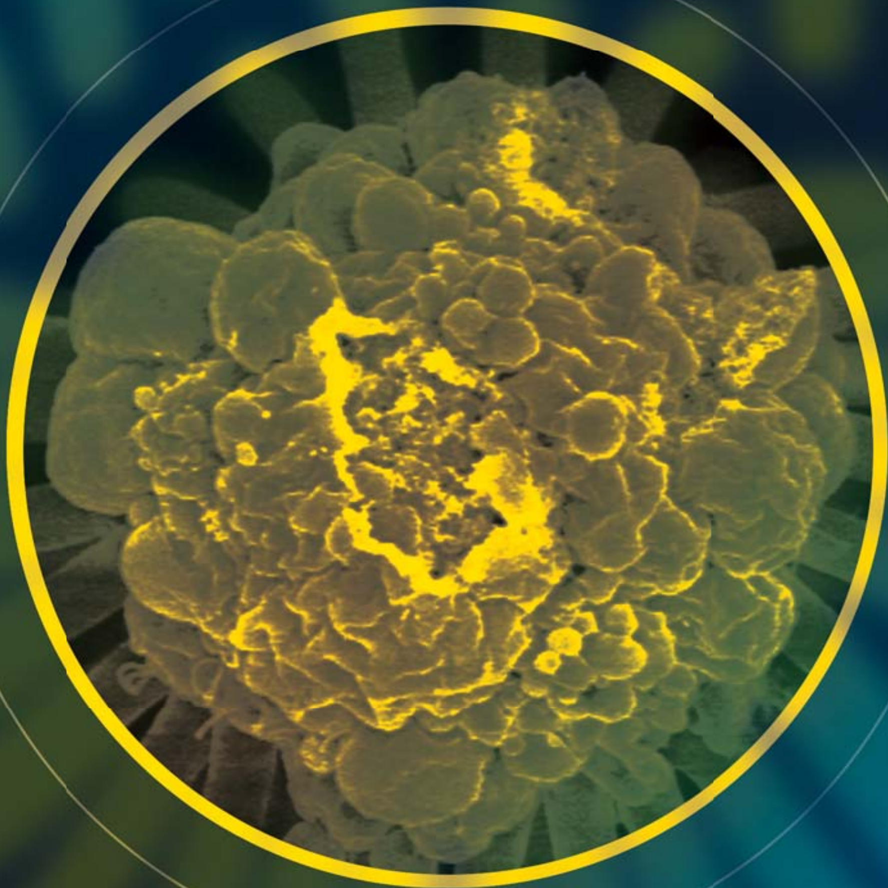
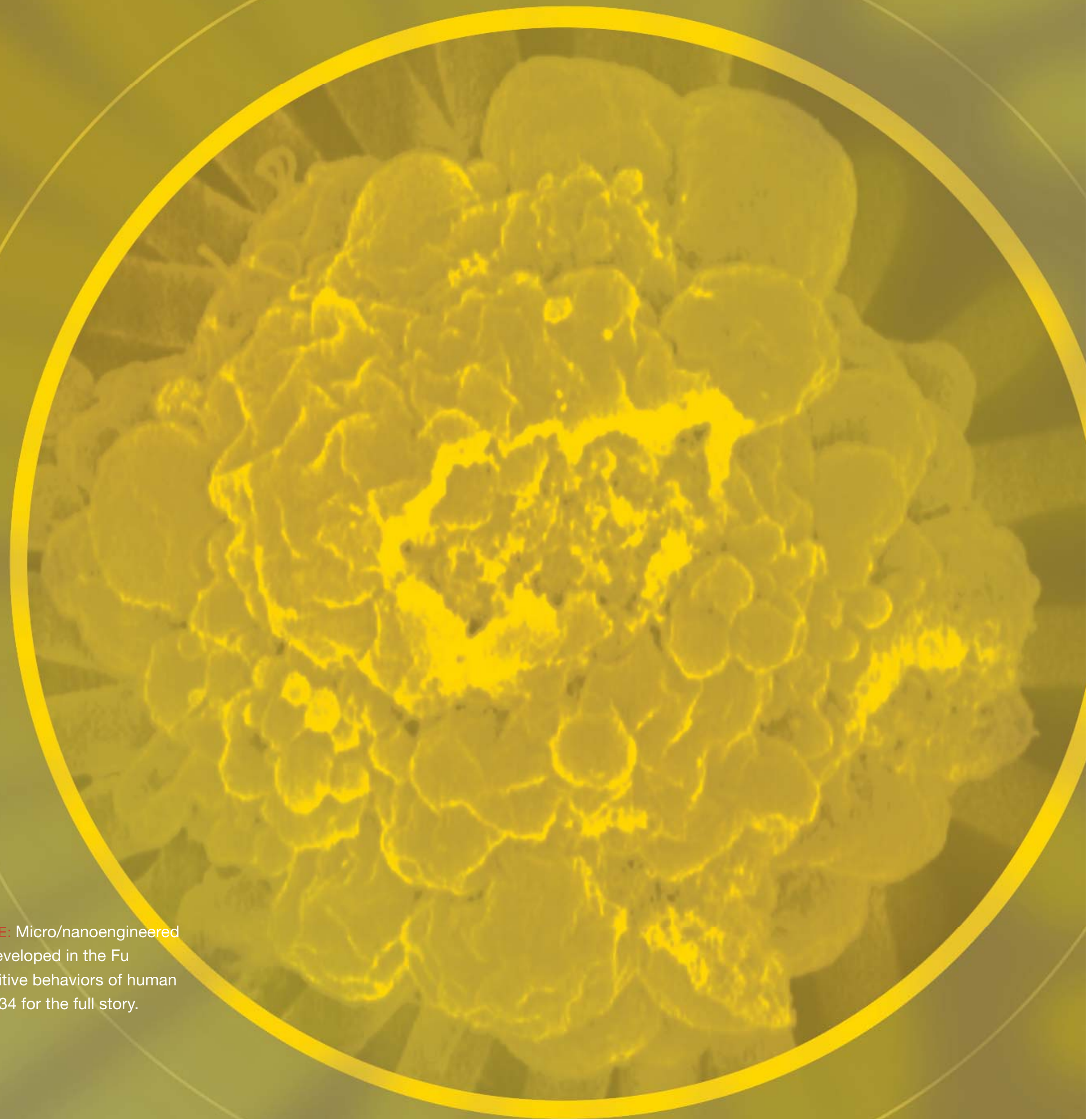
MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN
ANNUAL REPORT 2012-2013

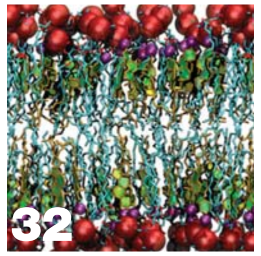


UNIVERSITY OF MICHIGAN

Mechanical Engineering Annual Report 2012–2013



ON THE COVER AND INSIDE FRONT PAGE: Micro/nanoengineered functional structures that have been developed in the Fu research group to study mechanosensitive behaviors of human stem cells and cancer cells. See page 34 for the full story.



Contents

Message from the Chair

"Our continual drive toward research breakthroughs, novel educational approaches and societal impact has made us one of the country's top mechanical engineering programs."

Welcome to the University of Michigan (U-M) Department of Mechanical Engineering (ME) 2012-13 annual report. Our continual drive toward research breakthroughs, novel educational approaches and societal impact has made us one of the country's top mechanical engineering programs. We are pleased to share our activities and accomplishments with you here.

Our new world-class research complex, a $46 million, 62,880-square-foot building project, continues on schedule and should be completed in spring 2014. This excellent new facility will enable transformative research activities that integrate core mechanical engineering with emerging areas, such as micro-, nano- and bio-systems.

Plans also are in place for a major renovation of the existing GG Brown building. This $50 million project will create a state-of-the-art student-centric instructional space for our students, faculty and staff. We are grateful to the State of Michigan for $30 million in funding toward the renovation.

In addition, the Department has received a significant endowment from our loyal and distinguished alumnus Tim Manganello, former executive chairman of BorgWarner Inc., and the BorgWarner Foundation. This generous landmark gift has endowed the ME Department Chair position at U-M, the first endowed department chair in the history of the College of Engineering.

ME faculty are recognized nationally and internationally for their research achievements and professional leadership. Our colleagues continue to lead various multidisciplinary research activities that impact both the scientific community and our society. As you will read in the pages ahead, investigators have made breakthroughs in fundamental and applied research across many fields, from energy, sustainability and advanced manufacturing to bio-systems and nano-technologies.

As always, our junior faculty colleagues have garnered prestigious and competitive young investigator awards this past year. We will soon welcome our newest faculty member, Neil Dasgupta, Stanford Ph.D. and currently a postdoctoral fellow at the University of California at Berkeley, to U-M ME. New faculty searches for the coming year also are underway.

We continue to create and enhance educational programs for our students, in Ann Arbor and around the world, including in China, Germany, Ghana, India and Japan. Our student societies and teams again showed the breadth and depth of their engineering education through their many competitive endeavors and successes.

Our alumni continue to shine, and we are grateful for their ever-present and outstanding support.

Thank you for your kind attention. Enjoy your reading, and here's to an extraordinary and productive year ahead.

Kon-Well Wang
Tim Manganello/BorgWarner Department Chair and Stephen P. Timoshenko Collegiate Professor

Faculty Profile

4
NAE Members

74
Society Fellows

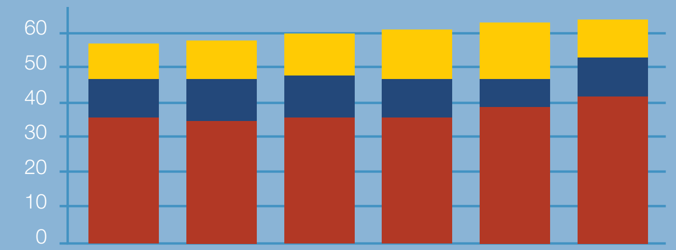
4
NSF PECASE or PFF Awards

31
NSF CAREER or PYI Awards

5
Current Journal Chief Editors

73
Current Journal Editorial Board or Assoc. Editor Appts.

Faculty Trends: Tenured and Tenure-Track

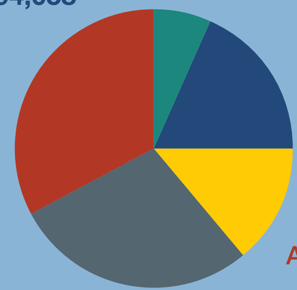


	FA08	FA09	FA10	FA11	FA12	FA13
Assistant	10	11	12	14	16	11
Associate	11	12	12	11	8	11
Professor	36	35	36	36	39	42
Total	57	58	60	61	63	64

Annual Research Expenditures

TOTAL RESEARCH EXPENDITURES
$34,494,058

2012-13

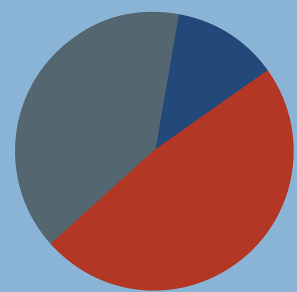


NIH	2,183,398
DoE	5,872,654
NSF	4,514,911
DoD	9,096,035
All Other	12,827,060

Degrees Conferred

2011-12

BSE 185
MSE 152
PhD 45



New ME Research Complex Nears Completion

Work continues on schedule toward a new, three-story mechanical engineering research complex. The 62,880-square-foot addition to the existing G.G. Brown Memorial Laboratories building is slated to be completed in spring 2014.

The U-M ME department continues to shape the future of mechanical engineering, and the new research complex will enable transformative research that will integrate core mechanical engineering with emerging new areas, such as micro-, nano-, and bio-systems.

The facility will be equipped with stringent temperature and humidity control and air filtration, and will be devoted to research in various areas: imaging and optics; bio-systems; nanoengineering; micro-bioengineering; materials, mechanics and mechanical testing; microdynamics and nanostructures. Collaborative workspaces and core laboratories will encourage continued multidisciplinary partnerships on existing and new projects.

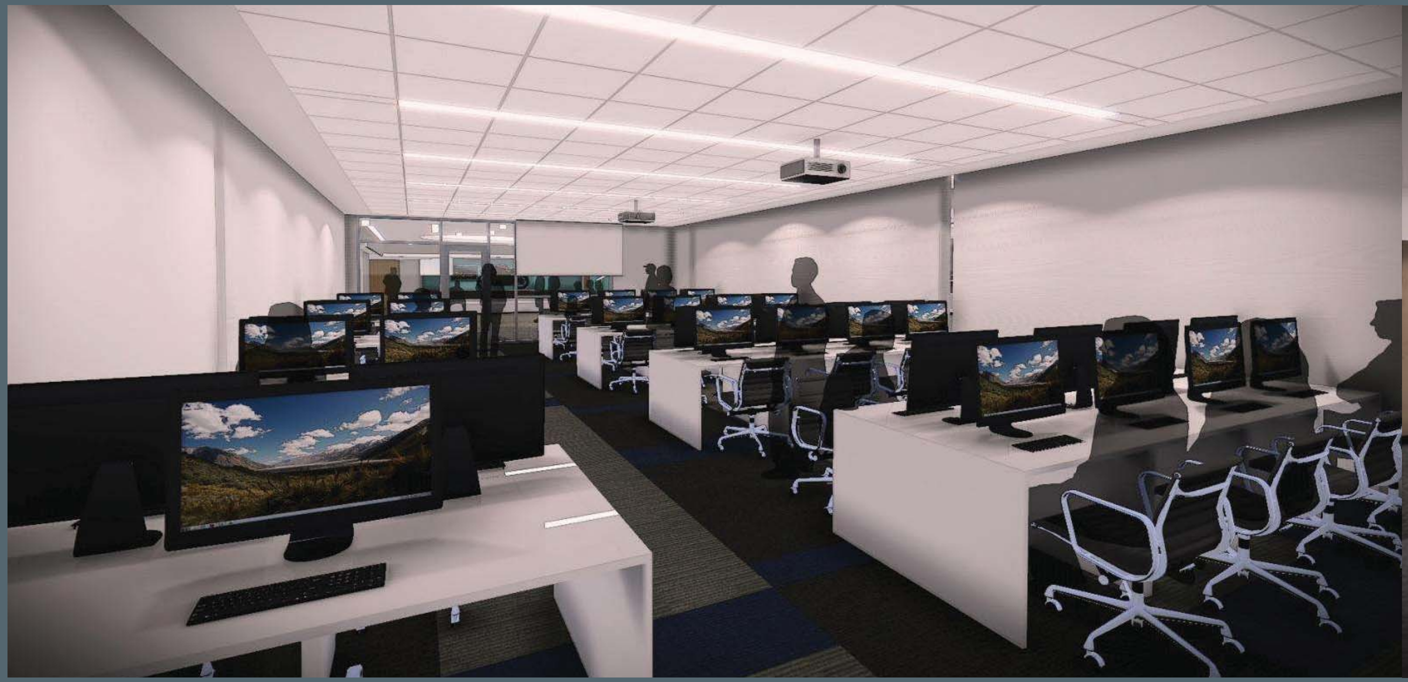
Eight special ultra-low vibration chambers designed to meet National Institute of Standards and Technology (NIST) vibration specifications will be housed below-grade. With access to state-of-the-art laboratories, investigators can conduct research at unprecedented levels of precision and accuracy and make key advances in multiple fields, including energy, manufacturing, health care and biotechnology.

The $46 million project is partially supported by $9.5 million from the NIST.

+ more on the web

Construction updates, architectural renderings and a real-time view of the project are available at **www.engin.umich.edu/facilities/ggbrown-construction-project**

$50 Million GG Brown Renovation
Realizing the Vision for New ME Home



"The planning and design of the GG Brown renovation is an integrated effort involving faculty, staff and students."

Tremendous growth in the ME department has led to a major, $50 million renovation of the existing GG Brown Memorial Laboratories building.

"The renovation of GG Brown achieves several important goals for our department, including the creation of a world-class educational facility," said **Kon-Well Wang**, Tim Manganello/BorgWarner Department Chair. The renovation will help create a central hub and "home" for ME students, faculty and staff.

State-of-the-art academic spaces are a fundamental part of the project. The Department will consolidate undergraduate instructional spaces for design, fabrication and laboratory work so they are conducive to collaboration across disciplines. New, innovative spaces will support the "Design, Build, Test" pedagogic paradigm.

Co-locating services as part of the renovation will create more accessible, efficient administrative and public spaces, and modernizing infrastructure will improve energy efficiency. An open staircase will promote visibility and facilitate interaction in public spaces, which will be refinished with new ceilings, flooring and paint and connect aesthetically to the new research complex addition (see related story on page 4).

The project will be completed in phases to keep disruption to a minimum.

The University has received $30 million for the renovation from the State of Michigan. The College of Engineering and the U-M Office of the Provost will fund the remaining cost of the project.

"The planning and design of the GG Brown renovation is an integrated effort involving faculty, staff and students," said Wang. "It's a very complex project, and I'm especially grateful to professors **Dawn Tilbury** and **Noel Perkins**, previous and current associate chairs for facilities and planning, and staff members **Merlis Nolan** and **Matt Navarre** for their outstanding leadership and efforts."

TOP LEFT TO RIGHT: Rendering of new state-of-the-art computer lab and mechatronics and design innovation education lab

BOTTOM RIGHT: Rendering of new stairway public space

ME Department Chair Endowment the First in College History

The ME department has received a significant endowment from alumnus **Tim Manganello**, former executive chairman of BorgWarner Inc., and the BorgWarner Foundation.

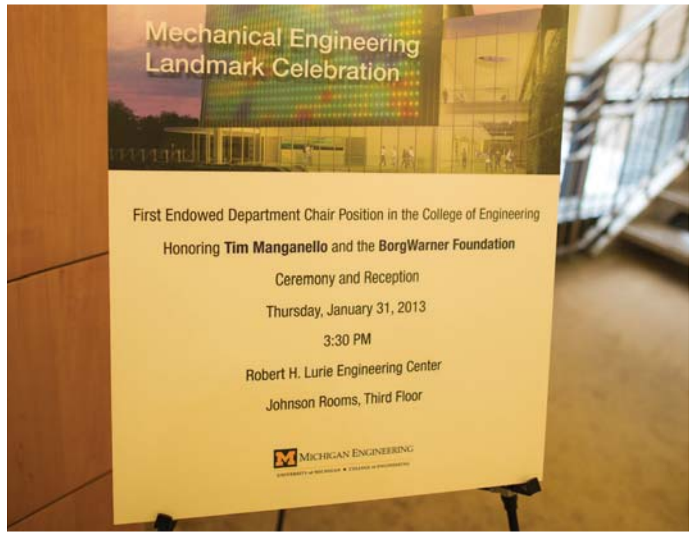
In January 2013, Manganello (BSE ME '72, MSE ME [Dearborn] '75, PDM [Dearborn] '81), the College of Engineering, and the Department celebrated a landmark $2 million gift that endowed the ME Department Chair position at U-M. This is the first endowed Department Chair in the history of the College of Engineering.

"This generous endowment from Tim and BorgWarner will generate funds that will enable new initiatives of significant importance to the Department of Mechanical Engineering and will help us achieve some of the goals that we established in our strategic plan," said Department Chair **Kon-Well Wang**.

BorgWarner also has donated a generous gift to name the Galleria in the new ME research complex addition (see page 4 for details) and has been a major sponsor of ME's SAE International MRacing team.

Manganello is a familiar face around the Department and College. He visits campus regularly as a mentor to speak to ME students in classes and in student societies, and he has served as a member of the College's Engineering Advisory Council.

RIGHT: Tim Manganello speaks at the ceremony announcing the gift



"This generous endowment from Tim and BorgWarner will generate funds that will enable new initiatives of significant importance to the Department of Mechanical Engineering and will help us achieve some of the goals that we established in our strategic plan."

Faculty Win Early Career Awards

Assistant Professor **Samantha Daly** has earned a National Science Foundation CAREER award, the agency's most prestigious award for early-career faculty. Daly won the award for her proposal, "Understanding Micromechanisms of Fatigue in Shape Memory Alloys."

Daly will investigate the fundamental mechanisms responsible for fatigue failure in materials known as shape memory alloys (SMAs), with a focus on deformation and phase transformation at the microstructural length scale. Understanding the links between microstructure and macroscopic behavior is a fundamental challenge in the design and use of materials. Components made from SMAs, such as in military, aerospace, biomedical and automotive applications, increasingly are being used under fatigue conditions, and a quantitative understanding of the effect of microstructure on their fatigue behavior is critically necessary.

The unique quantitative information on phase transformations that results from Daly's work will be used to improve the accuracy of lifetime and performance predictions as well as the optimal design of SMAs.

Daly also is planning several related educational efforts, including undergraduate summer internships, a collaborative effort with the Department of Mathematics at the University of Bristol, incorporation of research results into coursework and dissemination of research findings through a public seminar series and television show.

SAMANTHA DALY

Assistant Professor **Vikram Gavini** has been selected as an awardee in the Air Force Office of Scientific Research (AFOSR) Young Investigator Research Program (YIP). This year, the AFOSR awarded approximately $15 million in grants to 40 winning proposals through the program.

Gavini earned the award for his proposal, "Quasi-continuum reduction of field theories: A route to seamlessly bridge quantum and atomistic length-scales with continuum." He is the leader of the Computational Material Physics Group at U-M. His research team aims to develop computational and mathematical techniques to address various aspects of materials behavior, which exhibit complexity and structure on varying length and time scales.

The YIP recognizes scientists and engineers at research institutions across the United States who received PhD or equivalent degrees in the last five years and who show exceptional ability and promise for conducting basic research.

VIKRAM GAVINI

Gavini Wins Alexander von Humboldt Foundation Research Fellowship

Assistant Professor **Vikram Gavini** has won a prestigious Research Fellowship for Experienced Researchers from the Alexander von Humboldt Foundation.

Each year the Foundation brings researchers from 130 countries, and across all fields of academia, to carry out their research in collaboration with host institutes in Germany. Gavini was hosted jointly by the Max Planck Institute for Mathematics in the Sciences at Leipzig and the University of Stuttgart.

Gavini's research focuses on computational materials physics, with an emphasis on developing computational techniques for predictive modeling of complex materials systems. His work draws ideas from quantum mechanics, statistical mechanics and homogenization theories to create multi-scale models from fundamental principles.

Winners of the Humboldt Research Fellowship have established international reputations for research of the highest caliber. University of Michigan Professor of Mechanical Engineering Krishna Garikipati was a recent past winner of a Humboldt Research Fellowship.

The Humboldt Foundation was founded in 1953 and promotes international cultural dialogue and academic exchange. The Foundation currently boasts 48 Nobel Laureates among its 26,000 alumni.

Meet New Faculty

The ME department welcomes **Neil P. Dasgupta**, who is joining the faculty as assistant professor. He earned his PhD from Stanford University and is currently a postdoctoral fellow at the University of California, Berkeley.

Dasgupta's research lies at the intersection of nanotechnology, energy conversion and storage, and manufacturing. His goal is to develop scalable, low-cost techniques for nanomaterial fabrication to address complex energy-related environmental challenges.

Using techniques from several disciplines, Dasgupta's work has focused on the atomically-precise characterization and modification of surfaces and interfaces, which are fundamental to all energy conversion devices. His energy science research projects have focused on solar energy, catalysis and electrochemical energy storage.

At U-M, Dasgupta plans to develop new nanoscale materials and devices for energy applications, with an emphasis on earth-abundant materials, low-energy inputs and low-cost manufacturing processes. His expertise in the mechanical design of nanomanufacturing systems, design and characterization of energy devices and a strong foundation in basic materials chemistry will allow him to "explore new manufacturing processes to scale-up nanomaterials research from the laboratory to the factory. Tackling clean energy challenges requires large-scale production of high-quality materials at costs competitive with existing fossil-fuel resources," he said.

Drawn to U-M ME by the breadth and depth of the Department's technical expertise and strong interdisciplinary emphasis, Dasgupta also is excited about the new ME research complex (see related story on page 4), where his laboratory will be located. "I look forward to the opportunity to collaborate with the brightest minds—faculty and students alike—to inspire new research directions and scientific breakthroughs."

NEIL P. DASGUPTA

ME Faculty Selected for $120 Million Advanced Battery Research Partnership

DONALD SIEGEL

JYOTI MAZUMDER

S. JACK HU

A new Energy Innovation Hub established by the U.S. Department of Energy (DOE) will draw on the expertise and contributions of ME professors **Donald Siegel, Jyoti Mazumder** and **Jack Hu**. The three will work with other U-M researchers in materials science and chemistry to advance next-generation battery and energy storage technologies for hybrid and electric cars and a power grid that can store electricity generated from solar and wind energy.

One of five universities selected to participate in the DOE's Joint Center for Energy Storage Research (JCESR), U-M will receive $7 million of a total $120 million awarded for the project. The national research partnership also includes five national laboratories and four private companies, led by Argonne National Laboratory.

"This is a partnership between world leading scientists and world leading companies, committed to ensuring that the advanced battery technologies the world needs will be invented and built right here in America," said U.S. Secretary of Energy Steven Chu.

The JCESR is one of several DOE Energy Innovation Hubs that bring together many institutions and combine basic and applied research with engineering to accelerate scientific discovery in critical energy areas.

Peng Reports Advances in Clean Vehicle Research

The U-M-led Clean Vehicle Consortium (CVC), part of the $150 million U.S.-China Clean Energy Research Center (CERC), is on a mission to speed technological advances to improve fuel efficiency and reduce oil consumption. In January 2013, ME Professor **Huei Peng**, the U.S. director of the CERC - CVC, provided a progress update to officials from the U.S. Department of Energy and China's Ministry of Science and Technology.

The CVC is entering its third year of a five-year funding cycle and has made strides in the past 12 months, both in its six technical areas and its overarching goals. Scientists and engineers from academia, national laboratories and industry partners in both countries work together on the CVC's six research thrust areas: advanced batteries and energy conversion, advanced biofuels and clean combustion, vehicle electrification, advanced lightweight materials and structures, vehicle-grid integration and energy systems analysis. Fourteen U-M faculty and 16 graduate students are part of the effort.

The meeting, held in Washington, D.C., and led by U.S. Secretary of Energy Steven Chu and Chinese Minister of Science and Technology Wan Gang, also focused on two other current, joint energy research projects: coal technology and energy-efficient buildings.

LEFT TO RIGHT: Huei Peng, professor of mechanical engineering and U.S. director of the U.S. China Clean Energy Research Center—Clean Vehicle Consortium; Secretary of Energy Steven Chu; and Haoran Hu, chief scientist for Eaton Corp., a partner on the U-M-led consortium.

The CERC's founding in 2009 marks groundbreaking collaborations and intellectual property agreements between the U.S. and China on energy research and provides an avenue for the world's two biggest energy consumers to leverage, rather than duplicate, research investments.

Ni Advises World Economic Forum on Advanced Manufacturing

JUN NI

The economic downturn of 2008 and 2009 took a toll on countries around the globe. In response, the World Economic Forum (WEF) established a Global Agenda Council on Advanced Manufacturing in 2010 and turned to ME Professor **Jun Ni** to serve as vice chair.

Ni was selected by the WEF to help lead the Council after his 2008 keynote address on advanced manufacturing in Beijing.

"Many countries, including developed, emerging and developing, have been trying to identify what they can do to improve their manufacturing base, because manufacturing is such a vital foundation for economic development and the creation of high-paying jobs," Ni said. "But with so many stakeholders, their respective interests don't always align," he added.

To address that challenge, the WEF Global Agenda Council on Advanced Manufacturing serves as a neutral platform from which representatives from government, industry and academia can take a holistic view and identify strategies and policies for improving the global manufacturing landscape.

To date, the Global Agenda Council on Advanced Manufacturing has contributed to two WEF studies, The Future of Manufacturing and Manufacturing for Growth. It also is working on a competitive index to better elucidate interactions in the global value chain.

"If you take a single product," Ni said, "you're likely to find components from many countries; the product may have been designed in the United States and assembled in China—the value is distributed across many nations. With the new index, we're trying to understand all of those connections."

The Council also currently is working on strategic recommendations for supporting high-level, public-private dialogue and promoting manufacturing investments to take to the G20 Leaders' Summit in Russia in September 2013.

"The Council's work extends beyond the borders of the participating countries," Ni said. "Without change, the current level of global manufacturing cannot be sustained. There are many challenges, but we believe the cooperative approach of the Council can have a huge impact on overcoming them."

Brei Featured in ASME Video on Aerospace Materials

A recent video on the American Society of Mechanical Engineers website features a familiar face: ME Professor **Diann Brei**. In the video, Brei talks about new developments in aerospace materials. In particular she describes smart materials such as shape memory alloys -- lightweight materials that have the ability to react to a stimulus and "remember" their former state, much like muscles. These materials are being used to develop nature-inspired air vehicles and to improve the aerodynamics of automobiles. Engineers also use them to monitor vibration and other stresses in wind turbines.

The expertise of mechanical engineers is critical to any aerospace system, Brei said. These systems are some of the most complex and interdisciplinary, she added, requiring a synergistic and team-based approach. They provide many opportunities for mechanical engineers who want to "dream, and then really make a difference in their society."

DIANN BREI

+ more on the web

Watch Professor Brei discuss new developments in aerospace materials at **www.asme.org/kb/news---articles/media/2013/01/video-new-developments-in-aerospace**

ME Faculty-Led Big 10 Women's Mentoring Workshop Inspires Junior Faculty

Following an overwhelmingly successful inaugural event in 2010, ME professors **Ellen Arruda** and **Dawn Tilbury** co-organized a second Big 10 Women's Mentoring and Networking Workshop, held in 2013.

The two-day event, which took place in Milwaukee in April, drew some 60 female assistant professors and senior female faculty from Big 10 and other universities. Engineering deans from the Big 10 schools and several industry sponsors also participated.

Graduates of Big 10 schools account for more than 10 percent of bachelor's degrees in engineering and almost 17 percent of engineering PhDs in the United States. "The impact of these schools is big," said Tilbury, "and so affecting change at these universities can have a large impact on the careers of women faculty who participate in the workshop as well as on their engineering students."

Networking and mentoring are extremely important in professional careers, but "women assistant professors in engineering are often busy doing 100 different things and are not focused enough on these activities," added Arruda. "We wanted to design a workshop that would be helpful, not only because of opportunities for networking and mentoring, but also because of the wealth of specific, no-nonsense wisdom shared by a critical mass of highly successful senior women faculty."

Martha Pollack, vice provost for academic and budgetary affairs at U-M and professor of computer science, gave the workshop's keynote address. Session topics included management, negotiation, communication, entrepreneurship, identifying mentors and work-life balance. Industry panelists discussed opportunities for junior faculty. Participants shared their research and provided peer support and problem-solving advice to colleagues.

"The feedback from the workshop was incredibly positive again this year," said Arruda. "Many of the junior faculty noted specific things they were going to do as a result of participating."

Both Arruda and Tilbury expect another workshop in 2016, likely with new leadership. Said Tilbury, "This workshop has been very valuable for the faculty who attended, and we hope that future generations of junior women faculty will also have the opportunity to attend such an event."

Improving Mobility:
Insights Shared at 19th Automotive Research Center Review

"Mobility is key to the success of ground vehicle platforms; this includes robots," said Dr. Paul Rogers, director of the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) in his keynote address at the 19th Annual Program Review for the U-M-led Automotive Research Center (ARC).

Sponsored by TARDEC and directed by ME Professor **Anna Stefanopoulou**, the ARC is a Center of Excellence for ground vehicle modeling and simulation and focuses on basic scientific research in three areas: vehicle power and energy, mobility and safety.

LEFT: Dr. Paul Rogers, director, U.S. Army TARDEC, delivers his keynote address at the 19th Annual ARC Program Review

RIGHT: 19th Annual ARC Program Review attendees

ARC research covers many factors that influence ground vehicle mobility. Some projects focus on vehicle dynamics, new fuels, energy storage mediums and powertrain strategies, while others link the output from diverse topics into an integrated simulation framework.

Nearly 300 members of the automotive research community—representing academia, government and industry—met on North Campus for the two-day review in June. Attendees discussed the latest results from 33 individual ARC research projects.

Dr. **Tulga Ersal**, U-M assistant research scientist and ARC research integration lead, presented a case study that brought together four ARC projects. In this case, algorithms for optimal velocity for coverage planning with minimal energy were integrated with battery electrothermal models for managing the power source limits, physics-based simulations of terramechanics for predicting power requirements of versatile terrains, and online prognostics of remaining mission energy. The case study described the benefits of an integrated simulation framework to improve the mobility of a robot for a given mission through increased intelligence to optimize system performance.

Program keynote speakers from Cummins and General Dynamics highlighted the impact of the modeling and simulation tools developed by the ARC. In a climate of increased funding challenges, it is important to provide value to the customer, said ARC Director Stefanopoulou. "Not just for our sponsor TARDEC, but also for our industry partners who implement our findings in their next-generation products."

ME Faculty Retreat: Focus on Education and Curriculum

Participants in the annual faculty retreat, held in May 2013, spent a half-day discussing important topics related to ME educational programs and the curriculum.

Forty faculty attended the off-site event to share outcomes over the past year and continue in-depth grassroots discussions around a number of priorities identified in the Department's strategic plan. Since adopting the plan in 2010, the Department has made significant progress toward the strategic goals identified, including undergraduate and graduate education, faculty and staff development, research programs, facilities and space, and external relations.

During this and last years' retreats, faculty participants discussed ideas and proposals for the undergraduate program, including enhanced research opportunities and increased flexibility and technical diversity. Discussions about the graduate program included improved doctoral qualifying exams and program enhancements for master's students pursuing professional rather than research routes.

"Building upon a successful 2012 retreat, we had even more fruitful discussions this year," said **Kon-Well Wang**, Tim Manganello/BorgWarner Department Chair. "In alignment with the strategic plan, the Department already has made many changes, and faculty are motivated to continue that progress over the coming year and implement some of the proposals presented in May."

ME Student-Athletes Win NCAA Swimming Championship

The ME department was well-represented when the U-M men's swimming and diving team won the NCAA Division I championships in March 2013, a title the team has not held since 1995.

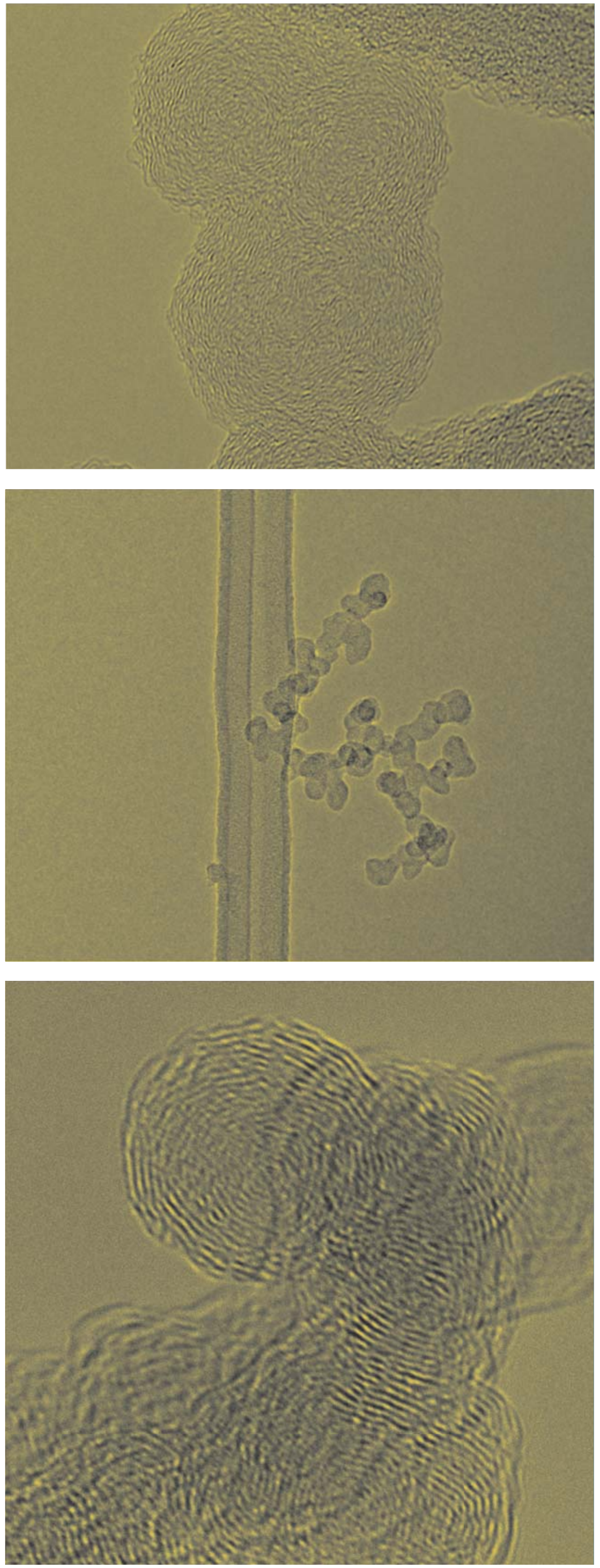
The four ME students included three swimmers—**David Moore**, **Sean Ryan** and **Connor Jaeger**—and diver, **James Ross**. All seniors now, the four embody the term "student-athlete." All are key members of the U-M swimming and diving team.

In addition, at the World University Games in Russia in July 2013, Ryan took home a gold medal. He finished the 1,500-meter freestyle in 14:57.33, ranking him fifth in the world.

Jaeger was an Olympian and 2013 Big Ten Swimmer of the Year. In June, at the U.S. Qualifiers Meet in Indianapolis, Jaeger placed first in the 400-, 800- and 1,500-meter freestyle. His 1,500-meter time (14:53.34) ranked him third in the world for that race. And, at the 2013 FINA World Championships in Spain, Jaeger won a bronze medal for the 400-meter freestyle.

"As impressive as their performance is in the pool, these student-athletes are also outstanding ME students because of their discipline and attention to detail," said Professor **Albert Shih**, who taught the group in Design and Manufacturing I (ME 250) and serves as their undergraduate research advisor.

Understanding and Developing Biofuels for Advanced Combustion



Biodiesel and other alternative fuels present a number of benefits along the road to improved fuel efficiency and energy independence. Biodiesel can be produced domestically from renewable, plant- or animal-based oils and can burn cleaner than petroleum-based diesel.

"But there is still a lot we don't fully understand and a lot we can improve upon," said Professor **André Boehman**, who joined the U-M faculty in 2012. Boehman's work centers on advanced fuels and combustion, emissions and exhaust aftertreatment, to make these fuels burn cleaner and more efficiently in internal combustion engines.

Boehman's research is highly interdisciplinary and spans combustion, fuel science, chemistry and materials science. He takes a wide, holistic view of alternative fuels, looking all the way back to the feedstocks grown to make the fuel, including plant genomics and crop and soil characteristics. His work in the U-M Lay Automotive Laboratory builds on previous research conducted at The Pennsylvania State University, where he served on the faculty for 18 years.

Several years ago while conducting research on exhaust aftertreatment, Boehman discovered that when biodiesel was burned in a turbodiesel engine, the character of the particulate matter, or soot, in the exhaust changed. In seminal findings, Boehman's research group showed for the first time that emitted soot from biodiesel fuel oxidizes more easily than soot from petroleum diesel. For the regeneration process in mandated particulate control filters, this finding meant that the collected particulate matter could more readily be burned off to improve filter effectiveness.

"Our mission is to improve the performance and efficiency of engines while reducing pollutant and life cycle carbon emissions to enable a sustainable transportation system."

"The effect we found showed that the soot was more easily burned off the filter during regeneration; it was a beneficial effect, and it made it quicker and easier to get rid of those unwanted particles," Boehman said.

The research included characterization of the nanostructure and the reactivity of soot particles. Boehman and colleagues sampled particles from exhaust gases and generated high-resolution, transmission electron microscopy images that provided a window inside individual, primary particles of soot. The particles structures range from some with neat, well-aligned layers and while others displayed an amorphous internal structure.

"We saw the spectrum," Boehman said, "from being completely non-structured to highly ordered graphitic layers. Some look like an onion in cross section, while others look like a bowl of noodles," he joked.

With a MATLAB-based software application he developed for quantitative analysis, Boehman's team was among the first to realize that the variation in structure also meant a variation in the reactivity of the particles, in other words in the oxidation mechanisms and how the particles burned. The more disordered the structure, the more reactive the particles. "We learned that oxidation was strongly controlled by the nature of the fuel you burn as well as by specific combustion conditions," he noted. Work continues in his lab on how advanced combustion strategies influence soot characteristics, which will aid in the further development of control strategies.

Boehman's work also has elucidated why biodiesel fuels and blends increase nitrogen oxide (NOx) emissions. Working with colleagues at Sandia National Laboratories during a 2006 sabbatical, Boehman conducted experiments leading to identification of the cause of the NOx increase as well as methods for controlling it. The studies were recognized with two national awards from the Society of Automotive Engineers.

Currently Boehman is investigating how fuel formulation can improve advanced combustion strategies. As the diesel combustion community moves to more dilute combustion and lower combustion temperatures in an effort to reduce emissions and improve thermal efficiency, "you tend to get higher levels of carbon monoxide and hydrocarbons that can be reversed with better fuel design," Boehman said.

Over the past year he and his research group have developed a "recipe" for fuel formulation that works well with advanced combustion strategies and doesn't yield increased carbon monoxide and unburned hydrocarbon emissions. Much of the research used Fischer-Tropsch diesel, a fuel not widely available in the United States, but Boehman is addressing that issue as well. He is looking into cost-effective ways to make similar fuels domestically from plant oils, currently from camelina oil, that isn't used as a food source.

"Our mission is to improve the performance and efficiency of engines while reducing pollutant and life cycle carbon emissions to enable a sustainable transportation system," Boehman said.

Boehman's extensive work characterizing fuel particulates also has led him to a new project, recently funded by the U-M MCubed initiative. With colleagues from the Medical School, he will investigate the potential health effects of soot nanoparticles from indoor gas cooktops and direct injection gasoline engines. The group's goal is to explore how ultrafine particles may exacerbate asthma. Future studies will also look at cancers related to particle inhalation.

These images are soot transmission electron microscopy (TEM)s and high-resolution transmission electron microscopy (HRTEM)s. **Photo credit: Current student, Chenxi Sun, and former student Dr. Juhun Song**

Understanding Heat Dissipation in Nanoscale Devices

As electronic devices become smaller and more powerful, there's one major stumbling block scientists and engineers have yet to fully understand and overcome: heat.

When electrical current passes through a conductive material, it generates heat. This process, known as Joule heating, results from the conversion of kinetic energy of the charge carriers —such as electrons and holes—into random atomic motion. Knowing precisely where within a system the temperature will rise, and by how much, is critical for the design of reliable, high-performance electronics, including computers, cell phones and medical devices.

At the macroscale, Joule heating is well understood and can be characterized using classic laws of physics. But these laws don't apply when it comes to describing heat dissipation and transport at the nanoscale and in atomic-scale devices.

"Currently, the lack of understanding of heat dissipation phenomena at the nanoscale poses a serious obstacle to technological progress towards creating nanoscale information processing and energy conversion devices," said **Pramod Sangi Reddy,** associate professor, who runs the Nanoscale Transport Laboratory.

"Today's transistors are nearing the 20- to 30-nanometer size, and their active regions have very small dimensions," Reddy added. Heat dissipation and the resultant temperature change in such nanoscale regions dramatically affect stability and performance.

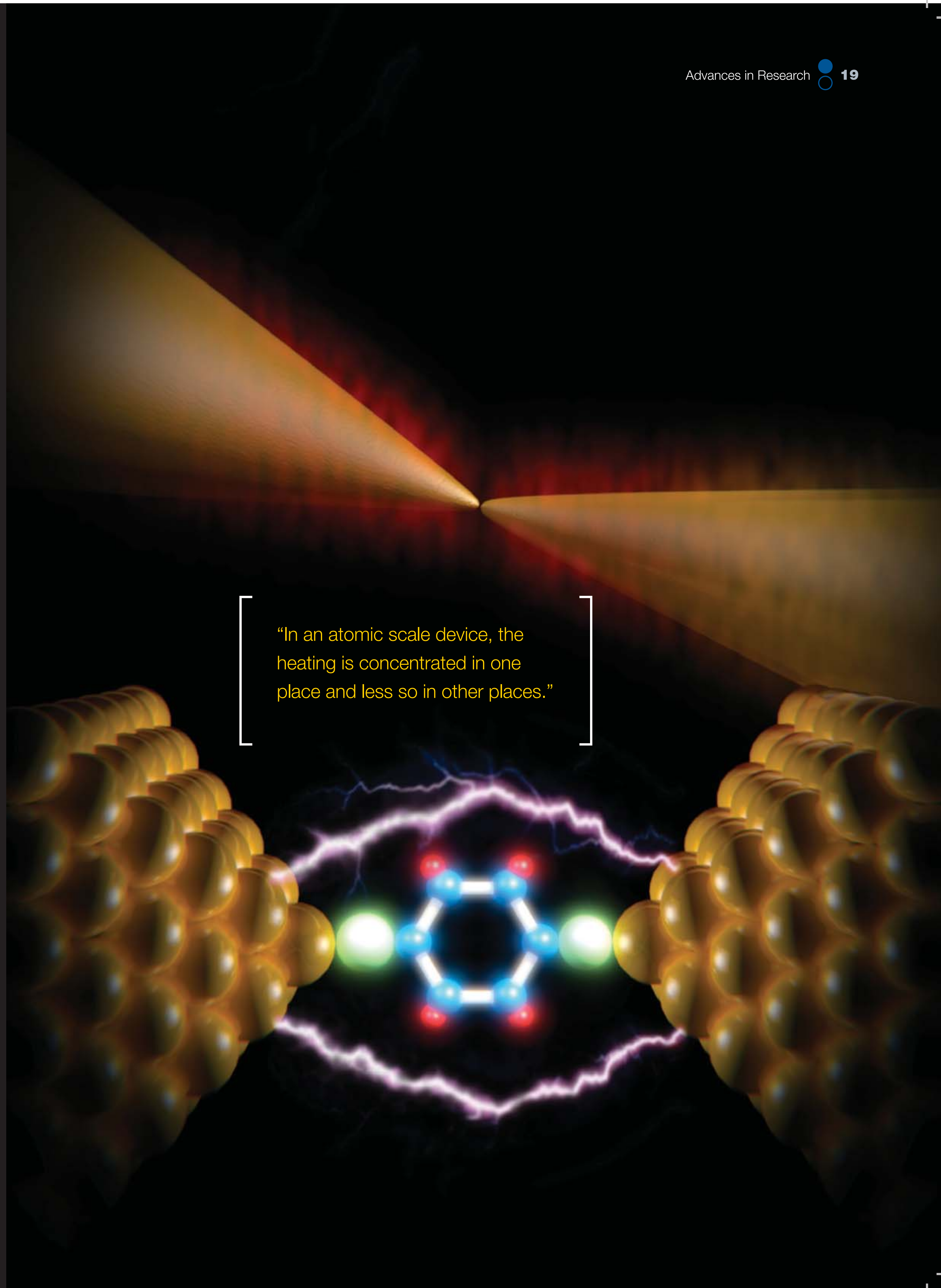
In work published in Nature in 2013 (DOI: 10.1038/nature12183), Reddy and colleagues in Germany and Spain have, for the first time, shown experimentally how a prototype atomic-scale electronic system heats up. The team demonstrated that heat dissipation in the electrodes of junctions is unequal and dependent on both the bias polarity and the identity of the majority charge carriers, either electrons or holes. In other words, when a nanometer-sized molecule acting as a "wire" connects two electrodes, the temperature predominantly rises in only one of them. By contrast, at the macroscale, the whole wire heats up, as do all of the electrodes connected to it.

"In an atomic scale device, the heating is concentrated in one place and less so in other places," Reddy said.

To carry out the research, Reddy's group developed several novel experimental tools and approaches. He and the team of two graduate students, **Woochul Lee** and **Wonho Jeong**, and a postdoctoral researcher, Dr. **Kyongtae Kim**, have created molecular scale junctions and custom-fabricated scanning probes with integrated nanoscale thermocouples in order to investigate thermoelectric effects, heat dissipation and heat transport.

The researchers also have established a framework that can be applied to heat dissipation in multiple types of nanoscale systems. The novel experimental tools Reddy and his team have devised will enable further and systematic studies of heat dissipation and transport at the atomic scale and ultimately have a significant impact on many fields.

The research at U-M was funded by the U.S. Department of Energy (DOE), the National Science Foundation and the DOE Center for Solar and Thermal Energy Conversion.



An artist's representation of atomic-scale heat dissipation, which poses a serious obstacle to the development of novel nanoscale devices. University of Michigan engineering researchers have, for the first time, established a general framework for understanding heat dissipation in several nanoscale systems. **Image credit: Enrique Shagun, Scixel**

"In an atomic scale device, the heating is concentrated in one place and less so in other places."

Turning Phonon Energy into Electric Potential
to Improve Device Performance

"Improving the efficiency through innovative design of the energy transport and conversion requires us to tailor, at the atomic level, the kinetics of the related principal energy carriers."

Improving the efficiency of energy conversion and reducing waste heat while improving the performance of high-power electronic and optoelectronic devices has long been a goal of engineering researchers and device developers.

"Improving the efficiency through innovative design of the energy transport and conversion requires us to tailor, at the atomic level, the kinetics of the related principal energy carriers," said Professor **Massoud Kaviany**, who heads U-M's Heat Transfer Physics laboratory.

Those principal energy carriers include phonons, electrons, fluid particles and photons, and Kaviany and his research team design atomic-level structures, including nanostructures and quantum confinements, in order to optimize the carrier energy kinetics. Recently his group has focused its attention on the use of heterobarriers, which are sudden changes in semiconductor material composition, used to reverse and reclaim some of the energy loss that occurs in electric resistive heating. The barriers allow for the moving electrons to gain some electric potential.

Electric current is the flow of those electrons that are free to move. In solids, they are found in the conduction band. The electrons in circuit gain energy by absorbing phonons, or collective inter-atomic vibrations associated with heat. These conduction electrons gain kinetic energy and move along because of an imposed electric field. Their number per unit volume depends on material additives, called dopants. Along the way, due to the electrical resistance that exists in all conductors, they lose their potential energy and create phonons. Now, the heterobarrier helps the electrons pick up phonon energy to gain potential energy while climbing up over it. This is called phonon recycling.

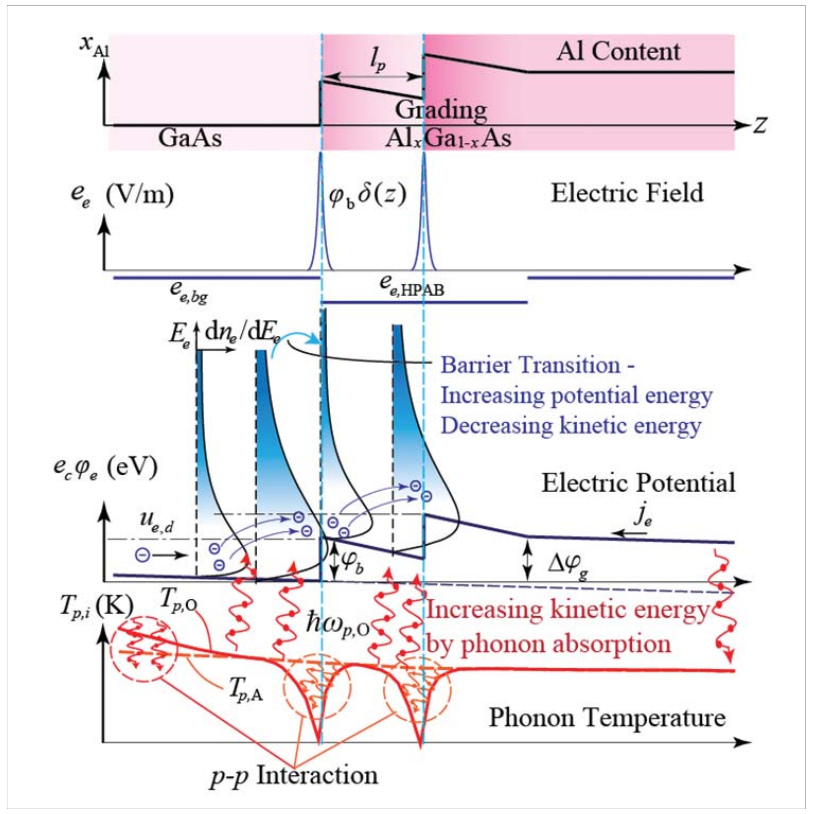
If a drifting electron meets a sudden variation in material composition—specifically a material that has been engineered so that the band gap is increased by nearly the amount of energy the electron has absorbed from the phonon—then the electron's electric potential becomes higher; it will not drop back to its previous energy level. In a circuit, the change in material composition, in other words the heterobarrier, can be used to take advantage of these excited electrons and boost their potential.

"The heterobarrier is engineered such that the increase in the band gap energy of the designed material is nearly equal to the energy given to the electron by a phonon," explained Kaviany. After the electron meets the heterobarrier, a continued, gradual change in material composition keeps the electron moving along at its new, higher, energy level.

There is a price associated with the energy boost, albeit a small one. "The cost of moving the electron along means that the potential decreases slightly," Kaviany said. "But if we introduce additional heterobarriers downstream, we can further raise the electric potential to compensate."

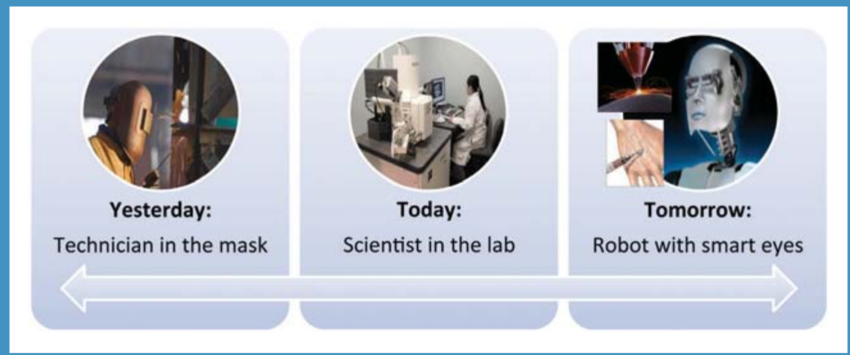
Monte Carlo simulations based on the interactions between electrons and phonons conducted by Kaviany and his team show that almost 20% of phonon energy can be converted to electric potential through use of a heterobarrier. "The heterobarrier changes the role of the phonon from energy thief to donor," he said, "from causing a drop in electric potential to causing a gain or recovery."

The work, published in the American Physical Society's *Physical Review B* (DOI: 10.1103/PhysRevB.87.075317), promises to have a significant impact. "We have shown that using this architecture in high-power circuits can lower device operating temperature and improve device efficiency and performance," Kaviany said.



LEFT: Distributions of aluminum content, electric field and potential, and phonon temperatures in the hot-phononabsorbing barrier structure. Aluminum content abruptly increases, creating the potential barrier, while the grading maintains the current. Phonon absorption populates electrons with higher energy than the barrier height, and this energy is converted to electric potential. The population of optical phonons quickly decreases at the barriers and recovers by upconversion.

Plasma Sheds Light on Manufacturing Quality



On-line quality control of manufactured parts has long been a vexing, and costly, problem for manufacturers of all types, including companies using more recent, advanced additive manufacturing processes such as direct materials deposition, light engineered net shaping and directed light fabrication.

"As engineers, we're problem solvers," said Professor **Jyotirmoy Mazumder**, who directs the U-M Center for Laser-Aided Manufacturing, "and how to detect defects in situ in manufactured parts and reduce scrap is a problem many industries have been facing for quite a long time."

Through his extensive research over the past 30 years on laser-aided manufacturing, Mazumder discovered more and more attributes and defects that can be identified through the plasma generated during certain manufacturing processes. Now he has developed a diagnostic and control system, dubbed the Smart Optical Monitoring System (SOMS), that analyzes that plasma in real-time, identifies and categorizes defects and potentially controls them. The system is the first and, to date, only one with the capability to provide in situ monitoring of phase transformation.

Conventional methods to monitor part quality include vision-, acoustic- and X-ray-based technologies. They take time, however, meaning many additional parts might be produced while samples are being analyzed, which results in wasted time and material and added expense.

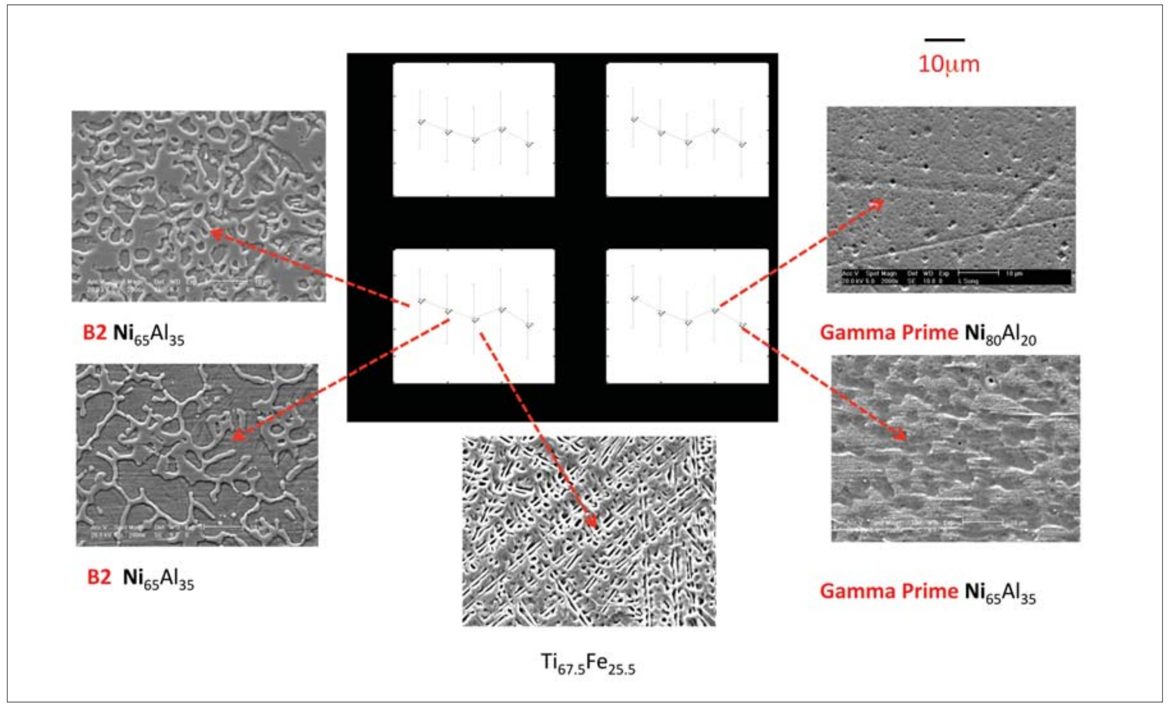
"Convenience, cost, safety and accuracy -- these are all factors we thought about from the beginning of the design process and built in," Mazumder said.

The SOMS system is comprised of an optical fiber, lens and spectrascope that are housed in a casing smaller than a shoebox. The spectrometer separates light wavelengths within plasma, with wavelengths each signifying a particular element; the intensity signifies the concentration. The ratio of elements changes as materials go through different phase transformations, a discovery that Mazumder made in 2010. "We took that discovery and put it into a system that can identify crystalline structure at the precise moment the phases are changing," he said.

The system can measure plasma characteristics directly or from a distance using the integrated lens. The data are then deconvoluted and analyzed with software Mazumder's team developed. The machine operator can view results in real-time via a user-friendly, dashboard-style display on a computer monitor.

From analyzing the plasma byproduct, the system can identify defects including cracks, porosity and surface deformation. It also can monitor and work with numerical control machinery to standardize geometry, temperature and cooling rate, composition and microstructure. Measurements can be taken as frequently as every two to ten milliseconds.

"Ultimately the system will enable manufacturers to 'certify as they build,'" Mazumder explained. "We're creating a new paradigm for advanced manufacturing that enables the identification and avoidance of defects while simultaneously evaluating product properties and quality."



ABOVE: In Situ identification of Ni-Al Alloy Phase Transformation using spectral Line Intensity Ratio

> "Convenience, cost, safety and accuracy—these are all factors we thought about from the beginning of the design process and built in."

Mazumder's invention can work with any type of additive manufacturing system in any industry, from arc and laser welding robotics to automotive and shipbuilding. He has formed a company to commercialize the SOMS system, and prototypes will be delivered to a select few industry beta-testers in summer 2013.

"We're looking forward to getting additional user feedback and making refinements. In the meantime, our research continues. This project is a great example of how fundamental scientific research at the University can be transferred to commercial use, solve long-standing problems that advance new technologies and paradigms in manufacturing," Mazumder said.

The fundamental and experimental research was supported by the Office of Naval Research and the U. S. Department of Commerce Advanced Technology Program. Prototype development has been supported by a National Science Foundation Small Business Innovation Research award.

Printing High Fidelity Electronics and Biosensors
at the Nanoscale

"Our goal is to create a simple yet informative model of the E-jet process—the process is very complex and therefore hard to model all the dynamics within a single framework."

Additive manufacturing is more than a trend or buzz word; it's a key enabling technology that has the potential to shift our current manufacturing paradigm. "Many technologic and economic needs have driven advanced manufacturing toward smaller devices with higher functionality at a lower price point -- that's a set of challenging requirements that we need new technologies and processes in order to meet," said Assistant Professor **Kira Barton**, who joined the ME faculty in 2011.

To address those requirements and maximize the benefits of additive manufacturing, Barton has co-developed methods to advance and control electrohydrodynamic jet, also known as E-jet, printing at the micro- and nanoscale.

Current manufacturing techniques, such as lithography, can create parts at the micro- and nanoscales, but they have limitations, including time, cost, waste and limited material choice. "Many of the harsh materials used in lithography are not compatible with biologic materials, so if you're building a biosensor for example, lithography would typically not be the right method to use," Barton noted.

E-jet printing uses electric fields to draw "ink"—including polymers, metals and biologic materials—from a nozzle and deposit it on a substrate. The process can be used for patterning biosensors, chemical mixing and high-fidelity printing of tiny electronic devices. Although E-jet printing overcomes many of the limitations in existing techniques, it has yet to transition to commercial use.

"Because of its high-resolution printing capabilities—we're talking less than 200 nanometers," Barton said, "and the diversity of inks we can print with, E-jet can work for a broad range of high-value applications. But for it to reach its full potential at that resolution, there are some complex issues related to modeling, process sensing or monitoring, and quality control that we have to address first."

Barton's research group is working to understand the fundamental science behind the E-jet technique in order to fuel such advances. Her research work includes innovative designs for advanced process capabilities, as well as the development of new modeling, sensing and control methods that will make the E-jet process a viable advanced manufacturing technique at these high-resolutions.

Traditional mechanisms for sensing, such as vision, are not typically viable at high resolutions. "Right now, these fabrication processes run open-loop," Barton said. "There are no sensors, models or integrated control. You start the process, optimize some parameters during a calibration phase, and then let the process run." Printing defects are not uncommon, since the lack of sensing and control make the process vulnerable to environmental and other unanticipated disturbances.

To remedy this, Barton and her team are investigating the complex interactions between the environment and the E-jet process and working to create a comprehensive model.

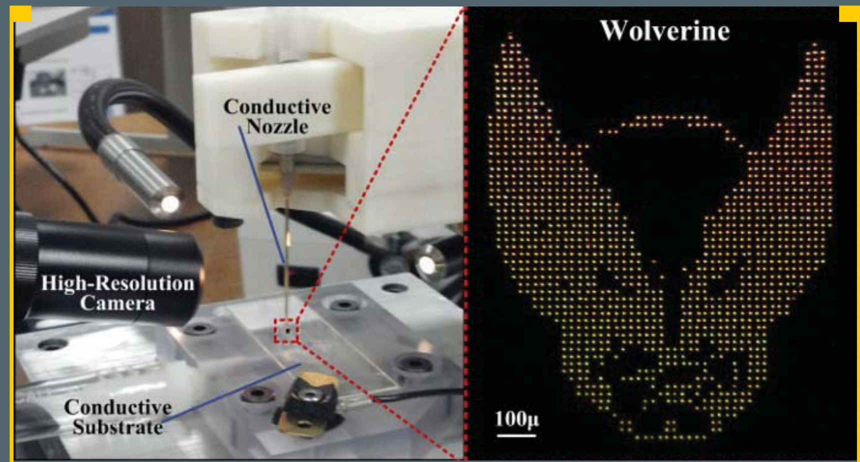
"Our goal is to create a simple yet informative model of the E-jet process – the process is very complex and therefore hard to model all the dynamics within a single framework," she said. "Simulation and experimental analysis will help us select the key process parameters, which we'll then integrate into strategies for monitoring and real-time control."

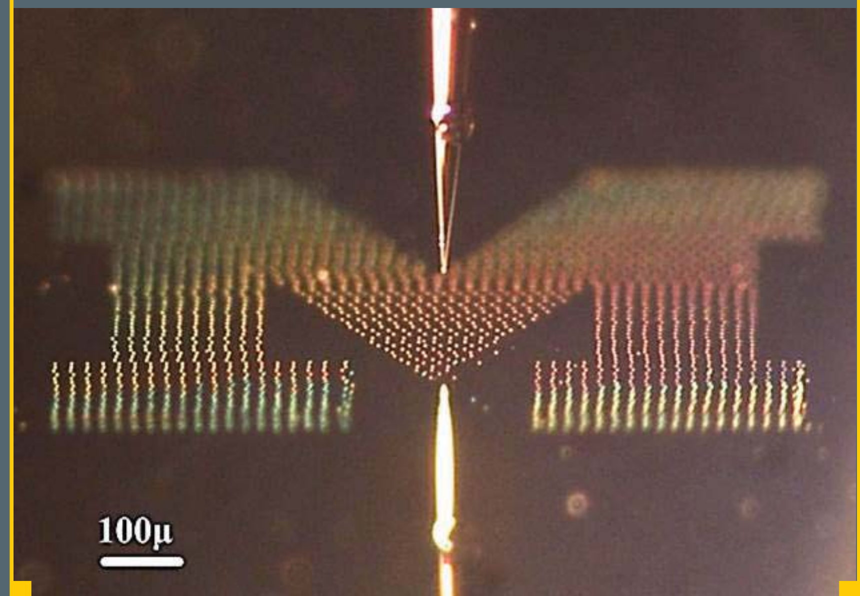
Barton's team also developed innovative printhead designs that make the E-jet process more flexible and broaden the range of applications for this process. She recently demonstrated a novel, advanced printhead that allows controlled, high-resolution deposition of silver and other materials on non-conductive surfaces. "This gives us the ability to not only print multiple, diverse materials in a range of viscosities, including particles suspended in materials, but it also lends itself to creating electrical connections and biological sensors on a range of substrates, including flexible surfaces," she said. "This has the potential to transform the way we use E-jet printing now by allowing us to print onto virtually any surface, a key enabling technology required for generalizable 3D printing."

In collaboration with the U.S. Air Force, Barton has been exploring new materials and novel ways of creating sensors with customized capabilities that might not be compatible with more established printing techniques. "E-jet is a natural potential process for these sensors and could provide the flexibility the Air Force is looking for as well as the resolution," she said.

Barton's research permeates the classroom as well. "As an educator, I want to help change the perception of what manufacturing is -- it's so much more than people realize." Getting that message out to the next generation of students and to the public more generally is important. Barton and her students have been working with the Ann Arbor Hands-On Museum to develop an exhibit to demonstrate advanced manufacturing capabilities and the differences between additive and subtractive manufacturing.

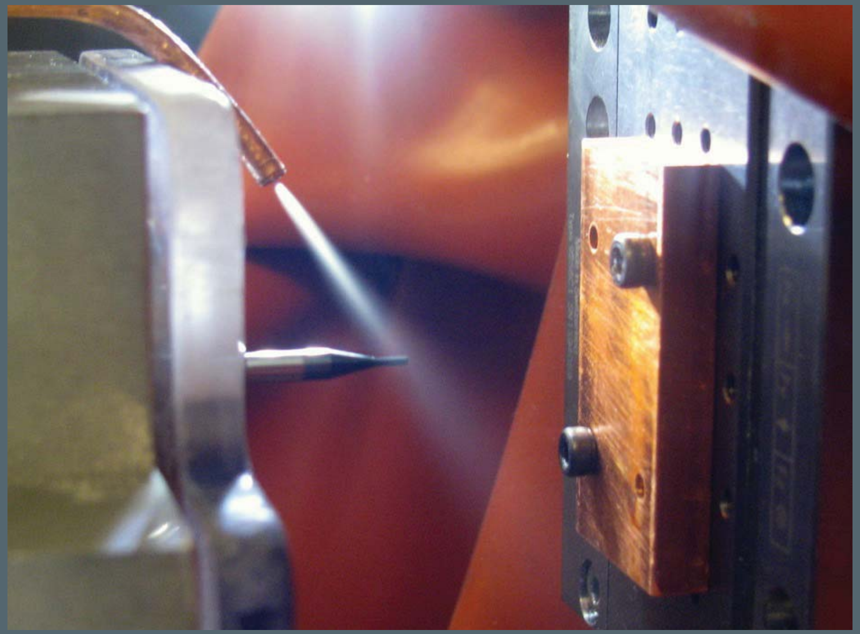
"There's some very exciting, interesting and creative work being done in the field," Barton said, "and we want to help transition those new ideas about manufacturing to the mainstream."





TOP: E-jet set-up located in the Barton Research Lab. Image of a wolverine printed on the e-jet set-up. Droplets are 3-4 times smaller than state-of-the-art printing processes.

BOTTOM: Block M printed using the e-jet system. Top nozzle image is the actual nozzle, while the bottom image is a reflection picked up by the substrate.



TOP: Recycled carbon dioxide spray delivering minimum quantity cooling and lubrication to a micromachining process

BOTTOM LEFT, RIGHT: Recycled carbon dioxide spray removing heat and delivering controlled quantities of lubricant to a machining process

Lab-scale version of the anaerobic membrane bioreactor for wastewater treatment and energy generation

> "Our goal is a net-zero process, which is one of the many forms that sustainability can take in engineered systems."

Sustainability
by Design

Sustainability might seem like an abstract concept unless it's used as a source of innovation to improve the environmental and social aspects of engineered systems. The research of **Steve Skerlos**, Arthur F. Thurnau Professor of Mechanical Engineering, does just that, spanning disciplines to address sustainability challenges in areas of environmental policy, product design, manufacturing and water treatment.

"We seek out the important sustainability questions that aren't currently being asked, and are willing to venture wherever solutions may lead us—energy, water, policy, manufacturing, you name it," said Skerlos, who also serves as director of Sustainability Education Programs for the College of Engineering and the director of the College's new Program in Sustainable Engineering.

Skerlos' work is frequently highlighted by the media for the currency and immediate relevance of his findings. A recent study, published in the journal *Environmental Science & Technology*, looked at the issue of pharmaceuticals in water. The research team focused on three common methods of discarding unused prescription drugs: so-called "take-back" programs, throwing them in the trash and flushing them down the toilet.

The modeling work Skerlos' team carried out showed that throwing unused pharmaceuticals in the trash was nearly as effective as take-back programs in terms of keeping active drug ingredients out of drinking water sources while generating an order of magnitude fewer air pollutants, such as smog and greenhouse gas emissions.

"We shared our findings with decision makers locally and in Washington D.C., and as with our recent studies on Corporate Average Fuel Economy standards for vehicles, we've found that our results have received high-level attention and are being acted upon," Skerlos said. "These are the problems we like to work on, where the research points to a clear and promising solution."

Skerlos and his research group also have devised a solution to a longstanding problem in the field of manufacturing: the metalworking fluids commonly used to cool and lubricate machining tools come with high financial, human and environmental costs. They are comprised of toxic chemicals, consume a lot of water, harbor bacteria, present health risks when inhaled, are difficult to dispose of, and can account for up to 18 percent of manufacturing costs. "They are a necessary evil," he said.

To find a promising solution, Skerlos' laboratory investigated the problem from multiple angles, looking at less toxic formulations, alternative recycling and disposal practices, new methods of bacterial control and other approaches. The result after a decade of research was the creation of a new type of metalworking fluid based on waste carbon dioxide compressed to its supercritical state.

Supercritical carbon dioxide is a highly efficient carrier of lubricants and also cools more efficiently than oil- and water-based metalworking fluids. It eliminates the health hazards and waste disposal and water consumption issues found today in factories all over the world. The invention led to a spin-off venture, Fusion Coolant Systems, which recently received its first round of funding from the U-M Frankel Commercialization Fund, private investors, the State of Michigan and the National Science Foundation. After several years of laboratory demonstrations and development, the technology is now in pre-production trials.

With colleagues in the Department of Civil and Environmental Engineering, Skerlos also is developing technology to convert wastewater into clean water, fertilizer and a biogas that can be used to generate electricity. This technology would convert today's energy-intensive treatment processes into next-generation sources of reuse water, agricultural input and electricity. Currently, wastewater treatment is responsible for about five percent of the electricity demand in the United States.

The research team has proven the technology in a laboratory setting. Now, a pilot project will begin at a municipal wastewater treatment plant about 10 miles from Ann Arbor. The full-scale bioreactor will treat some 800 gallons of wastewater daily once it goes online in fall 2013. The project is scheduled to run for one year.

"We're working toward wastewater treatment that doesn't require any additional electricity inputs," Skerlos said. "Our goal is a net-zero process, which is one of the many forms that sustainability can take in engineered systems."

Skerlos' passion for sustainability is clear, and he is even more excited about the next crop of sustainability challenges he and his students are targeting. These projects are an eclectic mix as well, ranging from retrofitting old buildings to be net producers of electricity and water to determining how to maximize the production of energy from mixes of industrial and food waste.

"The holy grail for us," Skerlos said, "is not just to create environmentally sustainable technologies, but to determine the mix of existing and emerging technologies that can inexpensively put society's use of material, water and energy on a more sustainable path."

Sustainability through Mechatronics

For Assistant Professor **Chinedum Okwudire**, who joined the ME faculty in 2011, there's one word that describes the motivation for and foundation of the research in his Mechatronics and Sustainability Lab: synergy.

"Really, what fascinates and drives me is the concept of synergy," Okwudire said, "the idea that something can be much greater than the sum of its parts. I believe that maximally exploiting synergy enables us to realize more sustainably engineered systems that can improve quality of life with minimal adverse effects."

To more fully exploit synergy in high-performance engineered systems, Okwudire employs mechatronics, or the integration of mechanical disciplines, electronics, controls and computers. The application of his research spans many fields, from automotive and biomedicine to robotics and manufacturing.

Currently Okwudire is applying his research to the design and control of advanced manufacturing machines in order to improve accuracy and speed—and, therefore, quality and productivity—while minimizing environmental and financial costs. "There are always compromises to be made," he said, "but we can reduce those by more fully exploiting synergy."

Toward that goal, Okwudire is conducting model-based studies of vibration reduction in ultra-precision manufacturing (UPM) machines, such as micro machine tools and coordinate measuring machines. These machines fabricate and measure complex parts with microscale features and nanoscale tolerances. The resulting parts are critical to high-performance microdevices and are largely responsible for advances in biomedicine, electronics, communications and many other fields.

But because of the level of accuracy required during fabrication, UPM machines suffer from unwanted vibration, both ground vibration and residual vibration from the machine itself as it executes motion commands. Manufacturers often use passive vibration isolators to reduce vibration but, while passive isolators are relatively inexpensive, reliable and don't require energy, they are less effective against residual vibration. Active vibration systems, by contrast, apply energy to counteract vibration, which makes them more effective, but it also adds significantly to overall cost and energy consumption.

"If we could use passive systems and achieve satisfactory performance," Okwudire said, "that would be the ideal option, and that's what we're trying to do."

While working in industry before joining the U-M faculty, Okwudire was designing a UPM machine and discovered that changing the location of its passive isolators significantly improved vibration reduction, but he and his colleagues didn't understand why. Now, in research supported by the National Science Foundation and industrial collaborations, he is trying to uncover the underlying principles behind vibration reduction as the isolator location changes.

To date, Okwudire and his research team have gained a clearer understanding of those underlying principles and have been creating a set of guidelines for how to better exploit the positioning of passive isolators and to inform the UPM machine design process. "The machines can become unstable if the isolators aren't integrated properly," he said. "Once we understand more, we will be able to reduce vibrations by optimizing the mechatronics at the design level, without the need for active isolation, which will directly impact manufacturers' bottom lines."

> "Really, what fascinates and drives me is the concept of synergy, the idea that something can be much greater than the sum of its parts."

Okwudire also is working to improve the performance and energy efficiency of feed drives, which coordinate motion in nearly all types of manufacturing machines. Their ability to feed and position parts precisely makes them a key component of overall product accuracy and quality. But feed drives consume a great deal of energy, in part because of their fixed electromechanical structure.

Conventional feed drives are designed conservatively, with fixed electromechanical structures that result in undesirable compromises in speed, accuracy and energy efficiency. Allowing the electromechanical structures of feed drives to vary, in real time, as a function of the manufacturing operation can reduce such compromises and lead to smarter and more sustainable manufacturing machines.

To demonstrate this principle, Okwudire and the researchers in his lab have devised a prototype hybrid feed drive with two actuators and whose mechanical structure changes depending on particular operating conditions. When the drive has to move quickly but without encountering much force, it goes into a "rapid positioning" mode; during the manufacturing operation, when it moves slower but encounters greater forces, it switches to a "cutting" mode.

With the prototype hybrid drive, Okwudire's group has demonstrated as much as a 50 percent reduction in energy consumption with performance equivalent to conventional drives—without unduly sacrificing speed and accuracy. Next steps include optimizing the drive's controller design and "pushing the limits," Okwudire said. "We want to more fully exploit the synergy and flexibility we've been able to introduce."

OPPOSITE PAGE: **Prototype of hybrid feed drive designed to intelligently switch between linear and rotary motor actuation in order to improve energy efficiency while maintaining high speed and accuracy.**

LEFT: **Ultra precision 5-Axis milling machine tool. Inset: Drastic reduction of machine's residual vibrations as a result of optimized passive isolator location.** Photo courtesy: Mori Seiki Co. Ltd.

Designing a MEMS-Based Cochlear Implant

"Now we're focused on the grand challenge of a completely implantable human prosthetic."

More than 15 percent of the U.S. population suffers from hearing loss, and that percentage is rising as we age. Cochlear implants can improve hearing and the ability to understand speech in certain types of hearing loss, particularly when coupled with hearing aids, but current technology, unfortunately, is far from ideal.

Professor **Karl Grosh**, who directs the U-M Vibrations and Acoustics Laboratory, is developing a fully implantable prosthetic microsystem that, just like the organ of Corti in the human cochlea, translates incoming sound to the neural impulses that enable hearing. His concept would address —and solve—some of the most pressing issues facing the current technology.

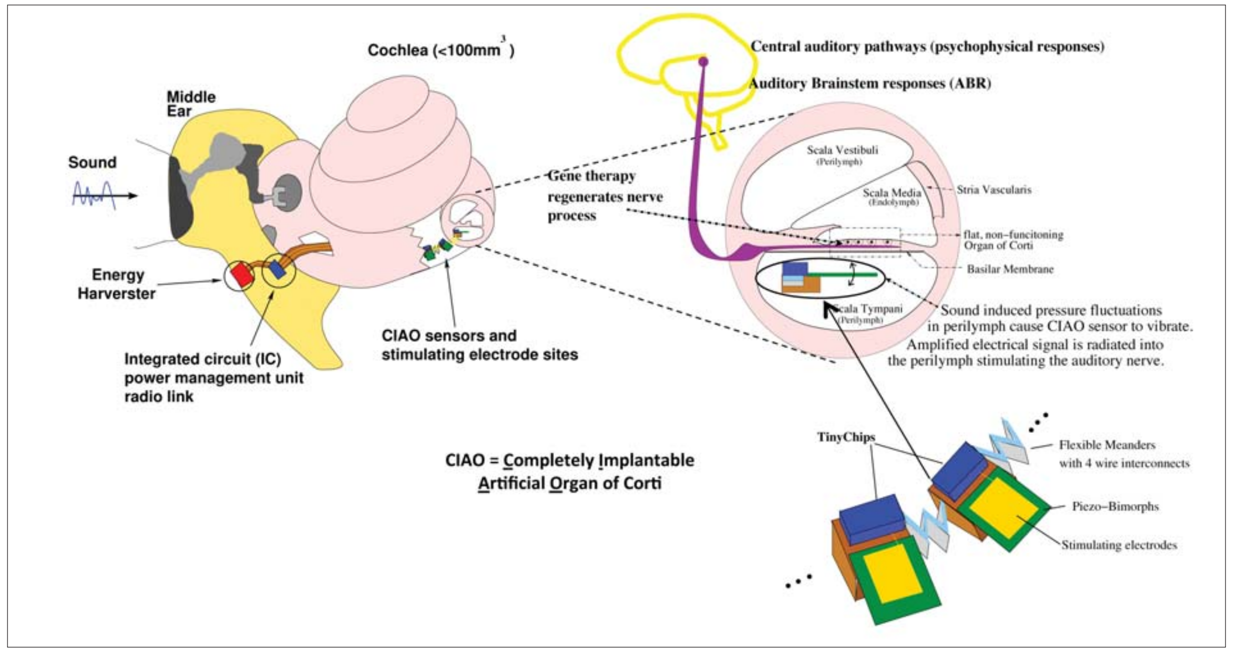
Grosh is leading a collaborative effort that includes professors David Wentzloff and Khalil Najafi in Electrical Engineering and professors Yehoash Raphael and Bryan Pfingst (director of the Auditory Prosthesis Perception and Psychophysics laboratory) of the Kresge Hearing Research Institute. The team is working to develop a Completely Implantable Artificial Organ of Corti (CIAO) platform. Mechanical Engineering PhD student Katherine Knisely has been spearheading the fabrication effort.

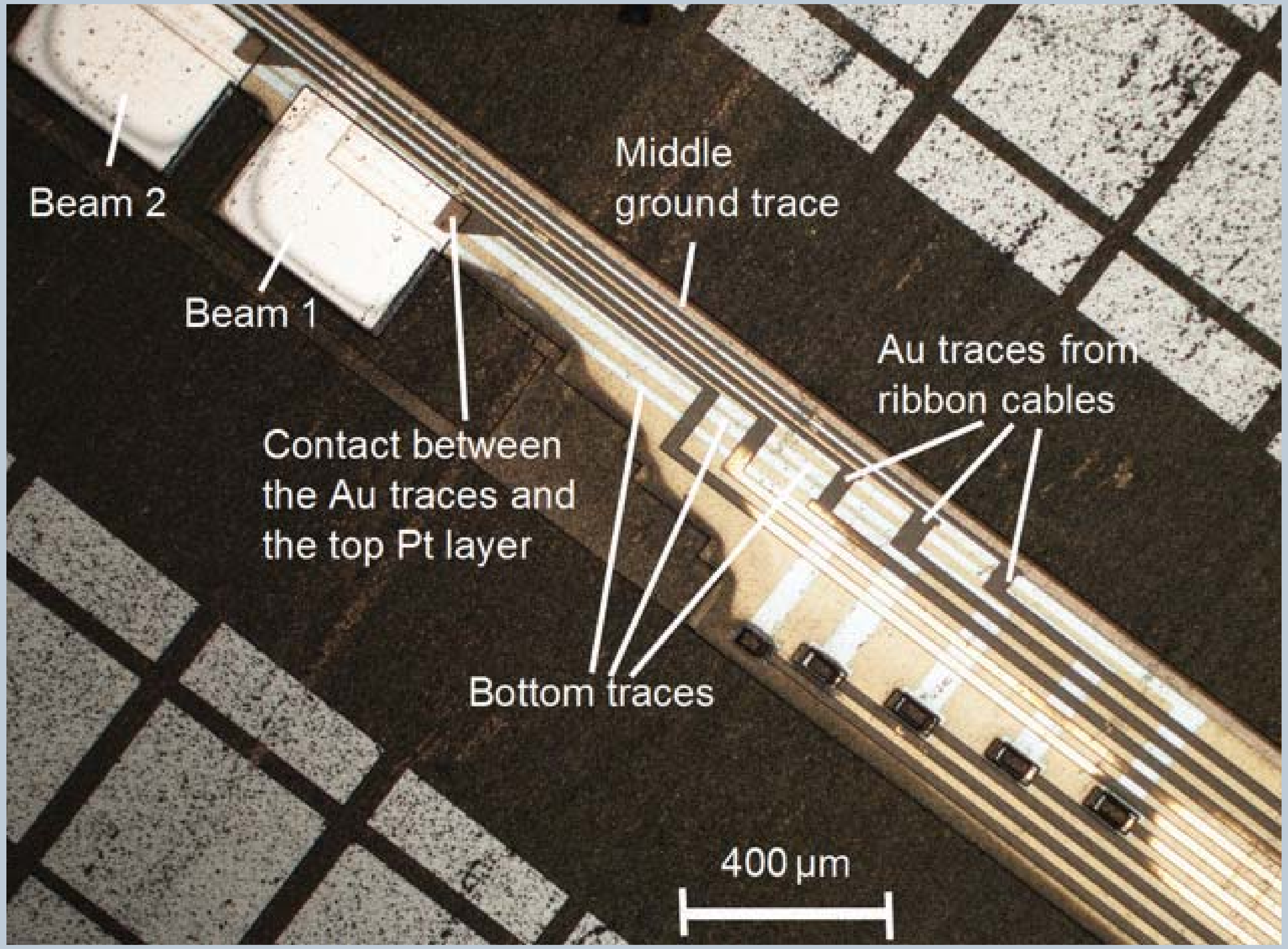
Building on Grosh's extensive modeling work, "we're taking advantage of what we learned from building microphones and our understanding from basic science of how the cochlea works and emulating that in a man-made design," he explained. "Our goal is to build an implant that is fully internal to the ear, doesn't require any external processing and is self-powered."

In the U-M team's CIAO design, sound is sensed by electrodes within the cochlea and piezoelectric components driven by vibrations in cochlear fluid. Using micro-electro-mechanical systems, or MEMS, fabrication techniques, Grosh has designed a flexible electrode with micron-level features and dimensions. This has been a challenge conventional cochlear implant technology has yet to overcome given the unique size requirements: about two centimeters in length but just one-half to one millimeter in width. Currently, electrodes are made manually, so consistency and cost have hindered advances.

BOTTOM: **(Left) The cochlea and middle ear shown with cochlear implant, energy harvester, and power management and wirelessly addressable power management unit. (Right) Cross section of the cochlea showing CIAO sensors replacing the non-functioning biological sensory cells. Nerve health is key and gene therapy is studied as a way to improve connectivity nerves to electronics and ultimately to the brain. (Bottom) The CIAO sensors and stimulating electrodes consist of piezoelectric bimorphs on a substrate (brown). The CIAO units are connected via flexible meanders and to TinyChips amplifier/power management units.**

OPPOSITE PAGE: **Photograph of fabricated prototype showing flexible piezoelectric beams and metallic (gold and platinum) interconnects.** Photo credit: Katherine Knisely.





Grosh's CIAO amplifies the output electrical signal from the piezoelectric components, much like the biologic organ of Corti. The amplified signal is then retransmitted to stimulating electrodes, thereby eliminating the need for an external microphone as well as an external processing unit. In conventional cochlear implants, a microphone is worn outside the ear and connected to the processing unit, which is mounted to the skull with a surgically implanted magnet. Users must remove the external components before bathing or swimming and must have the magnet surgically removed if they were to need to undergo magnetic resonance imaging.

The team's design also shortens the distance between auditory nerve fibers and CIAO electrodes, and promises to improve the health of patients' spiral ganglion neurons—the nerve cells found in the cochlea—through gene therapy. The novel therapeutic approach stimulates growth of these neurons, which not uncommonly degenerate in patients with damaged cochleae, and also lowers the microsystem's power requirement significantly.

While conventional cochlear implants require an external battery, the CIAO would be powered by an integrated power supply or supercapacitators that would be recharged by a thermoelectric generator or vibrational energy harvester.

In addition to safety, comfort and cosmetic advantages, the CIAO design holds the potential to improve audio quality. Grosh predicts the combined improvements will lead to a higher adoption rate among individuals with certain types of hearing loss.

The CIAO platform also could serve as smart microphone technology that, Grosh said, "transforms frequency just like the cochlea does" in speech- and music-related sound processing applications. In higher frequency ranges, it could be used as a microwave filter for telecommunications and for defense applications.

"We've already invented a better mousetrap," Grosh said of the improved piezoelectric MEMS microphone his research group demonstrated in 2008. "That wouldn't have come about without a lot of energy toward understanding and trying to imitate the cochlea. That's the winding way of research; now we're focused on the bigger grand challenge of a much-improved human prosthetic."

The work to date has been supported by The U-M Center for Organogenesis, the U-M MCubed program, which funds high-impact, interdisciplinary research, and private donors.

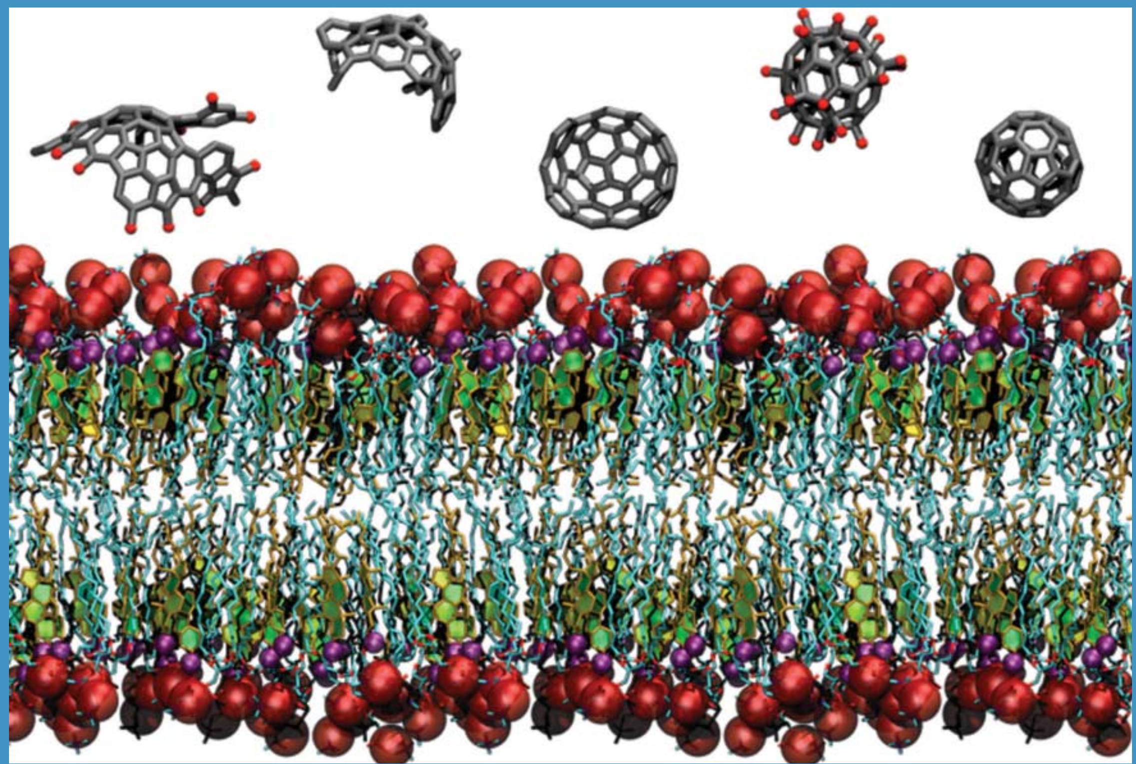
Understanding the Formation and Health Effects of Carbon Nanoparticles

"Through our modeling efforts, we hope to elucidate the fundamental processes that underlie nanoparticle genesis and toxicity."

Environmental nanoparticles are common in the air we breathe, the intentional and unintentional byproducts of many important engineering processes. For example, carbonaceous nanoparticles (CNPs) formed during combustion are a significant emission from internal combustion engines and pose a serious health hazard. The health effects stem from their composition, which includes carcinogenic polycyclic aromatic hydrocarbons (PAHs), and their small size (less than 100 nanometers), which increases toxicity to humans since nanoparticles of this size can penetrate cellular membranes.

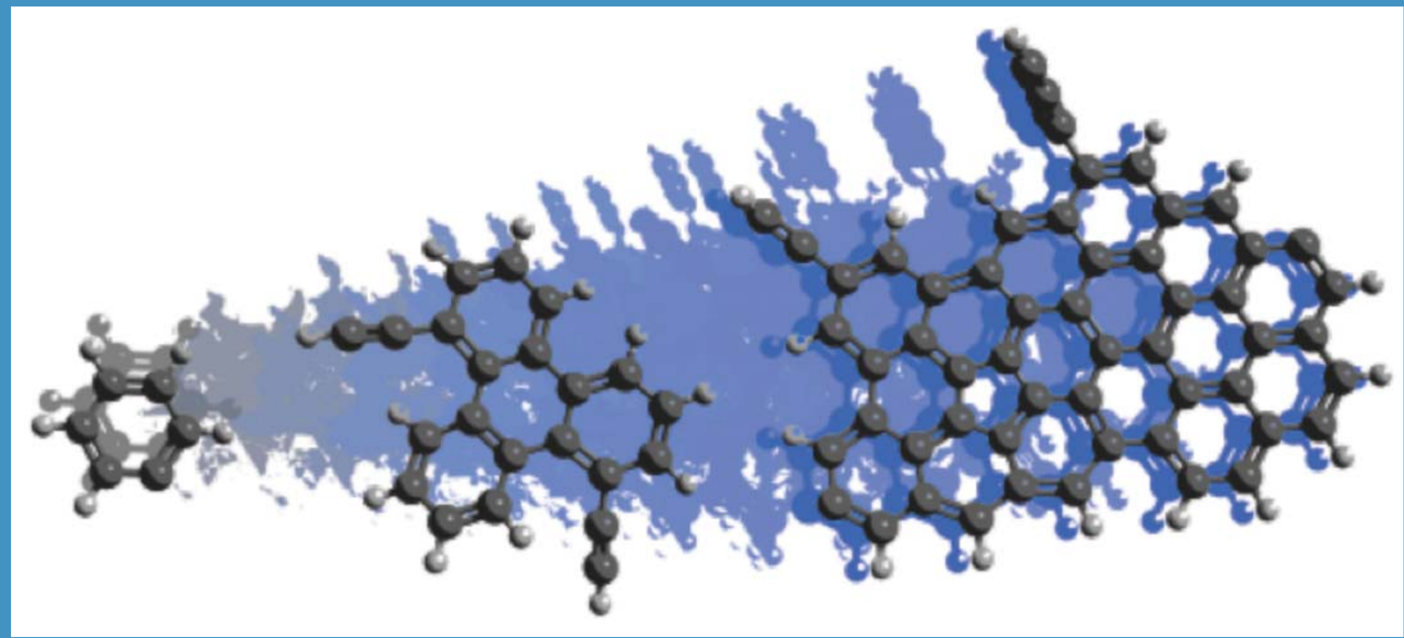
"Both the formation and health effects of nanoparticles are difficult to interrogate experimentally, due to the atomic scale on which they occur," said Associate Professor **Angela Violi**, who leads the Multiscale Molecular Science and Engineering Laboratory at U-M.

Violi's work involves studying the genesis and effects of these environmental pollutants, aiming to illuminate the physical and chemical phenomena underlying these processes using theoretical models that provide unprecedented atomistic detail. By understanding the fundamental processes of nanoparticle formation and toxicity, her work will inform the design of mitigation strategies for engine design and health treatment protocols.



Since CNPs in the sub-100 nanometer size range represent between 35 and 97 percent of particulate emissions by number, the design of pollution control strategies for engines requires a fundamental understanding of their formation. Violi's research group has developed a theoretical model to elucidate particle inception, that is, the transition between gas- and solid-phase, which is a poorly understood but important process. Currently, the model describes the chemical growth of PAHs from gas-phase species to nano-sized structures, the first step of particle inception.

A new model, named AMPI2, employs an approach based on the kinetic Monte Carlo technique and produces detailed chemical growth trajectories of CNPs, enables analysis of CNP morphology, and links structure with chemical growth mechanisms. This capability illustrates the impact of AMPI2 as a computational tool for understanding CNP growth and ultimately informing the design of novel combustion technologies.



Understanding the effects of nanoparticles on human health begins with studying the mechanisms through which nanoparticles enter and affect cellular metabolism. Violi's current work in this area involves collaboration with the research group of Professor Martin Philbert, dean of the U-M School of Public Health, to investigate the permeation and effects of carbonaceous nanoparticles in plasma membranes. Her modeling efforts characterize both the thermodynamic and dynamical behavior of permeation using a variety of molecular dynamics techniques.

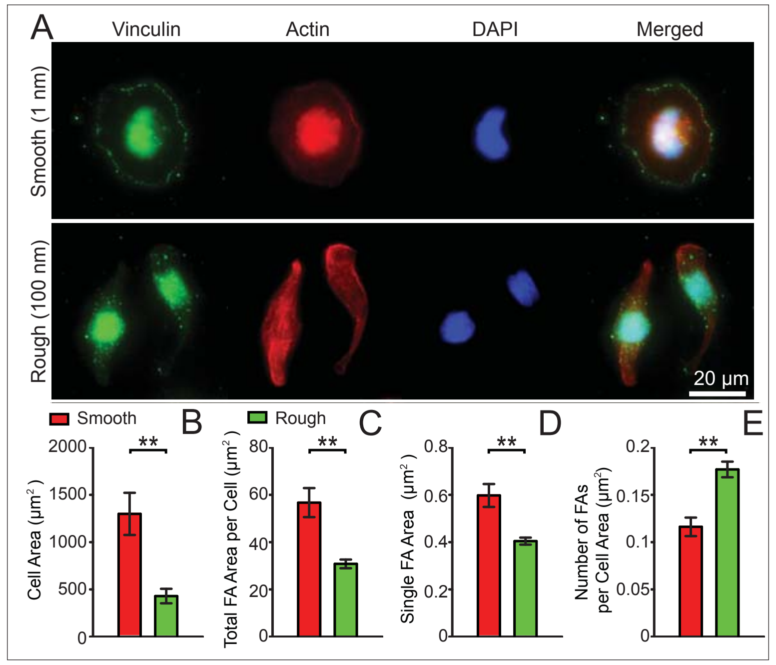
Using metadynamics, Violi's team is able to reconstruct free energy surfaces that describe the energetic barriers, or resistance of the membrane to penetration by a permeant. The free energy surface also gives the most energetically favorable position of a permeant in a membrane. She is working to improve the current level of simulation detail, relative to previous work, by considering more complex membranes involving three to four classes of lipids and cholesterol. This added complexity significantly impacts the behavior of permeants. More specifically, lipid rigidity and free volume in the hydrophobic portion of the bilayer alters the preferred position of a permeant trapped in the membrane.

Future work in Violi's laboratory will involve increasing the capabilities of the models to describe more complex phenomena and provide a more complete picture of these processes. The phenomena will include physical aggregation of CNPs, which contributes greatly to particle inception, as well as more complex permeants and membranes.

"Through our modeling efforts, we hope to elucidate the fundamental processes that underlie nanoparticle genesis and toxicity," Violi said. "Our results will facilitate the synthesis of experimental observations and greatly impact efforts not only to understand but also to ultimately control nanoparticles in our environment."

OPPOSITE PAGE: Visualization of a shortened growth trajectory depicting the growth of a phenyl radical into a larger polycyclic aromatic hydrocarbon.

TOP: Visualization of a model cell membrane and a variety of permeants that are part of current investigations.



Improving Cancer Detection, Prognosis and Monitoring

Cancer cells that "break away" from tumors and travel through the blood to other parts of the body can be deadly. In fact, 90 percent of cancer-related deaths stem from metastasis. These circulating tumor cells (CTCs) have been the subjects of much clinical and biomedical research in recent years, since CTCs can serve as excellent diagnostic and prognostic markers, sometimes replacing invasive biopsy procedures.

"The CTCs have been shown to be directly connected to patient outcomes," said **Jianping Fu**, assistant professor and director of the Integrated Biosystems and Biomechanics Laboratory. "They clearly offer a window of opportunity for patients and also to those of us interested in studying the biological nature of cancer metastasis." How do CTCs circulating in the blood differ from the cancer cells in solid tumors? Why do these cells break away and travel? What strategies can be used to block the escape process of CTCs? "Those answers would provide insights for future therapeutic interventions and personalized treatment approaches," Fu said.

Capturing and isolating CTCs from a blood sample is not without major challenges, however. The CTCs are typically present in the blood in low abundance, on the order of one CTC per billion blood cells.

"Circulating tumor cells are a problem of great clinical and biomedical significance, but the technical issues related to how to capture CTCs from unprocessed or minimally processed blood samples are very challenging," Fu said.

The most common method for isolating CTCs today relies on the use of capture antibodies that recognize specific antigens expressed on the surface of CTCs. But scientists are finding that CTCs are much more heterogeneous than previously thought, and "using capture antibodies will miss some sub-populations of CTCs that don't express those target surface antigens. Researchers believe those subgroups of CTCs might be cancer stem cells or cancer progenitor cells that lead to secondary tumors and therefore are the most dangerous," Fu said. "We need a strategy that can capture CTCs, regardless of their surface marker expression."

Fu and his research team have developed such a strategy. His approach is based not on CTC phenotype—such as surface marker expression or cell size, which scientists also have used to try to capture them—but on function: since they form tumors, CTCs are necessarily adherent. In stark contrast to blood cells, they attach readily to surfaces, and their adhesion strength is high.

To leverage CTCs' adherent properties, Fu is using a common nanofabrication technique, reactive ion etching, to precisely pattern and roughen a glass surface. Blood samples placed on the surface are incubated and analyzed. The CTCs in the blood sample begin to attach to the roughened surface almost immediately, and Fu has found that more than 90 percent of CTCs in the blood sample can be captured.

Others have observed that nanorough surfaces can enhance CTC capture, but Fu's research group is the first in the world to do so *without* using capture antibodies, as explained in a cover page article published in the American Chemical Society journal *ACS Nano* (DOI: 10.1021/nn304719q).

The simplicity of Fu's approach paves the way for larger-scale fabrication of nanorough surfaces, a critical component for mainstream clinical use and chip-based and/or disposable diagnostic and prognostic devices. "Our strategy would provide a unique advantage," he said.

The team is conducting further experiments on different cell lines and types of cancers. Fu currently is working with collaborators from the U-M Medical School and testing preclinical and clinical blood samples. Preliminary results using preclinical blood samples suggest his approach is effective. "Our strategy can capture CTCs with almost uniform performance regardless of the surface protein expression of cancer cells," he said.

Going forward, Fu plans to use some of the micro- and nanofluidic tools his research group has developed to isolate and analyze low-abundant CTCs cells from preclinical and clinical blood samples in order to study the biophysical properties as well as surface protein expression patterns of CTCs. "These tools enable biochemical and biomedical phenotyping of CTCs," he said. "We have the capability to examine the biological nature of CTCs down to a single-cell resolution."

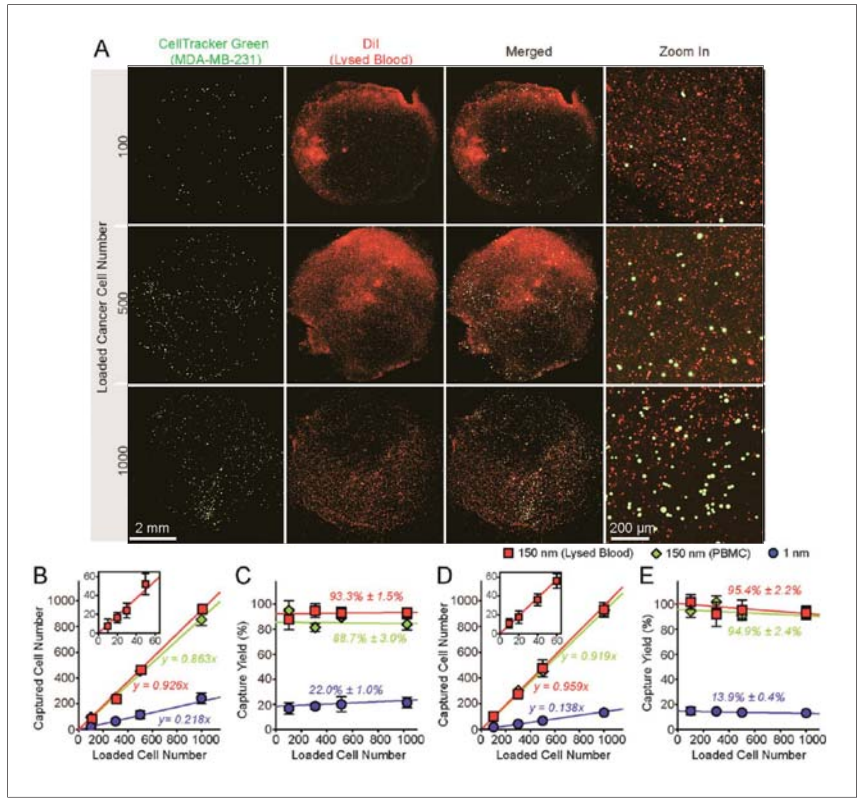
The work has been supported by the U-M Comprehensive Cancer Center, the Michigan Institute for Clinical and Health Research and the National Science Foundation.

"It may be a simple strategy," Fu said, "but it provides the opportunity to learn much more about the metastatic process. For the first time, clinicians and cancer researchers will have access to cancer cells as they transition from primary to secondary tumors. It's very exciting."

OPPOSITE PAGE: Effect of nanotopological sensing on focal adhesion (FA) formation of MDA-MB-231 cells. (A) Representative immunofluorescence images of MDA-MB-231 cells adherent on smooth (Rq = 1 nm) and nanorough (Rq = 100 nm) glass surfaces after 24 h of culture. Cells were co-stained for nuclei (DAPI; blue), actin (red), and vinculin (green). (BE) Cell area (B), total FA area per cell (C), average single FA area (D), and number of FAs per cell area (FA density; E) of MDA-MB-231 cells adherent on smooth (Rq = 1 nm) and nanorough (Rq = 100 nm) glass surfaces after 24 h of culture. Error bars represent (s.e.m. (n > 30). Statistical analysis was performed by employing the Student's t-test. Double asterisk (//) indicates p < 0.01.

RIGHT: Capture and enumeration of cancer cells. (A) Representative fluorescence and merged microscopic images showing known quantities of MDA-MB-231 cells as indicated spiked in lysed blood captured on nanorough glass surfaces (Rq = 150 nm) 1 h after cell seeding. Target MDA-MB-231 cells were labeled with CellTracker Green before spiked in lysed blood that was prestained with Dil. (BE) Regression analysis of 1-h capture efficiency for MCF-7 (B,C) and MDA-MB-231 (D,E) cells on smooth (Rq = 1 nm) and nanorough (Rq = 150 nm) glass surfaces. In panels AE, known quantities of cancer cells (n = 101000) were spiked in 500 µL of growth media containing PBMCs or 500 µL of lysed blood as indicated. For PBMC samples, cancer cells were mixed with PBMCs at a constant ratio of 1:1. Insets in B and D show correlations between captured cell number and loaded cell number for n = 1060, indicating efficient capture of low abundant CTCs. Solid lines represent linear fitting. Error bars represent (s.e.m. (n = 4). of MDA-MB-231 cells to PBMCs. Results were obtained 1 h after cell seeding. In panels AD, a fixed number of cancer cells (1000) were mixed with PBMCs in growth media to achieve cell ratios from 1:1 to 1:200. Error bars represent (s.e.m. (n = 4).

> "Our strategy can capture CTCs with almost uniform performance regardless of the surface protein expression of cancer cells."



Looking at Cell Dynamics and Mechanics
from the Top Down and Bottom Up

Assistant Professor **Allen Liu** joined the U-M faculty in 2012 and promptly established the Laboratory of Cellular and Molecular Systems. The lab focuses on research questions that lie at the interface of biology and engineering.

"Underlying the work we do is my fascination with cellular dynamics and mechanics," Liu said. "And the common theme connecting our research is biological signal processing at the cell membrane, since that's the interface cells use to interact with their environment."

To understand the complex cellular phenomena, Liu takes both a "top-down," or systems biology, and "bottom-up," or synthetic biology, approach. The goal is to develop a quantitative understanding of how cells detect and respond to various aspects of their environment.

More specifically, Liu focuses on the process of endocytosis, or the way in which cells internalize nutrients. The fundamental functional unit of this process is a clathrin-coated pit (CCP). Self-assembly of clathrin on the plasma membrane helps form the vesicles that bring molecules in from outside the cell.

"We're trying to understand how this process is affected by various physical and chemical inputs as well as how it controls the expression and activity of signaling receptors on the cells' surface," he said. "We think cell membranes and receptors hold the key."

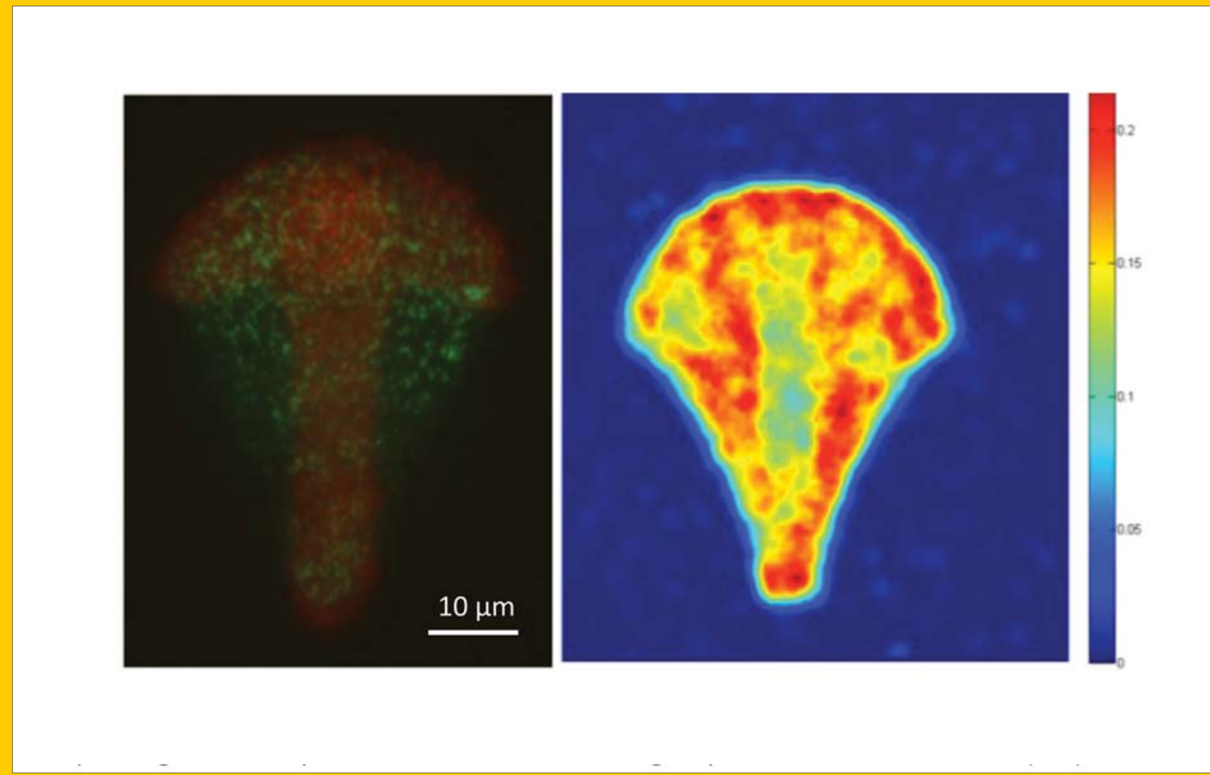
To better understand CCPs, Liu and his group have developed imaging tools—total internal reflection fluorescence microscopy coupled with computational analysis—to get a closer look at how cell characteristics affect their dynamics. The combination is a very powerful approach to comprehensively reveal cellular dynamics.

Liu's team also has used micro-contact printing techniques to create adhesive patterns to standardize cell size and shape in order to learn how cells organize spatially and how their dynamics vary in a spatial manner.

"We have a lot of questions about endocytosis," Liu said. "Do the cells eat (form vesicles) only in certain places? Do they eat faster in some places than others? How fast do they eat, and what regulates that?"

Liu plans to take the findings and extend the research to look at the internalization of a specific receptor, CXCR4 (chemokine receptor type 4). "This molecule is incredibly important," he said. "It's the most overly expressed chemokine receptor in breast cancer and in many other cancers also, and it's a co-receptor for HIV (human immunodeficiency virus). What we really want to know is, how does endocytosis regulate the internalization of this receptor?"

> "Platelets have a prescribed set of jobs to do—they bind to injured vasculature and trigger the blood clotting cascade—and they're medically relevant because of shortages in clinical settings."



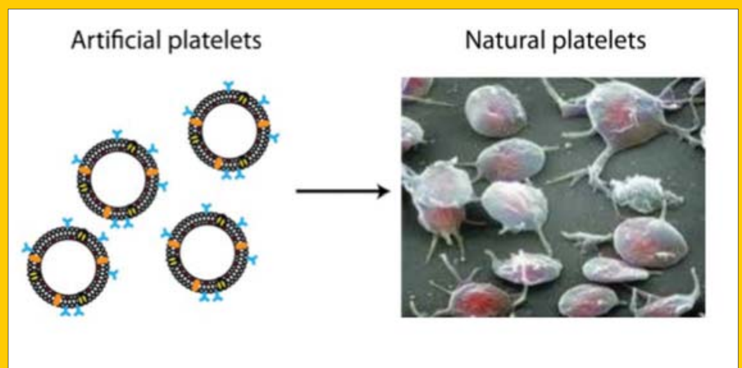
In other ongoing research in Liu's lab, he and his team are developing tools and methods to combine proteins and other biomolecules into systems and cellular devices. "When we think about a cell, it needs to receive information from its environment; it needs to process that information; and it provides an output, such as a chemical signal," he said. In some instances, cells convert mechanical energy to biochemical energy.

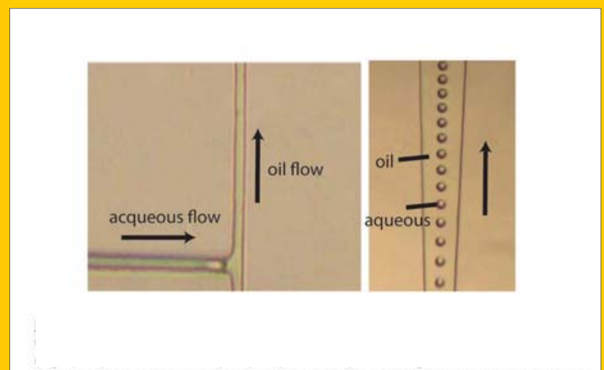
In 2012, Liu received a National Institutes of Health Director's New Innovator Award to take that concept and apply it to the development of an artificial cellular system that mimics the behavior of biologic platelets. These cells play a key role in the control of bleeding, and they are the only type of blood cell that lacks a nucleus, making it easier for engineers to try and replicate their function.

"Platelets have a prescribed set of jobs to do—they bind to injured vasculature and trigger the blood clotting cascade—and they're medically relevant because of shortages in clinical settings," Liu explained. Platelets are easily contaminated, and they don't survive long outside the body.

"The idea is to generate a particle with a vesicle that contains embedded proteins, can sense mechanical forces and can convert the mechanical force to biochemical information," Liu said. To date he has conceived a simple, signal transduction pathway in a three-molecule system.

Ultimately Liu plans to design and build artificial systems that can act as molecular sensors. "If we can understand the signaling pathways, we can harness the protein machinery to detect molecules in a sample," he said. "That type of sensing platform would be widely useful across many applications."





OPPOSITE PAGE: (LEFT): **Building artificial platelets. The goal of this project is to develop a lipid bilayer vesicle platform that would function similarly to natural platelets upon sensing injured vasculature.**

(RIGHT): **Droplet microfluidics for encapsulation as model for building artificial cells. (Left) Simple T-junction for generating water-in-oil emulsion. Channel width is 20 um. (Right) Droplets coated with a phosphilipid monolayer traveling down microfluidic channel.**

TOP: **Spatial organization of clathrin-coated pits (CCP's). (Left) Microcontact printing is used to pattern adhesive area for single epithelical cells. Fibronectin (red) pattern restricts cell shape to a pie shape and CCPs are labeled in green. (Right) Density map of CCPs of multiple aligned cells.**

Design and Manufacturing Courses Spark Student Creativity

In Design and Manufacturing I, II and III (ME250, 350 and 450 respectively), students transform ideas into real, manufacturable products and working engineered systems. The ME department's core design curriculum, also known as X50, has gained recognition nationally for its breadth, depth and innovation.

Design and Manufacturing I (ME250) focuses on the design process, materials and manufacturing. Students learn engineering drawing; CAD (computer-aided design) and solid modeling; how to use mechanical elements such as bearings, gears and springs; and manufacturing processes. They work in a machine shop on mills, lathes and laser and water jet cutters.

Coursework—both lecture material and hands-on experience—culminates in a popular course project, a tournament known as the "ball tower competition." To compete, student teams design and build a remote-controlled machine to gather ping-pong and squash balls from the tower, modeled after the North Campus Lurie Bell Tower, all while avoiding obstacles on the tabletop arena.

Design and Manufacturing II (ME350) focuses on the model-based design of mechanical and mechatronic systems. Mechatronics, introduced into the course several years ago by ME Associate Professor **Shorya Awtar**, is the synergistic integration of mechanics, electronics, control theory and computing into product design and manufacturing to optimize functionality.

For the current ME350 course project, created by Professor **Diann Brei** and Lecturer **Mike Umbriac**, student teams work on a real-world design problem: a wheelchair attachment capable of moving a backpack between the back of the wheelchair (so the user can more easily navigate doorways) and the side of the chair (so the user can access the pack).

The teams designed and built a mechanical system that included a four-bar linkage mechanism to move the backpack into two positions and orientations. Students incorporated an electric motor with integrated encoder so the attachment decelerates during the last 10 degrees of travel. The teams also designed a transmission to achieve the desired torque and speed profile and integrated infrared sensors to stop motion if an obstacle is encountered.

"Initially all I knew about this course was that it involved designing a wheelchair mechanism that included a motor and transmission," said **Michael Gorski** (BSME '14). "After diving into the project and seeing it evolve into a more sophisticated mechanism, I began to realize how theory meshed with carefully executed design decisions to produce a useful device. That's the moment I appreciated the course for showing the amount of purposeful thought that goes into even the most simple of designs."

"ME250 and 350 have really tied together what I learned from my previous engineering classes and also introduced new concepts," said **Mark Coughlin** (BSME '14). "Actually making parts I designed on the computer in the machine shop has given me a whole new appreciation of the manufacturing field. Now I'm able to create more appropriate engineering drawings and better design for service."

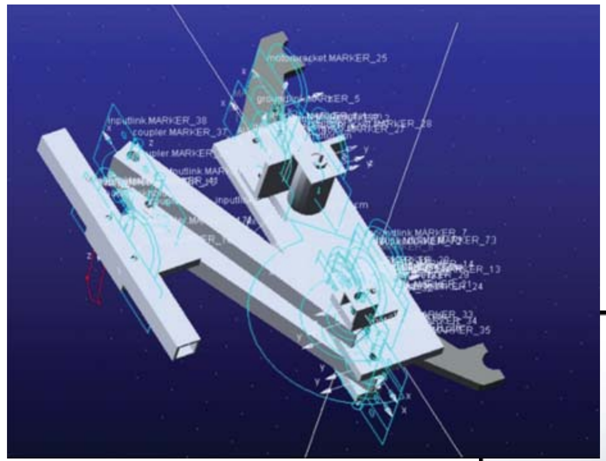
"The course project is a big motivator," said Assistant Professor **C. David Remy**, ME350 instructor. "The students really take ownership and want to make their designs look good and professional in addition to meeting the specifications."

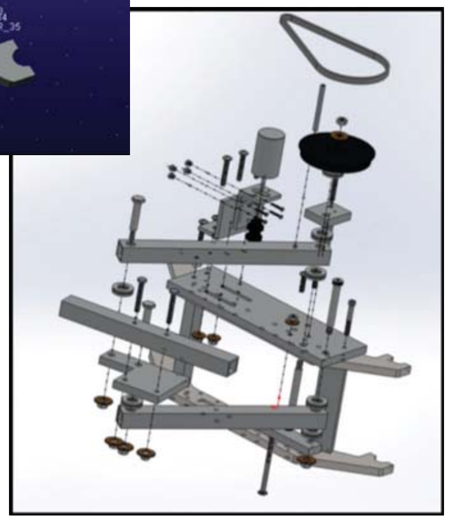
Design and Manufacturing III (ME450) builds on the previous two X50 courses. Course projects come from faculty, alumni and industry sponsors, including ArcelorMittel, Coherix and Johnson Controls.

> "Their work is impactful. It's not uncommon for students to come up with economical solutions for problems sponsors may have been trying to figure out for a long time."

OPPOSITE PAGE : ME250 students Kody Young and Adrian Sanchez maneuver their remote-controlled machine past the moving wave field to try to capture the wolverine during the project competition at the Design Expo. **Photo credit: Patrick Barron**

RIGHT: Isometric view of ADAMS model and the project's exploded view.





"Project sponsors are routinely impressed by the level of sophistication of student work," said **Gordon Krauss**, course coordinator. "Their work is impactful. It's not uncommon for students to come up with economical solutions for problems sponsors may have been trying to figure out for a long time."

Recent projects included a redesigned lumbar support tensioning mechanism for automotive seating; kinematic analysis, redesign, testing and prototyping a new automotive piston connection system; design of a reaction wheel for satellites to control attitude in space; development of a computer-controlled three-dimensional printer for hydrogels; and design of a steerable robotic light source for complex eye surgeries.

"I am always amazed to see what the students can accomplish," said Richard Wineland, manager of engine systems at EcoMotors. "I continuously use their project results to show how fresh eyes can produce respectable results at a low cost, when sound fundamental thinking is backed up by simple physical correlation testing. Their half scale, low speed, low cost, quickly made test model provided just as much information as our $250,000 engine running $100,000 tests. It is an inspiration to EcoMotors."

As for the coming academic year, Krauss said, ME450 students can look forward to enhanced rapid prototyping capabilities for additive manufacturing and additional experiential classroom opportunities. The ultimate goal is to equip student-engineers to become lifelong learners.

"Early in the semester, I often hear 450 students say, 'But no one taught me this,' referring to some specific aspect of engineering or science. That's the point. They have to learn about it on their own," Krauss said. "Sometimes that's easy because there are a lot of published papers on a topic, and sometimes that's difficult because what's known is protected as trade secrets. But therein lies the opportunity—if students can learn independently, they're going to make much better engineers."

Global Health Design:
Improving Maternal and Infant Healthcare

While in Ghana performing clinical observations, University of Michigan students (from left) Julia Kramer, Doga Kumusoglu, Maria Young and Marcus Papadopoulos pose at the northern border of the country.

Providing healthcare services in resource limited settings presents tremendous challenges to health workers. Thanks to an innovative Design for Global Health experience created and led by Associate Professor **Kathleen Sienko**, several ME students, as well as students from other engineering departments, are helping overcome those challenges.

"The Design for Global Health experience allows students to have a real impact on health service delivery in underserved areas. Through clinical immersion and collaborative, hands-on design, students address major global health challenges," Sienko said.

The program emphasizes four key aspects of global health design: design ethnography, co-creation with end-users, intercultural training, and in-depth exposure to a specific thematic area (currently maternal and infant healthcare).

For Sienko, the framework for appropriate engineering design in healthcare, particularly in resource-limited settings, must include cultural, economic, and environmental factors, which all influence the adoption, use, and sustainability of new technologies.

This approach appealed to **Julie Kramer** (ME '14), who is part of the summer 2013 cohort. "My interest in global health design was sparked by the idea of learning from a community and working with them to design something. I'm passionate about the importance of collecting ethnographic data and using it to effectively inform the design process," she said.

Student cohorts spend eight weeks in Ghana, observing medical teams at Komfo Anokye Teaching Hospital (KATH) in Kumasi as well as at district hospitals and rural clinics.

"We quickly discovered that the neat diagrams in our textbooks looked nothing like an emergency procedure in Ghana, due to high patient volumes and limited resources," said **Elizabeth Hyde** (BME '13), part of the summer 2012 cohort.

Based on their observations, students individually identify particular challenges and issues, discuss these observations with their peers and develop formal needs statements. Once the team identifies the top issues, it conducts further research and interviews, both at KATH and during a two-week stay at Korle Bu Teaching Hospital in Accra.

Before returning to U-M, the team analyzes the needs assessment and, in collaboration with physicians in Ghana and at U-M, selects one challenge for which it will explore potential solutions through the senior capstone design course, ME 450.

"This project allows us to truly live the entire design process," said **Marcus Papadopoulos** (ME '14). "In Ghana we have assessed needs, chosen a space to design, and defined requirements." The team is working on a blood pressure device to identify women at risk for pre-eclampsia, a pregnancy-related condition characterized by high blood pressure and high levels of protein in the urine. "We will design, build, and test with the intention of bringing a prototype back to Ghana in the spring of 2014. We hope to design a product that works well and can be easily implemented into the current culture," he said.

In 2012, the team worked on a low-cost but robust and reliable fetal heart monitor. In 2011, the first spinout company from the Global Health Design program, DIIME (Design Innovation for Infants and Mothers Everywhere), was founded by U-M graduates who decided to pursue the commercialization of a blood salvage device.

Sienko also has received support from Covidien and Medtronic, two multinational medical device companies, to adapt the immersion and design experience for minimally invasive surgery, cancer and cardiovascular challenges in China. This summer, Sienko also initiated a pilot program in Addis Ababa, Ethiopia, with Dr. Senait Fisseha from the U-M Department of Obstetrics and Gynecology. Sienko hopes to offer undergraduate and graduate students the opportunity to choose among multiple African and Asian field site options in the coming years.

> "The Design for Global Health experience allows students to have a real impact on health service delivery in underserved areas."

+ more on the web

For more information on the Multidisciplinary Design Minor Global Health Design Specialization, visit **http://sitemaker.umich.edu/specialization/Home**.

LEFT: UM-SJTU Joint Institute administrators in Shangai during the ceremony of a 10-year partnership agreement.

Collaboration and Growth:
U-M - SJTU Joint Institute Enters Eighth Year

The novel partnership known as the University of Michigan - Shanghai Jiao Tong University Joint Institute (JI) is entering its eighth year. On a mission to build a global partnership and world-class institute for engineering education, the JI has graduated its fourth class, and as in previous years, astonishingly 80 percent of graduates have been accepted to some of the world's top graduate programs.

Likewise, recruitment for the incoming freshman class has yielded an impressive student body, according to ME Professor **Jun Ni**, who was instrumental in creating the JI and who serves as its founding dean. "It's become very popular, particularly among students in Beijing and Shanghai, outperforming peer institutions," Ni said.

Close to 60 U-M undergraduate students studied at the JI during the 2012-13 academic year, nearly double the number last year. "When I walk around the JI campus, I see a lot of maize and blue Michigan t-shirts," Ni joked. "The feedback has been positive. Students love the overall experience—the environment, the friendship, gaining a greater understanding of a rapidly developing country, and a real appreciation of Chinese culture and the people."

The two universities also have agreed to extend funding for several joint research projects in the areas of renewable energy, biomedicine and nanoscience and technology.

"The additional funding demonstrates that both universities see the value and benefit of these research projects," said Ni. "Many of the funded projects already have produced significant results and, as a result of the seed funding, some of the research teams are now ready to seek external support."

This past year, seminars for high school students gave a number of young people a taste of engineering education. Participating students spent a day at the JI and took part in cultural activities and class lectures and attended the Design Expo. "For many of the visiting students, it was their first hands-on engineering experience, and they showed a great deal of interest in the different projects and prototypes," Ni said.

Going forward, the JI's growth plans include expanding its graduate program and a third academic discipline. In addition, the design process is well underway for a new JI building on the SJTU campus, with an expected completion date of summer 2015.

The JI's success has not gone unnoticed. China's Ministry of Education, which oversees over 3,000 Sino-international cooperative educational programs, declared the JI a model to emulate. The Chinese government issued a case study of the JI that has been distributed to educational institutions throughout the country.

"Establishing and working with the JI has been so rewarding," Ni said, reflecting on the past seven years. "You can see how it's made a real impact. Our program is highly praised both inside and outside China."

> "Students love the overall experience—the environment, the friendship, gaining a greater understanding of a rapidly developing country, and a real appreciation of Chinese culture and the people."

Laying the Foundation
for Student-Led Projects in India

In March 2013, ME seniors **Michelle Pascual** and **Labiba Quaiyum** joined a College of Engineering delegation to India, where they spent a week laying the groundwork for future student-led engineering projects.

Both Pascual and Quaiyum, who graduated in May, served on the board of the U-M chapter of the Society of Women Engineers (SWE). Second-year student **Erica Dombro**, a project leader with BLUELab (Better Living Using Engineering; see related story on page 44), also joined the group, as did ME Professor **Krishna Garikipati**.

The U-M contingent traveled extensively, visiting schools, meeting with teachers and alumni and touring factories and surrounding towns. Students held in-depth discussions with alumni business owners about opportunities for socially responsible engineering projects and community development work.

Pascual and Quaiyum returned to India with 13 SWE colleagues in May 2013 to design and run an engineering camp for 80 local secondary school students. The camp was based in Walchandnagar, Maharashtra, home of Walchandnagar Industries.

Dombro is heading a BLUELab team that will work near the city of Kalol, Gujarat, where another alumni-owned company, SETCO Automotive, is based. Currently she is working with locals and nonprofits to begin a needs assessment. Likely project areas include water or waste management. She and BLUELab team members plan to travel back to India with prototypes in spring 2014.

> "No one is saying our project ideas are too complicated. They're saying, 'Let's think large-scale' and, although that can be overwhelming, we're going to start with one house, one village. I know India is going to be an awesome place to work."
>
> -Erica Dombro (BSE '16)

ME Department Leads
New Japan-US Education Program

A new exchange program between Nagoya University in Japan and U-M is enabling global research opportunities to graduate engineering students at both universities.

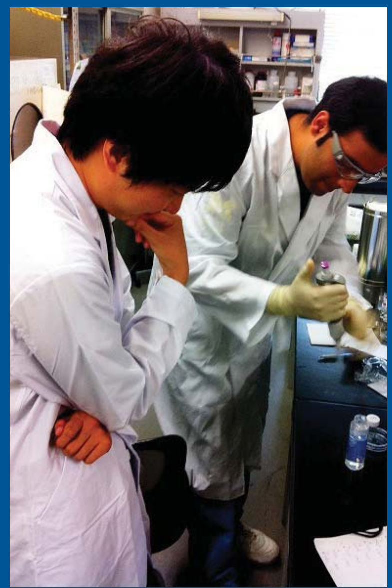
Driven largely by the Mechanical Engineering departments at the two institutions, the new education program is funded by the Japanese government. The Japan-U.S. Advanced Collaborative Education Program, or JUACEP, facilitates two-to-twelve month overseas research experiences for master's and doctoral students. Professor **Katsuo Kurabayashi** serves as U-M program coordinator, working with professors Yang Ju and Noritsugu Umehara, Nagoya University program co-directors.

The first group of Nagoya University graduate students came to U-M in March 2012, a second group arrived in August 2012. Another group is scheduled to spend two months in U-M faculty labs in August 2013.

Likewise, to date over 20 U-M engineering graduate students have spent three months at Nagoya University conducting research in faculty labs there. About 80 percent of program participants hail from the ME department. These students can transfer credits earned at Nagoya University to U-M, toward their ME graduate degree.

In March 2013, several U-M professors traveled to Nagoya for a joint faculty workshop. "There was a very productive exchange of ideas about research and education," said Kurabayashi, "and the international research collaborations are beginning; the students are the bridges between faculty at the two universities."

The JUACEP is not the first joint program for Nagoya University and U-M. Michigan



ME students have been participating in an automotive summer research program in Nagoya for nearly two decades.

"There's a long history and a strong international partnership between U-M and Nagoya University," said Kurabayashi. "The two institutions understand one another and have had a real synergistic relationship."

> "Students are very responsive to these challenges and to developing the interpersonal skills required to approach problems within the context of other cultures."

Emily Zumbrunnen, (Industrial and Operations Engineering) and Michelle Pascuale (ME) speaking with Professor Krishna Garikipati at a school near Walchandnagar, India. A U-M alumnus (Chakor Doshi) is the president of Walchandnagar Industries, the company that hosted the visit. In the foreground is Sita Syal (Chemical Engineering).

ME Students Gain Valuable
International Experience

International experience is anything but foreign to ME students and faculty. During the past academic year, some 100 ME undergraduates participated in an international experience through a variety of study abroad, work abroad or co-curricular and service learning programs.

"ME certainly has a strong showing when it comes to international programs, and ideally I'd like to see all our students—in the Department and across the College—gain international experience," said ME Professor **Greg Hulbert**, who serves as faculty advisor to the College's International Programs in Engineering office.

ME students and faculty also have taken the lead in developing new co-curricular and service learning programs abroad, which are rapidly growing and extremely popular. Professor **Kathleen Sienko** has developed global health programs in Ghana (see related story on page 40); Professor **Krishna Garikipati** serves as faculty advisor to a new program in India, co-created by several ME students and the Society of Women Engineers; and Professor **Steve Skerlos** advises the Better Living Using Engineering Laboratory, or BLUELab, which leads ongoing projects in multiple countries (also see related story on page 44).

"ME has seen fantastic growth in this area," said Hulbert. "Students are very responsive to these challenges and to developing the interpersonal skills required to approach problems within the context of other cultures."

The ME department also has about 30 students pursuing the International Minor for Engineers, the College's first minor, co-developed by ME Professor **Volker Sick** and first offered in 2008. The program requires that students immerse themselves in a foreign culture for at least six weeks.

The immersion aspect of international experiences is critical, said Hulbert, who has seen the benefits and value of living, working and studying in foreign cultures firsthand. In addition to his role as faculty advisor to International Programs, he himself has studied and taught abroad, and his children have participated in study abroad programs as well.

"Students build self-reliance," Hulbert said. "They come to understand that people think and approach problems differently than they do. They develop skill sets to navigate and co-exist and thrive in another culture. It makes them a much more developed and rounded person than what's possible otherwise."

Such skills are a prerequisite to a successful career in engineering. "It's widely recognized that international experience is a necessary component of engineering education in today's globalized environment," said Hulbert.

In recognition of the value of international experiences, the IPE office and the College are continually working to increase opportunities for students to live, work and study abroad as well as to make it feasible both financially and academically.

The strategies are working. "Without a doubt, the number of students participating in international programs is up significantly across the College," Hulbert said. "Students are understanding that this is important for their own growth, personally and professionally. They hear it from faculty, and they hear it from their peers who have participated in international programs. Word gets out about how meaningful it was, and then they want to go, too."

Matt Grocoff poses for a photo on the porch of his house. Members of the Michigan Engineering student team BLUELab will design and implement a Net Zero water system for the Grocoff house. The system will attempt to take the house "off the grid," and provide for all the water needs of the Grocoff family living in it. The U-M students' goal is to capture and treat enough rainwater on site to supply the house with clean drinking water, then find creative solutions for recycling or reusing waste water for cleaning or irrigation.
Photo credit: Marcin Szczepanski/ Multimedia Producer, Michigan Engineering

BLUELab:
10 Years of Sustainable, Global Design Solutions

The popular, student-led organization, Better Living Using Engineering Laboratory, or BLUELab, recently turned 10 and has been "pushing the envelope in a lot of ways," said faculty advisor and ME Professor **Steve Skerlos**.

BLUElab has also recently grown to 150 members, who hail from within and outside the College of Engineering. Part of this growth has been due to the flexibility and can-do spirit of the organization.

"BLUELab is really an incubator for sustainability ideas that students are pushing; that makes it much more than a club that implements sustainable design projects in the developing world," Skerlos said.

Members run sustainability lecture series and conferences for U-M students and the general public. They develop sustainability education content for local K-12 students as well as technology courses at U-M. They work with the University to minimize energy and solid waste on campus. They hold a sustainability job fair for U-M undergraduates, and they get involved locally to grow gardens that produce sustainable food.

For students engaged in design projects in the United States and abroad, new opportunities have been created for them to receive course credit, for instance through the College's Minor in Multidisciplinary Design and through the new Program in Sustainable Engineering. Currently there are six major projects within BLUElab, including the award-winning Living Building Challenge team.

The Living Building Challenge team aims to retrofit a 100-year-old home on Ann Arbor's Old West Side to produce more water than it consumes. The home is already a zero-energy building, meaning it generates more electricity than it uses.

"Achieving net-zero water use is much harder than net-zero energy use," Skerlos said. "It's not something that's been done before on an individual home of this age."

To meet the challenge, students have undertaken modeling work to understand how best to deploy a new system in the most cost-effective way. The project is in the conceptual design phase currently, and Skerlos expects the team will start testing and prototype development in the fall of 2013.

Another BLUELab team is focused on technologies to generate biogas, which can serve as an alternative source of cooking fuel. The team has designed a biodigester that converts animal waste to methane and has implemented several in Nicaragua and Liberia as well as the U-M Matthaei Botanical Gardens—winning a number of national awards in the process.

Other projects include rainwater harvesting and filtration, solar heating, and wind turbines with woven fabric blades that generate both clean energy and a source of revenue for weavers in Central America.

But BLUELab wouldn't be successful as an organization if it simply came up with clever designs and built one or two of them abroad. The aim is for environmentally, culturally and economically sustainable technologies that will be used by local communities, both in the United States and in developing areas, long after BLUELab students leave.

"Sure, students can take a trip and install a biodigester or a water filtration system, but what's going to make that community, wherever it may be, build another and another and another?" Skerlos said. "That's the critical question BLUELab members are asking—and answering."

+ more on the web

For more information on BLUELab projects and events, visit **http://bluelab.engin.umich.edu/**.

Solar Car Team
Plans to Shine Down Under with Generation

Still basking in the glow—but not resting on the laurels—of four consecutive and seven overall national titles, the U-M Solar Car Team has been hard at work designing and building its twelfth vehicle, *Generation*.

The new car was unveiled in June 2013, with subsequent media coverage by *The New York Times*, Michigan Radio, Mashable and others. The team has made significant changes this year, driven by new regulations for the biannual World Solar Challenge competition, held in October in Australia. Those changes include four wheels instead of three, an increased driver field-of-vision, and new driver packaging requirements.

To test the new car, the team will hold a "mock race" in July, taking *Generation* on a round-trip spin from North Campus to Ohio, Indiana, Kalamazoo, Holland, Petoskey and Bay City, before returning to Ann Arbor.

"We're looking forward to the mock race, which will allow us a chance to shake down the vehicle and show it off to the public," said **Aaron Frantz** (BSE ME '13), the team's operations director. The route and stops appear on the team's website so fans can see the car along the way.

Generation took more than 100 student team members and over $1 million to build. "The biggest thing we've learned," said Frantz, "and that most every project team learns, is how to apply the classroom fundamentals of engineering to a very real-world project. The support of the College's Wilson Student Team Project Center and the Multidisciplinary Design Program has been an invaluable resource in achieving this."

Sponsors have been "incredibly supportive of *Generation*," as well, Frantz said. "Each of them is invaluable, but a special shout-out to **Charles (Chuck) Hutchins** (BSE MEAM '57), our number one fan. As both a sponsor of the team and die-hard Wolverine, Chuck has been with us at every race since 1990 and is planning on returning with us to Australia for World Solar Challenge 2013 this fall."

World Solar Challenge is daunting: a 1,800-mile course through the remote Outback, from Darwin in the north to Adelaide in the south. Frantz says the team is going with "no expectations. The changes in rules means that everybody is starting from nearly a blank slate."

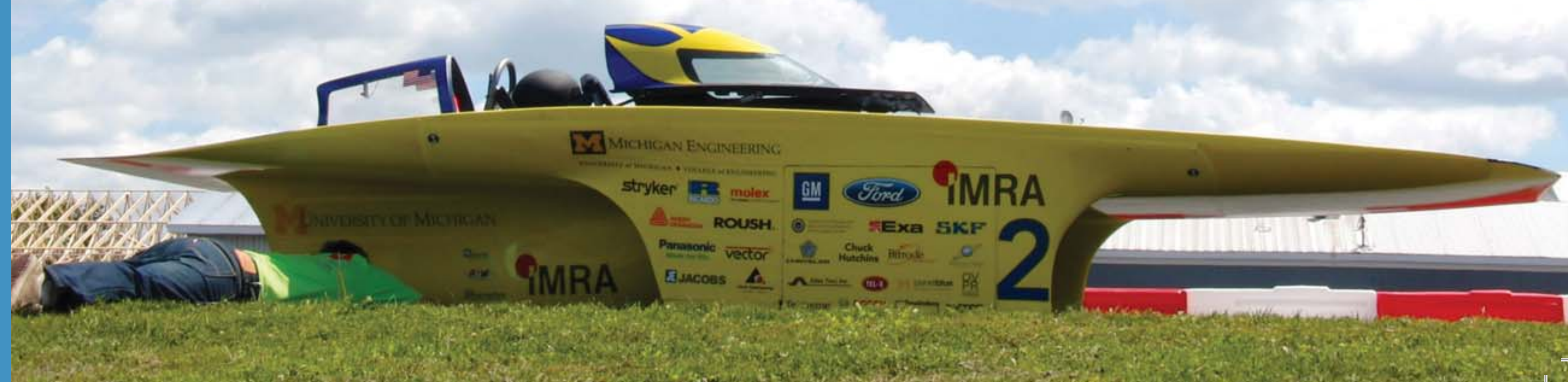
But Frantz is still certain of one thing: "The team's overarching goal is to be the best Solar Car team in the world, excelling in performance and innovation. We plan to live up to this goal, and hopefully bring the world championship back to America for the first time since GM won the inaugural race in '87….We're going to give the other teams a run for their money."

Several other ME students hold leadership positions with Frantz, including **Garrett Simard** (BSE ME '15), mechanical engineering lead; **Arnold Kadiu** (BSE ME '15), structures lead; **Steve Hwang** (BSE ME '14), mechanical engineer, and **Preston Strauch** (BSE ME '14), metals manufacturing lead.

+ more on the web

For more information, visit **http://solarcar.engin.umich.edu/** or follow **@UMSolarCarTeam** and **@i_am_generation** on Twitter.

> *Generation* took more than 100 student team members and over $1 million to build.



Baja Racing Rocks Off-Road

The Society of Automotive Engineers U-M Baja Racing team ended the 2012-13 season muddy but proud. Garnering the most points at all three Baja competitions this season earned the team its first Mike Schmidt Memorial Iron Man Award, the championship prize.

Each year, Baja teams build a new off-road, single-seat car with a stock, 10 horsepower engine. Some 200 teams from around the world compete. The U-M team outfitted its 2013 vehicle with a gearbox, which helped boost speed and durability. Members also built a custom drivetrain and suspension.

Their work paid off. At the first competition, at Tennessee Tech University, the team won the endurance race, a "major accomplishment" and one of the team's proudest moments, said **Calvin O'Brien** (ME '13), 2013 team captain. It was the first endurance win for U-M Baja since 1995. The team placed sixth overall.

At its second competition, held at Western Washington University, U-M Baja took third in acceleration and, again, won the endurance race, giving it a first place win overall.

At Rochester Institute of Technology, the team placed fourth overall, second in endurance and third in both acceleration and hill climb.

O'Brien credits good prioritization and workload management for the strong season. "Early on there was a push to make a lot of changes to the car, but ultimately we decided against many of these so we could ensure plenty of testing time after the car was completed. The added testing time helped us determine weaknesses in our design and to improve the durability."

Given how well that strategy worked and given the team's plans to make more changes in the coming season, it has already built in plenty of testing time to its 2013-14 schedule.

A top goal for the coming season is to improve in the design portion of the competition. "Our performance has been at an extremely high level, but the design judges have been asking to see greater analysis from us," O'Brien said. With support from the ME department and both longtime and new sponsors, the team has recently acquired new electronics for data acquisition and analysis.

Support in all its forms is vital to the team's success, O'Brien added. "We're really fortunate to have a lot of dedicated sponsors, and we also started working with several new sponsors this year, including our newest title sponsor, GKN."

Incoming team captain **Brandon Amat** (ME '14) is expecting a strong 2013-14 season. "I'm very excited for the upcoming season given the amount of talent we're retaining. A big focus of ours will be on recruitment in the fall months; success comes a lot easier when the team is larger and you have more people to concentrate on different parts of the car. We aim to sustain the success we saw this year for many more years."

+ more on the web

To learn more about U-M Baja, visit **https://www.facebook.com/michiganbajaracing**.

Calvin O'Brien, the driver at the team's competition at Rochester Institute of Technology. **Photo credit: Christopher O'Brien.**

A Winning Formula:
MRacing Finishes the 2012-13 Season Strong

The University of Michigan Formula SAE team, MRacing, returned from Formula Student Germany 2013 with another top-ten finish to its name. Overall, the team placed ninth among the 75 teams competing at the Hockenheimring.

The team's goal for the year had been to improve vehicle's aerodynamics, which was accomplished with a new wings package. "We designed the entire car around it," said **Joe Martin** (BSE ME '15), 2014 team captain and drivetrain system leader.

The new wings required other design changes, including to the cooling system, suspension, frame and drive train. In testing, the team saw a five percent improvement in lap time. "We'll be expanding on the car's aerodynamics significantly this coming year, looking for even more downforce," Martin said.

The changes paid off in competition. At Formula SAE Michigan, held at Michigan International Speedway (MIS), MRacing made the design finals and did well in other static events. But a failure during the endurance portion of the competition led to a disappointing overall finish.

The setback at MIS was the team's greatest challenge of the competition season but served as a motivating force. "The team did a great job of pulling together, identifying the problem and figuring out what needed to happen to make sure it didn't happen again. You could see how motivated everyone was to improve in our results in Germany and in the design of next year's car," Martin said.

At Formula Student Germany, MRacing placed sixth in the skidpad competition, its best showing ever, tenth in autocross and seventh in endurance, leading to a ninth place finish overall.

The team plans to compete in three competitions in the 2013-14 competition season. In addition to MIS and Germany, it will compete in Formula SAE Lincoln in Nebraska in June. The comeback in Germany this year fueled the competitive spirit and Martin said the team's goal is to finish first in Lincoln and among the top three at MIS and the top five in Germany.

But the team's sights are set on more than race results. "From a leadership perspective, the [seniors] want to leave the team with the knowledge and resources it needs to continue to be successful and also to expand the team," Martin said. "Whether someone can spend 50 hours a week or five hours a week, the more help you have means the more the team can get done."

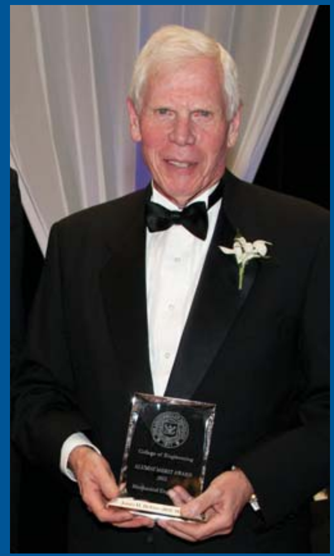
As in years past, MRacing is grateful for the generous, enthusiastic support it receives from title sponsor BorgWarner as well as the College of Engineering, Bosch, Witzenmann, Powers and Sons, Chrysler and many others. Alumni also have provided a great deal of mentorship and support, as has faculty advisor **Tim Gordon**, ME research professor.

"The team relies heavily on everyone's help. The companies, in particular, give us a lot of design feedback and help with development work," Martin explained. "That input is invaluable to the design and development of a professional level race car—they leave students with skills critical to their success in whichever field their careers take them."

+ more on the web

For more information on MRacing, visit **http://mracing.engin.umich.edu/**.

DeVries Receives 2012 ME Alumni Merit Award


JAMES H. DEVRIES

ME alumnus **James H. DeVries** (BSME '67) has received the 2012 ME Alumni Merit Award. The Alumni Merit awards recognize distinction at the department level and honor those who personify the College of Engineering's tradition of excellence.

Millions of people are alive today because of the cardiovascular surgical equipment DeVries invented. While still a student at U-M, DeVries helped develop some of the first commercial heart-lung machines, including the one Dr. Christiaan Barnard used in the first human heart transplant. This work paved the way for a career in medical device innovation.

DeVries worked for Dick Sarns, medical device developer and founder of Ann Arbor-based NuStep, and, later, Baxter Laboratories before founding his own company, DLP Inc. The company designed and produced products to protect the heart during cardiovascular procedures. Such technologies have included heart-lung machines, donor organ storage and cell separation equipment. From its beginnings in Grand Rapids, the company expanded to include satellite locations in Holland, France, England and Germany.

DeVries has been recognized with numerous other awards for his outstanding contributions and achievements, including the Entrepreneur of the Year Award in 1992, the Business Person of the Year Award in 1993 and the Medical Hall of Fame Award in 2000. He is named on over 100 U.S. patents.

Since retiring in 2002, DeVries has embarked on a second career in sculpting. His work can be seen in a number of public collections across the world, including Duke University Divinity School, Kettering Medical Center, Cornerstone University in Grand Rapids and Seva Bharat in India. He and his wife Judy have three children and nine grandchildren.

Bayazitoglu Receives 2013 ME Alumni Merit Award


YILDIZ BAYAZITOGLU

Mechanical Engineering alumna **Yildiz Bayazitoglu** (MS ME '69; PhD '74) has been selected to receive the 2013 ME Alumni Merit Award.

Dr. Bayazitoglu joined Rice University in 1977 and has served as the Harry S. Cameron Chair Professor of Mechanical Engineering since 1996. Previously, she was assistant professor at the Middle East Technical University in Turkey and a visiting assistant professor at the University of Houston. She earned her bachelor's degree in mechanical engineering at Middle East Technical University in Ankara, Turkey.

Dr. Bayazitoglu has made significant contributions to thermo-physical property determination and containerless processing of materials, radiation and convective heat transfer, phase-change heat transfer, oil reservoir fluid flow heat transfer, cryogenic tank thermal analysis, hydrogen-oxygen fuel cells, solar collector analysis, micro- and nanoscale heat transfer, and thermal modeling of the human head and optimization of hypothermic therapies. Her work has been published in reputable journals and high caliber proceedings, and she has more than 200 publications in technical journals and conference proceedings. She also has co-authored two undergraduate textbooks, *Elements of Heat Transfer* and *A Textbook for Heat Transfer Fundamentals*. Currently, she is the editor-in-chief of the *International Journal of Thermal Sciences*.

Dr. Bayazitoglu has amassed a long list of honors, including the Society of Women Engineers (SWE) Distinguished Educator Award, many awards from Rice University and, from the American Society of Mechanical Engineers (ASME), the Heat Transfer Memorial Award. She is a fellow of the ASME and of the American Association of Advancement of Science.

In 2012, Dr. Bayazitoglu was made an honorary member of the ASME, and she received the SWE's Achievement Award, the highest award given by the organization.

Yoram and Alina Koren Conference Room Dedicated

In October 2012 the Department honored longtime faculty member Professor **Yoram Koren** and his wife of almost 50 years, **Alina**, with the dedication of the Yoram and Alina Koren Conference Room in the Herbert H. Dow Building. The conference room was dedicated to celebrate the Korens' many contributions to the University, to the technical community and to society.

The ceremony was hosted by Mechanical Engineering Chair **Kon-Well Wang** and College of Engineering Dean **David Munson**. Many ME faculty and numerous other individuals attended the ceremony, including former doctoral students who came from Korea for the event, a further testament to the wide impact Koren has had on so many people as a mentor, peer, researcher and friend.


Professor Yoram Koren and his wife Alina cutting ribbon to the Koren Conference Room

"Dedicating a room to Alina and me is indeed a great honor, and we feel uplifted," Koren said in his remarks.

Koren's professional accomplishments include groundbreaking work in the areas of reconfigurable manufacturing, manufacturing automation and robotics. His visionary research has earned some of the most prestigious honors in the field of manufacturing. At U-M, he has won the Stephen S. Attwood Award, the highest faculty honor presented by the College, and he was named a Distinguished University Professor, one of the highest recognitions the University can bestow upon a faculty member. He also is an elected member of the National Academy of Engineering, one of the highest professional honors accorded an engineer.

As Wang said during the ceremony, "Yoram is a wonderful colleague. He is a senior statesman who is full of passion and compassion. He is a team builder and a wonderful mentor to many individuals."

Papalambros selected for Distinguished University Professorship


PANOS PAPALAMBROS

ME Faculty **Panos Papalambros**, the Donald C. Graham Professor of Engineering and professor of mechanical engineering, as well as professor of art and design, and professor of architecture, has been awarded a Distinguished University Professorship (DUP). This appointment is one of the highest honors the University can bestow upon an eminent member of the faculty.

Each Distinguished University Professorship bears a special name, determined by the appointive professor in consultation with his dean. Papalambros was named the James B. Angell Distinguished University Professor of Engineering.

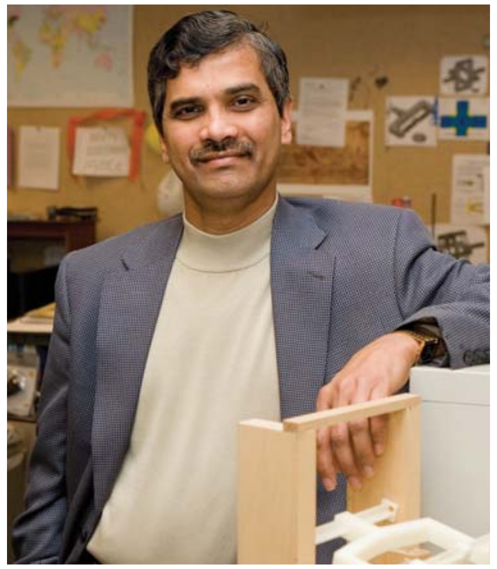
The Distinguished University Professorships recognize exceptional scholarly and/or creative achievements, national and international reputation, superior teaching and mentoring, and an impressive record of service. In creating these positions in 1947, the Board of Regents intended that Distinguished University Professors be recognized for their great contributions to the University and the nation.

Kota Named Herrick Professor

Professor **Sridhar Kota** has received the Herrick Professorship of Engineering. The professorship was established in 1995 by the Herrick Foundation of Detroit to recognize distinguished work in interdisciplinary, mission-oriented manufacturing.

During the past two decades of his career, Professor Kota has distinguished himself as an outstanding academic leader who bridges the gap between theory and practice in engineering research and education. Through his scholarly work, entrepreneurship and leadership, Kota has had a tremendous impact on various aspects of manufacturing.

Kota pioneered a new research field of compliant systems design for manufacturing without assembly. He has demonstrated the transition from novel design concepts to innovative manufacturing of hard goods in the marketplace through numerous inventions and a start-up company. He also played an instrumental role in defining the nation's manufacturing agenda and helped create the Advanced Manufacturing Partnership, which led to the Manufacturing Innovation Institutes announced by President Obama.



SRIDHAR KOTA

VOLKER SICK

Sick Named Arthur F. Thurnau Professor

Professor **Volker Sick** has received a prestigious Arthur F. Thurnau Professorship. The honor is given to faculty members who have made outstanding contributions to undergraduate education.

Sick serves as director of the Walter E. Lay Automotive Laboratory and a university co-director of the General Motors Engine Systems Research Collaborative Research Laboratory. In 2012, Sick was appointed Associate Vice President - Natural Sciences & Engineering through the University's Office of the Vice President for Research.

Several Mechanical Engineering faculty have been appointed Arthur F. Thurnau professors in past years, including Jim Barber, Noel Perkins, Steve Skerlos, Alan Wineman and Margaret Wooldridge.

Faculty Awards & Recognition

EXTERNAL AWARDS

ELLEN ARRUDA
American Orthopaedic Society for Sports Medicine (AOSSM) Excellence in Research Award, 2012

Ann Arbor SPARK Boot Camp Award, 2012

SHORYA AWTAR
SAE Ralph R. Teetor Educational Award, 2012

JAMES BARBER
Text and Academic Authors Association (TAA), 2012

SAMANTHA DALY
SEM Young Investigator Lecturer, 2013

NSF CAREER Award, 2013

Hetenyi Award from Society of Experimental Mechanics, 2012

AFOSR Young Investigator Research Program Award, 2012

JIANPING FU
NSF Career Award, 2012

VIKRAM GAVINI
AFOSR Young Investigator Research Program Award, 2012

Humboldt Foundation Research Fellowship, 2012

JACK HU
ASME Mfg Science & Engr Conference Best Paper Award, 2012

ASME William T. Ennor Manufacturing Technology Award, 2012

ERIC JOHNSEN
ONR Young Investigator Award, 2012

SRIDHAR KOTA
Herrick Professorship of Manufacturing in Engineering, 2012

ALLEN LIU
NIH New Innovators Award, 2012

JYOTI MAZUMDER
National Academy of Engineering, 2012

JUN NI
Shanghai Science and Technology Int'l Cooperation Award, 2013

SME Gold Medal, 2013

JWO PAN
SAE Henry Ford II Distinguished Award for Excellence in Automotive Engineering, 2012

SAE Arch T. Colwell Merit Award, 2012

ASEE Archie Higdon Distinguished Educator Award, 2012

DAVID REMY
ETH Medal for outstanding PhD thesis (ETH Zurich), 2012

PRAMOD SANGI REDDY
DARPA Young Faculty Award, 2012

ALBERT SHIH
ASME Mfg Science & Engr Conference Best Paper Award, 2012

VOLKER SICK
SAE International Leadership Citation, 2012

DON SIEGEL
SAE Ralph R. Teetor Educational Award, 2013

JEFF STEIN
ASME DSCD Michael J. Rabins Leadership Award, 2012

BRUCE TAI
ASME Mfg Science & Engr Conference Best Paper Award, 2012

MICHAEL THOULESS
Fellow, Institute of Materials, Minerals and Mining in UK, 2012

DAWN TILBURY
SWE Distinguished Engineering Educator Award, 2012

GALIP ULSOY
ASME Charles Russ Richards Memorial Award, 2013

TÜBİTAK Special Award, 2012

HUI WANG
ASME Mfg Science & Engr Conference Best Paper Award, 2012

NEW FELLOWS

ANDRE BOEHMAN
SAE Fellow, 2012

DAVE DOWLING
American Physical Society Fellow, 2012

JACK HU
CIRP Fellow, 2012

HONG IM
ASME Fellow, 2012

WEI LU
ASME Fellow, 2012

JUN NI
Int'l Society for Nanomanufacturing (ISNM) Fellow, 2012

Int'l Society of Engineering Asset Management (ISEAM) Fellow, 2012

WILLIAM SCHULTZ
American Physical Society Fellow, 2012

DAWN TILBURY
ASME Fellow, 2012

MARGARET WOOLDRIDGE
SAE Fellow, 2012

UM AWARDS

ELLEN ARRUDA
CoE Ted Kennedy Family Team Excellence Award, 2012

SHORYA AWTAR
CoE 1938E Award, 2013

BRENT GILLESPIE
Provost's 2013 Teaching Innovation Prize (TIP), 2013

TIM GORDON
CoE Kenneth M. Reese Outstanding Research Scientist Award, 2012

SRIDHAR KOTA
ME Department Achievement Award, 2012

KATSUO KURABAYASHI
ME Department Achievement Award, 2013

WEI LU
Rackham Faculty Recognition Award, 2012

ME Department Achievement Award, 2013

JONATHAN LUNTZ
CoE Kenneth M. Reese Outstanding Research Scientist Award, 2013

JYOTI MAZUMDER
Distinguished University Innovator Award, 2012

PANOS PAPALAMBROS
Distinguished University Professor, 2013

VOLKER SICK
Arthur J. Thurnau Professorship, 2013

CoE Education Excellence Award, 2012

Rackham Master's Mentoring Award, 2012

KATHLEEN SIENKO
ME Department Achievement Award, 2012

Provost's 2012 Teaching Innovation Prize (TIP), 2012

Rackham University Undergraduate Teaching Award, 2012

STEVE SKERLOS
Arthur J. Thurnau Professorship, 2012

ANNA STEFANOPOULOU
CoE Research Excellence Award, 2012

MICHAEL THOULESS
CoE Education Excellence Award, 2013

SACUA Distinguished Faculty Governance Award, 2012

GALIP ULSOY
CoE Stephen S. Attwood Award, 2012

ANGELA VIOLI
Rackham Faculty Recognition Award, 2013

Rackham Henry Russel Award, 2012

MARGARET WOOLDRIDGE
CoE Service Excellence Award, 2012

FACULTY PROMOTIONS

SHORYA AWTAR
to Associate Professor with Tenure

BOGDAN EPUREANU
to Professor with Tenure

VIKRAM GAVINI
to Associate Professor with Tenure

TAE HYUNG KIM
to Assistant Research Scientist

GRANT KRUGER
to Assistant Research Scientist

WEI LU
to Professor with Tenure

JONATHAN LUNTZ
to Associate Research Scientist

KENN OLDHAM
to Associate Professor with Tenure

PRAMOD SANGI REDDY
to Associate Professor with Tenure

KATHLEEN SIENKO
to Associate Professor with Tenure

Student Awards

GRADUATE STUDENT AWARDS

AHMAD ALMUHTADY
International Conference on Operations Research and Enterprise Systems Best Paper Award, 2013

JUSTIN BEROZ
William Mirsky Memorial Fellowship, 2012

CHRISTOPHER BYNES
NSF Fellowship, 2012

INDRANIL DALAL
Ivor K. McIvor Award, 2012

MATHIEU DAVIS
Fulbright US Student Award, 2013

DAVID HIEMSTRA
CoE Distinguished Leadership Award, 2013

William Mirsky Memorial Fellowship, 2012

JESSANDRA HOUGH
NSF Fellowship, 2012

ADAM KAMMERS
Caddell Team Award for Research (Samantha Daly faculty), 2013

Azarkhin Scholarship, 2012

PETER LILLO
NSF Fellowship, 2012

JINJIN MA
Rackham Distinguished Dissertation Award, 2013

KAITLYN MALLETT
NSF Fellowship, 2012

IBRAHIM MOHEDAS
NSF Fellowship, 2012

PHANI MOTAMARRI
Rackham Predoctoral Fellowship, 2013

POOYA MOVAHED
Azarkhin Scholarship, 2013

SEID SADAT
Richard and Eleanor Towner Prize for Outstanding PhD Research1, 2013

PAUL SCHREMS
ASME Innovation Showcase (Ishow), 2013

DANVIR SETHI
William Mirsky Memorial Fellowship

SHRENIK SHAH
William Mirsky Memorial Fellowship, 2012

GREGORY TEICHERT
NSF Fellowship, 2012

UNDERGRADUATE STUDENT AWARDS

SERGEI AVEDISOV
Lloyd H. Donnell Scholarship, 2012

KENDRA BORCHERS
R & B Machine Tool Company Scholarship, 2012

WILLIAM CHEN
Caddell Memorial Scholarship, 2013

CHRISTOPHER COYNE
R&B Tool Scholarship, 2013

MICHAEL CZARNECKI
Robert M. Caddell Memorial UG Award, 2012

MICHAEL ERICKSON
R & B Machine Tool Company Scholarship, 2012

BRANDON EVANS
ME Academic Achievement Award, 2012

GRACE GU
ME Spirit Award, 2012

JINGJIE HU
Robert M. Caddell Memorial UG Award, 2012

ZACHARY HWANG
ME Spirit Award, 2013

VAISHNAVI ILANKAMBAN
R & B Machine Tool Company Scholarship, 2012

BRIAN KEYT
R&B Tool Scholarship, 2013

NICHOLAS MONTES
Caddell Memorial Scholarship, 2013

MAX OLENDER
Lloyd H. Donnell Scholarship, 2013

TYLER OLSEN
R & B Machine Tool Company Scholarship, 2012

ADAM STEVENS
Robert M. Caddell Memorial UG Award, 2012

NICK TURNBULL
ASME Innovation Showcase (Ishow), 2013

HAIPEI ZHU
R&B Tool Scholarship, 2013

ZIQI ZHU
R&B Tool Scholarship, 2013

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Design
MICHIGAN CREATIVE

ME new research complex construction site.
See page 4 for details.
PHOTO: MARCIN SZCZEPANSKI, UNIVERSITY OF MICHIGAN, COE, MULTIMEDIA PRODUCER

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