
Youngseok Oh

Poster Session – 1st place
John Redmond

Poster Session – 2nd place
James Allison

DYNAMICS & VIBRATIONS
Oral Session – 2nd place
Jing Zhou

ENERGY & ENVIRONMENTAL RESOURCES
Oral Session – 2nd place
Brendan O'Connor

EXPERIMENTAL NANOMATERIAL
Oral Session – 3rd place
Anupam Pathak

FLUID DYNAMICS & COMBUSTION (APPLIED)
Oral Session – 1st place
Brian Elbing

FLUID DYNAMICS & COMBUSTION (FUNDAMENTALS)
Oral Session – 2nd place
Gaurav Bansal

FLUID DYNAMICS & CONTROLS (APPLIED)
Oral Session – 3rd place
Seung Hwan Keum

MICROFLUIDICS & DEVICES FOR BIOLOGICAL APPLICATIONS
Oral Session – 3rd place
Gregory Sommer

MODELING FOR MANUFACTURING & FABRICATION
Oral Session – 2nd place
Ram Vijayagopal

Poster Session – 1st place
Jaewon Choi

SYSTEM ANALYSIS & CONTROLS
Oral Session – 1st place
Richard Hill

Oral Session – 2nd place
Scott Moura

Poster Session – 2nd place
Dongsuk Kum

TISSUE ENGINEERING & BIOMECHANICS
Oral Session – 3rd place
Harish Narayanan

Symposium Presentation Winners
Smitesh Bakrania
Chia-Yuan Chang
Kyoungjoon Chang
Kiran Dsouza
Gi Suk Hwang
Woo Kyun Kim
Serge Li Hoi Foo-Gregory
Andreas Malikopoulos
Kristen Mills
Songtao Tang
Sun Yi

Undergraduate Student Honors & Awards

Distinguished Achievement Award
Ryan Doss

Distinguished Leadership Award
Rosa Abani
April Bryan
Elizabeth Coon
Patricia Pacheco

J.A. Bursley Prize
Kelly Bryan
Brett Muller

Lloyd H. Donnell
Ryan Doss

Lubrizol Scholarship
Sean Cook
Zhili Zou

MESLB Scholarship: Transfer Student Award
Jeremy Brown
Tom Serbowicz

Future Leader Award
Jeremy Brown

Impact Award
Phillip Scott

Outstanding Service Award
MingMing Yang

R & B Scholarship
Katherine Peretick
Benjamin Przeslawski
Kristopher Schilling
Aaron Williams

Robert M. Caddell Memorial Award
Michael J. Bohn
Tong Zhang

PhD Degrees Granted

Fall 2006

Eurico Emanuel Almeida
Reconfiguration and Verification of Modular Discrete Event Control Systems
Chair: Dawn Tilbury

Dongmei Chen
Modeling and Control of PEM Fuel Cell Humidification Systems
Chair: Huei Peng

Niranjan Deo
Micro and Macro-Mechanics of the Mammalian Cochlea
Chair: Karl Grosh

Sun Min Kim
Electrokinetic Preconcentration and Separation of Proteins in Microfluidic Devices for Biochemical Analysis
Chair: Charlie Hasselbrink

Jac Hong Lee
A Real-Time Simulation Model for Tracked Vehicles
Co-Chairs: Noel Perkins & Zheng-Dong Ma

Jiayin Li
Thermoelastic Contact Problems in Automotive Brakes and Clutches
Chair: James Barber

Vinod Natarajan
Spark-Assisted Compression Ignition: An Experimental Investigation into How Spark Ignition Advances Combustion Phasing in Gasoline MCCI Engines
Chair: Volker Sick

Hatem Orban
Analysis of Deformation during Structural Tube Hydroforming
Chair: S. Jack Hu

Konstantinos Varsos
Generation of Force Fields for Disturbed Manipulation
Chair: Jon Luntz

Shih-Hsun Yin
Enhanced Nonlinear Dynamics for Structural Health Monitoring
Chair: Bogdan Epureanu

Winter 2007

Chinar Aphale
Drag Reduction at Low and High Reynolds Numbers
Co-Chairs: Steve Ceccio & Bill Schultz

Kyoungjoon Chang
Modeling and Analysis of an HCCI Engine during Thermal Transients Using a Thermodynamic Cycle Simulation with a Coupled Wall Thermal Network
Chair: Dennis Assanis

Chia-Jui Chiang
Modeling and Control of Homogeneous Charge Compression Ignition Engines with High Dilution
Chair: Anna Stefanopoulou

Kyoo-Sil Choi
Residual Stress near Fillet and Roller Fatigue in Crankshaft Fillet Rolling Process
Chair: Jwo Pan

Ashish Deshpande
Pseudo Robot Based Methods to Analyze Kinematics and Dynamics of Robotic Systems from a Design Perspective
Chair: Jon Luntz

Jaspreet Dhupia
Effect of Joint Nonlinearities on the Dynamic Performance of Machine Tools
Co-Chairs: A. Galip Ulsoy & Reuven Katz

Yingxin Gao
The Role of Extracellular Matrix in Lateral Transmissions of Force in Skeletal Muscle
Co-Chairs: Alan Wineman & John Faulkner

Vasilleios Hamosfakidis
A Two Conserved Scalar Model for HCCI and PPCI Engine Applications
Chair: Dennis Assanis

Manbae Han
Species Resolved Hydrocarbon Emission Profiles from Advanced Diesel Combustion and Characterization of Heat-up Diesel Oxidation Catalysts
Co-Chairs: Dennis Assanis & Stani Bohac

Rui He
Modeling, Analysis, and Experimental Investigation of Root Canal Instrumentation Process
Chair: Jun Ni

Nikhil Joshi
Methodologies for Improving Product Development Phases through PLM
Chair: Deba Dutta

Jonathan Kadish
Some Problems Pertaining to the Mechanics of Accreted Planetary Bodies
Co-Chairs: James Barber & Peter Washabaugh

Amey Karnik
Water Management in a Polymer Electrolyte Membrane Fuel Cell Using an Anode Recirculation System
Co-Chairs: Anna Stefanopoulou & Jing Sun

Alexander Knafl
Development of Low-Temperature Premixed Diesel Combustion Strategies and Formulation of Suitable Diesel Oxidation Catalysts
Chair: Dennis Assanis

Cheng-Shu Kuo
A Simple and Versatile Iterative Implicit Solver for Incompressible Flows with Particular Emphasis on Fixed and Free Curved Boundaries
Chair: Michael Chen

Yong Lei
Intelligent Maintenance in Networked Industrial Automation Systems
Chair: Jun Ni

Jia Li
Experimental Investigation of Mistuned Bladed Disks System Vibration
Co-Chairs: Steve Ceccio & Christophe Pierre

Kuo-Cheng Lien
Biomechanical Analyses of the Maternal Pelvic Floor During the Second Stage of Labor
Co-Chairs: James Ashton-Miller & John Delancey

Jianbo Liu
Autonomous Anomaly Detection and Fault Diagnosis
Co-Chairs: Jun Ni & Dragan Djurdjanovic

John Parmigiani
Delamination and Deflection at Interfaces
Chair: Michael Thouless

Xiulin Ruan
Fundamentals of Laser Cooling of Rare-Earth-Ion Doped Solids and its Enhancement Using Nanopowders
Chair: Massoud Kaviany

David Salac
The Directed Self-Assembly of Nanostructures: Electric Pressure, Dipole, Double Layer and Cracking Mechanisms
Chair: Wei Lu

Jangho Shin
A Study of Flexible Multibody System with Finite Shell Elements
Chair: Noboru Kikuchi

Sang Heon Song
Vibration Analysis and System Identification of Mistuned Multistage Turbine Engine Rotors
Co-Chairs: Christophe Pierre & Matt Castanier

Vijay Srivatsan
A Fixtureless Approach to High-Precision Non-Contact Dimensional Inspection of Freeform Parts
Co-Chairs: Deba Dutta & Reuven Katz

Alan Tkaczyk
Microfluidic Switching and Electrowetting Techniques
Co-Chairs: Ron Larson & Shuichi Takayama

Eric Winkel
High-Reynolds Number Flat Plate Turbulent Boundary Layer Measurements and Skin-Friction Drag Reduction with Gas or Polymer Injection
Co-Chairs: Steve Ceccio & David Dowling

Min Zhang
Measurement Scheme and Classification Methods for the Development of a "Product DNA" Concept in Manufacturing
Co-Chairs: Jun Ni & Dragan Djurdjanovic

Rui Zhang
Tracer-Based Laser-Induced Fluorescence Diagnostic and Their Application to Spark-Ignition Direct-Injection Engines
Chair: Volker Sick

Jing Zhou
Joint Decision Making on Preventive Maintenance and Reconfiguration in Complex Manufacturing Systems
Co-Chairs: Jun Ni & Julie Ivy

Qiang Zhou
Molecular Dynamics Study of the Molecular Basis of the Tube Model for Entangled Polymers
Chair: Ron Larson

Summer 2007

Natasha Chang
Acoustic Characterization of Cavitation in Reverberant Environments
Co-Chairs: David Dowling & Steve Ceccio

Ercan Dede
Analysis, Design and Optimization of Structures with Integral Compliant Mechanisms for Mid-Frequency Response
Chair: Greg Hulbert

Hao Du
Weld Quality Monitoring and Estimation for Gas Metal Arc Welding of Aluminum
Co-Chairs: S. Jack Hu & Wenkao Hou

Ugur Ersoy
Modeling, Analysis, and Quality Monitoring for Gas Metal Arc Welding of Aluminums
Co-Chairs: S. Jack Hu & Elijah Kannatey-Asibu

Daniel Georgiev
Synergy in Teams with Incomplete Information
Co-Chairs: Dawn Tilbury & Pierre Kabamba

Mehmet Haliloglu
A Multi-Scale, Multi-Domain Approach to Wall-Modelling for LES of High Reynolds Number Wall-Bounded Turbulent Flows
Chair: Rayhaneh Akhavan

Zhijang He
Effects of Aeroelastic Phenomena on the Vibration Localization in Mistuned Bladed Disks
Co-Chairs: Christophe Pierre & Bogdan Epureanu

Aftab Khan
Predictive Inspection Based Control Using Diagnostic Data for Manufacturing Processes
Co-Chairs: Dawn Tilbury & James Moyne

Minjoong Kim
Modeling, Control, and Design Optimization of a Fuel Cell Hybrid Vehicle
Chair: Huei Peng

Hyoseok Lee
Experimental Studies on Mixing of Multiple Turbulent Jets in Non-Reacting and Reacting Flows
Co-Chairs: Arvind Atreya & Rayhaneh Akhavan

Rui Li
Experimental and Numerical Analysis of High-Throughput Drilling of Titanium Alloys
Chair: Albert Shih

Olivier Poudou
Modeling and Analysis of the Dynamics of Dry-Friction-Damped Structural Systems
Chair: Christophe Pierre

Tanakorn Tantanawat
Optimal Design of Compliant Systems for Dynamic Applications
Chair: Sridhar Kota

Fall 2007

Deniz Akcabay
Physics Based Washing Machine Simulations
Co-Chairs: David Dowling & Bill Schultz

Melody Baglione (Papke)
Development of System Analysis Methodologies and Tools for Modeling and Optimizing Vehicle System Efficiency
Co-Chairs: Jun Ni & Dennis Assanis

Shiyao Bian
Kilohertz Cinematographic Particle Image Velocimetry Measurements of Turbulent Flow Past a Shallow Cavity
Co-Chairs: Steve Ceccio & James Driscoll

Kwok-Leung Chan
High Resolution Thermal Imaging for Electrical and Optical Characterization of Electronic and Photonic Devices
Chair: Kevin Pipe

Sehyun Chang
A Flexible Hierarchical Model–Based Control Methodology for Vehicle Active Safety Systems
Chair: Tim Gordon

Lei Cheng
Cochlear-Base Transducers: Modeling and Design
Chair: Karl Grosh

Tulga Ersal
Realization-Preserving Simplification and Reduction of Dynamic System Models at the Graph Level
Chair: Jeffrey Stein

Claudia Fajardo
Development of a High-Speed UV Particle Image Velocimetry Technique and Application for Measurements in Internal Combustion Engines
Chair: Volker Sick

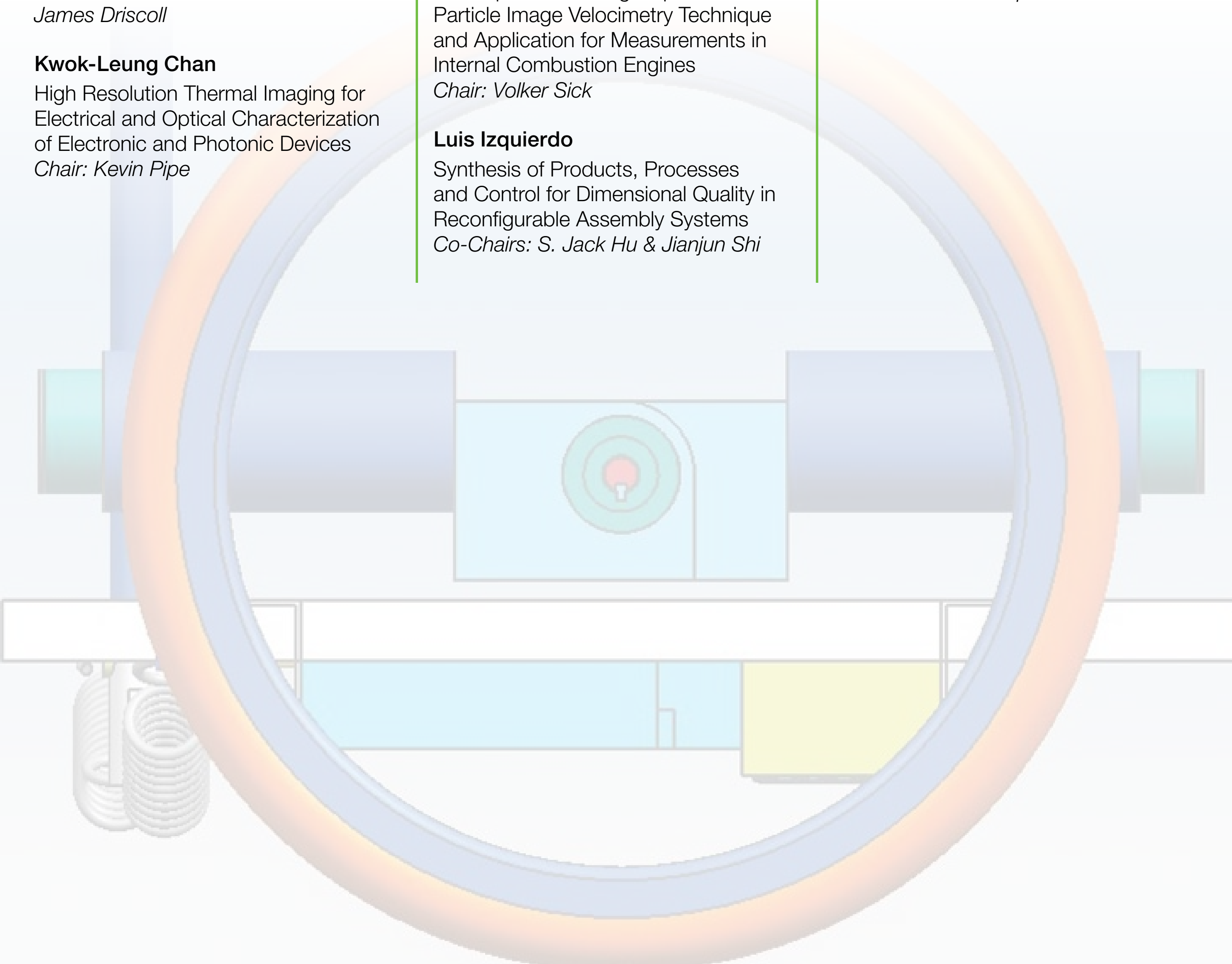
Luis Izquierdo
Synthesis of Products, Processes and Control for Dimensional Quality in Reconfigurable Assembly Systems
Co-Chairs: S. Jack Hu & Jianjun Shi

Chen-Chun Kao
Monitoring and Control of Micro-Hole Electrical Discharge Machining
Chair: Albert Shih

Lin Li
Short-Term Supervisory Control of Manufacturing Systems
Chair: Jun Ni

Jinming Liu
Modeling, Configuration and Control Optimization of Power-Split Hybrid
Chair: Huei Peng

Harish Narayanan
A Continuum Theory of Multiphase Mixtures for Modeling Biological Growth
Chair: Krishna Garikipati



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