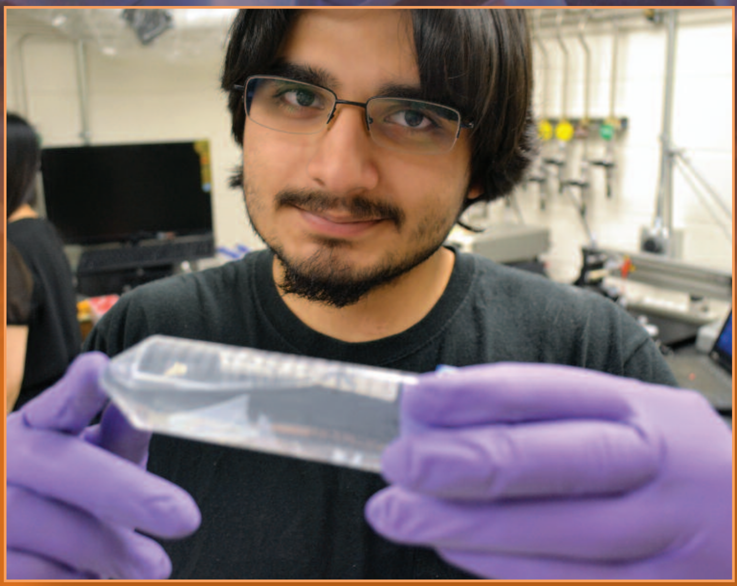
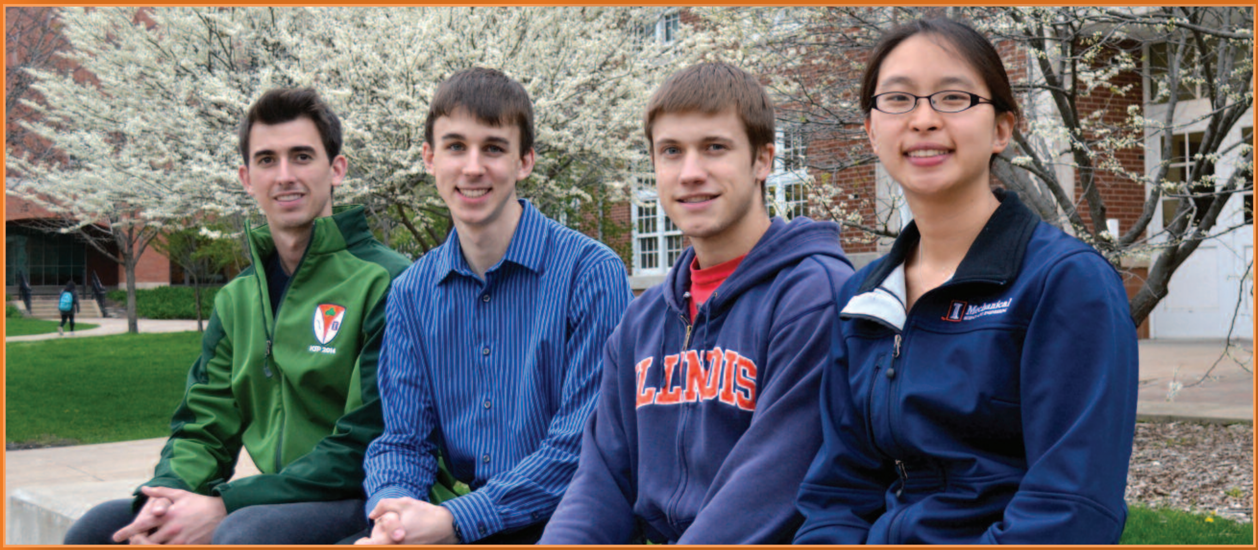
ENGINEERING AT ILLINOIS

Fall 2014

# Mechanical
## SCIENCE AND ENGINEERING





Moving the World Forward

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**Mechanical Science and Engineering**

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Placid Ferreira

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Cover: (Top row) Ping-Ju Chen and Jonathan Bunyan from Assistant Professor Sameh Tawfick's research group. (Bottom) Matt Condon, Kendall Rak, Marc Deetjen, and Julia Huynh, MechSE students named to the Senior 100 Honorary in 2014.

## Launching the U.S. digital manufacturing revolution

A 94,000-square-foot facility on Goose Island in Chicago will soon be the home of the Digital Manufacturing and Design Innovation Institute (DMDII). The MechSE Department is heavily involved with this incredible new initiative, which was announced by President Obama at the White House in February 2014. See page 10 to learn more.

Join our social networks—just go to mechse.illinois.edu!



## From the Department Head

Having now completed five full years as MechSE's department head, I am extremely pleased with the current state of the department. I will share my thoughts on a few news items with you in this letter, but in the scope of all that is being accomplished by our students, faculty, and alumni, this is truly just the tip of the iceberg.

Our students continue to amaze us. In the pages that follow, we cover but a small portion of their great recent accomplishments. One of the most notable achievements involved senior **Katie Neville**, who was awarded the Harvey H. Jordan Award from the College of Engineering. This marks the third consecutive year a MechSE student has received this honor, which is awarded to the top student in the entire college.

Following our recent magazines that have highlighted MechSE's research in bioengineering and energy, this magazine begins with a special section on manufacturing. As a society, we have come full circle in regard to manufacturing, and the country has recognized the need for having a strong and vibrant manufacturing sector in our economy. This has brought new opportunities for MechSE in manufacturing research and education, some of which are described in this special section. I hope you enjoy reading it.

In other faculty news, Professor **Andrew Alleyne** has taken on the post of Associate Head for Undergraduate Programs. He is uniquely qualified to fill this crucial role, and our students could not ask for a more dedicated and insightful leader. I wish to thank his predecessor, Professor **Kenneth Christensen**, for his hard work and for everything he accomplished in this position. This included an extremely rigorous and impressive study and presentation of our undergraduate programs for an ABET accreditation review, the results of which we will share in the Spring 2015 magazine.

We also recently underwent an external program review from faculty at peer institutions. Their assessment of MechSE aligned precisely with our own—that the "high reputation of the department (is) justified by the excellence of its graduate and undergraduate programs and by a dynamic research enterprise grounded in the fundamentals." The review team also agreed with our self-assessment regarding the increasing number of highly qualified students applying to MechSE: increases in faculty size and facility space are demanded.

Our work on these needs is already underway. We are excited that several highly qualified new faculty members will join the department in Fall 2014, a great start on our plan to add at least 20% more professors in MechSE.

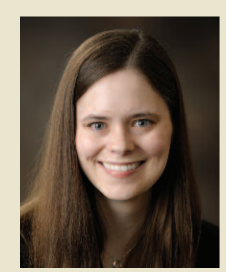
Regarding facilities, we are now completing the conceptualization phase for an addition to the Mechanical Engineering Building, and for renovating and expanding the current space, in an effort to improve the quality of our instructional facilities, create more hands-on learning opportunities, and promote collaboration and teamwork among our students. Given the challenging financial climate in the state and at the university, we will rely heavily on the generosity of our alumni and friends to make these expansions a reality, and we are pleased to say that the reaction from the few alumni who have seen the plan has been overwhelmingly positive. The resounding message has been, "Let's make this happen!"

I share this enthusiasm for continuing MechSE's trajectory toward producing the world's finest engineers while creating the best possible student experience in mechanical science and engineering. If enough people feel the same, we will indeed make it happen.

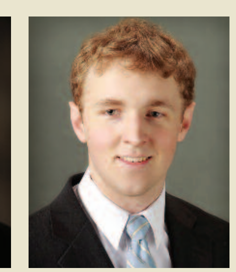
With best regards,

Placid Ferreira
Department Head
Tungchao Julia Lu Professor

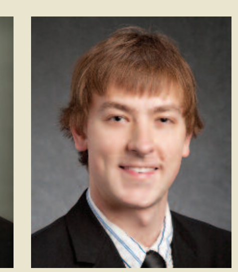
## MechSE students setting the pace



Katie Neville



Daniel Borup



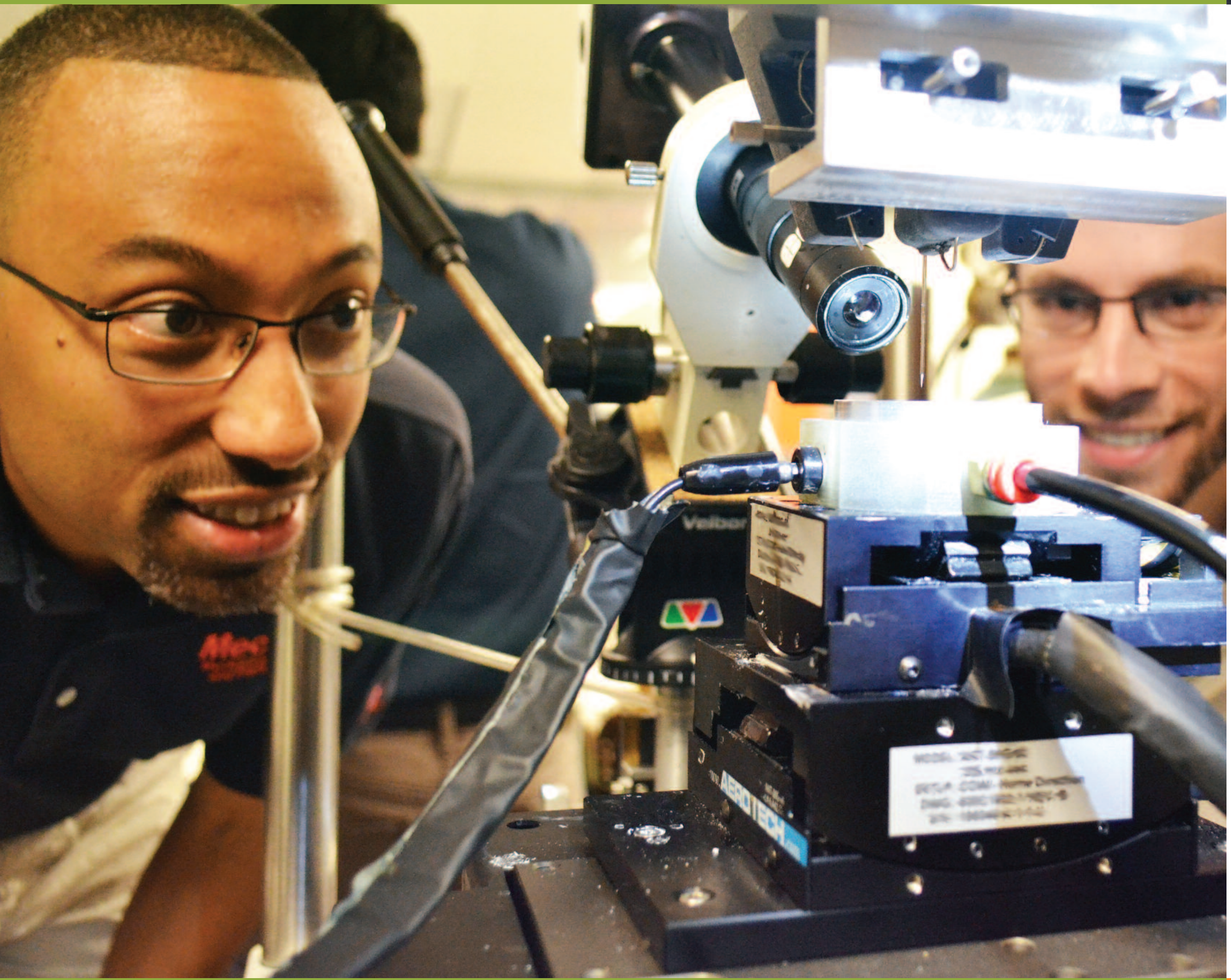
Luke Zaczek

When **Katie Neville** (BSME '14) was named the winner of the Harvey H. Jordan Award in Spring 2014, it marked the third consecutive year in which a MechSE student received this prestigious honor. The previous winners were **Daniel Borup** (BSME '13) and **Luke Zaczek** (BSME '12). Harvey H. Jordan served for many years as a professor of general engineering and as an associate dean in the College of Engineering. This annual award honors him by recognizing the scholastic achievement and character of an outstanding senior. It is given to only one student per graduating class in the entire College of Engineering.

# MechSE & Manufacturing

## Producing big ideas on small technology

No sector has represented the lifeblood of the United States over the past century more than manufacturing, and the machinery that powers American manufacturing has been a major area of study in this department since our first semester back in 1870. As in years past, our faculty members today are recognized as leaders who are continually advancing manufacturing knowledge, methods, and analysis. In this special section, we profile professors **Shiv Kapoor**, **Andrew Alleyne**, **Seok Kim**, **Sameh Tawfick**, **Brian Thomas**, **William King**, and **Placid Ferreira** and their manufacturing research.



SPECIAL SECTION

Professor Shiv Kapoor (center) and his research group, L-R: James Zhu, Asif Tanveer, Soham Mujumdar, Chandra Nath, Surojit Ganguli, and Napassawan Kanskulthorn.

"From legendary MechSE figures **Kenneth Trigger**, **Bei Tse Chao**, and **James Leach**, to recent professors **Richard DeVor** and **Mark Shannon**, the department's faculty has a long tradition in ground-breaking manufacturing research," said Professor **Placid Ferreira**, department head of Mechanical Science and Engineering (MechSE) at Illinois. "Much of the work done here has had an impact across the manufacturing sector and is now standard practice throughout the world."

The most fundamental manufacturing research in the department's early days was centered on understanding the physics behind manufacturing processes. Research then advanced to the study of thermal aspects of manufacturing. Today, MechSE researchers study how design and manufacturing integrate, as well as how to collect and utilize information to assess manufacturability and manufacturing costs in the process. And in typical Illinois fashion, these researchers have uncovered and articulated the "science" behind the practice—as you will read in the pages that follow.

### New microscale manufacturing processes have macroscopic impact

While Professor **Shiv Kapoor**'s research has always been in manufacturing, it was not always in microscale manufacturing. He has worked with companies like Caterpillar, Ford, GM, and John Deere on the macroscale level. About 15 years ago, he and a team of colleagues distributed a survey to investigate where the trends in manufacturing were heading.

"We were looking for where the trend was going in manufacturing," Kapoor said. "So we looked around and surveyed all over the world, we had a team going and visiting different countries, and we found out that there was a lot of miniaturization taking place. In most of the places they were all looking for the same kind of manufacturing: microscale. But there was not much tooling and equipment available to do that. They had the need, but they were using the old technology to make those smaller parts, which was very inefficient. So we came back and we started thinking about how we can really develop new equipment, new machines."

The idea was to create manufacturing tools that were specific to microscale manufacturing. Kapoor and his group learned quickly that there are challenges when a process is scaled down, and sometimes to manufacture something at the microscale requires changing the macroscale process altogether.

"Titanium and some other materials are very difficult to machine even at the macroscale," Kapoor said. "But then we got into the microscale, and it was even more challenging. So we said the process with which they make it is not the same that we should use at the microscale; at macroscale we take two or three steps to make machining of these hard materials to the finish, but we don't have that much room. So we started thinking about a new process, and we built the machine again in a new configuration that will meet specific requirements for machining hard materials."

A clear example of Kapoor's innovation is in its application to the medical industry. Surgical blades that need to be especially precise and sharp—such as those used in

### Alumni in Manufacturing: Curtis Vass

**Curtis Vass** (BSME '84) has developed an impressive track record as a technology executive in semiconductor and solar equipment manufacturing, leading business development, operations, and product development. His career has included the positions of general manager of a product group at Applied Materials, CEO of Astrowatt, Inc. until 2012, and now executive vice president of business development for Scifiniti, Inc., a crystalline silicon technology company.

Left: Professor Andrew Alleyne and graduate student Herschel Pangborn use the Electrohydrodynamic-Jet Printing System developed by the NanoCEMMS Center at Illinois. This system can deposit high-resolution droplets for fabricating biological sensors, micro-optical devices, and highly integrated electronic devices.



# **Cleanroom facilities** provide unique advantage for MechSE researchers

Of all the qualities that make the MechSE Department a standout at Illinois and throughout the nation, the Micro-Nano Mechanical Systems (MNMS) Laboratory is one of the biggest and most unique.

Better known as the MNMS Cleanroom, this valuable and extremely well-run lab is located on the second floor of the Mechanical Engineering Building. It was built in 1998, with a second phase added in 2005, and much of the credit for its existence goes to the late MechSE professor **Mark Shannon**.

"Professor Shannon was the founding director of the MNMS Laboratory," said MechSE department head **Placid Ferreira**. "He had the foresight to realize that micro- and nano-scale sciences would become an integral part of the mechanical engineering discipline. He single-handedly founded and equipped this unique teaching and research facility that has been so immensely beneficial to the Department of Mechanical Science and Engineering."

Throughout his career, Shannon greatly advanced nanoscale, microscale, and mesoscale science and technologies that address real-world problems.

The MNMS Cleanroom is a 3,800-square-foot suite of labs and related support rooms, including two cleanroom laboratories for research in the design and fabrication of small-scale mechanical systems. The lab supports research and instruction in the general area of micro- and nano-electro-mechanical systems (MEMS & NEMS), and nano-chemical-electrical-mechanical-manufacturing systems (Nano-CEMMS). The current focus is on devices employing nano-to-microscale mechanisms and the integration of these mechanisms into meso-scale devices.

The MNMS laboratory has class 100 and 10 cleanrooms for the microfabrication, inspection, and testing of devices. The cleanrooms house a range of state-of-the-art equipment for lithography, etching, deposition, analysis, and many other broad-use machines, from an electronic visions wafer-bonding system and a programmable curing oven to a vacuum annealer and an ultrasonic cleaner.

It is rare for an engineering department to have its own cleanroom facilities located in-house, where faculty and student researchers have access to cutting-edge equipment in a contamination-controlled environment right at their fingertips. Many top Illinois researchers outside of MechSE also utilize the MNMS Cleanroom on a regular basis.

Graduate student Hohyun Keum works in the MNMS Cleanroom, a facility that provides an opportunity for research and discovery that is otherwise unattainable in a typical laboratory setting. It is equipped with state-of-the-art equipment for lithography (EVG620), etching (STS Pegasus ICP-DRIE), deposition (AJA International and Kurt J. Lesker DC and RF sputterers, MVD, and tube furnace), and many other broad-use machines. Along with fabrication tools, the cleanroom is also equipped with eight fume hoods for wet processing and many analysis tools.


optical surgery—are often made of diamond. Very sharp edges can be produced with diamond, but diamond blades are incredibly expensive and difficult to manufacture. Kapoor started to look at different ways and different materials he could use to make a sharper surgical blade, without the difficulty and expense.

"There is an amorphous material we found called bulk metallic glass, which has no grains," Kapoor said. "And we found that it's biocompatible. If you heat it, it becomes very malleable and behaves like polymer, and then you can draw it as sharp as you can. We have built a machine that does this, and we can get to a 60-80 nanometer edge radius! Now we are working on enhancing the features so we can get a finish of 30-60 nanometers."

Another project is applicable more to the aerospace industry, where titanium is a popular material. Titanium has a very low thermal conductivity, so when it is machined, all the heat at the cutting interface goes to the tool, and so the tool wears out very quickly. The typical solution is to flood the machine with high-pressure cutting fluid to try to draw some heat away, but the fluid doesn't effectively reach the actual contact region between the tool and the metal piece because of its viscosity. This is a problem most often seen in macromanufacturing, but Kapoor, using his knowledge of micromanufacturing, has innovated a solution called an atomization-based cutting fluid spray system.

"We take the cutting fluid and atomize it," Kapoor said. "We make small droplets of this cutting fluid, and then we inject these droplets on the tool itself. And once we put enough microscopic drops, we get to make a thin film of fluid. The concept is that I cannot penetrate into that interface with a lot of cutting fluid, but if I make a very thin film fluid, with certain velocity, I can get this thin film to penetrate to the interface. And in the process I really save a lot of cutting fluid."

Reducing the amount of cutting fluid used is good for the environment, and for the workers of machining plants. Some cutting fluids include chemicals that can irritate the skin and lungs with extended exposure.

## Precision-control algorithms crucial for quality manufacturing

Professor **Andrew Alleyne** sometimes finds it challenging to explain his research in systems and controls. He and his group perform advanced modeling of complex systems and develop sophisticated control algorithms for a variety of applications.

"For folks that are not familiar with the manufacturing process, sometimes it's a little bit hard," Alleyne said, "because at the core, what I contribute are the algorithms and those are hard to see. It's hard to touch an algorithm. But you have to ask yourself, what's a good decision worth to you? Good algorithms make good decisions, and those can be worth a lot."

Manufacturing machines need controlled algorithms to dictate precisely when and how they need to move, sometimes to an accuracy of one-tenth of a micron or smaller. These precision machines can be used to create electronics or sensor systems, or bio-engineering systems like tissue scaffolds. The emphasis is on the optimized combination of speed and precision; going faster means precision is more difficult to obtain. Controlling these machines


Postdoc Chandra Nath and graduate student Napassawan Kanskulthorn discuss the atomization-based cutting fluid (ACF) spray system developed by Nath and Professor Shiv Kapoor. Their system uses an ultrasonic atomizer to spray a thin layer of cutting fluid onto the cutting tool-chip interface, reducing the cutting temperature and friction coefficient. This means more effective machining of difficult-to-cut materials like titanium and nickel alloys, improved tool life, energy efficiency, and improved impact on the environment due to a vastly reduced need for cutting fluid.



to such a high level of precision can be incredibly difficult at times. If a machine is printing something at a scale of 10% the size of a human hair, and it must make a sharp turn with a half-micron accuracy, the speed of the printing tip must be carefully coordinated by a fairly intelligent algorithm to make it through the turn quickly, without accidentally being pulled off-course by inertia as it turns.

"The way I explain it to my family and friends is that 'I make big stuff go fast,'" Alleyne said. "And what they pay me for is to make it stop. Anybody can make big stuff go fast; the hard part is to make it stop where you want."

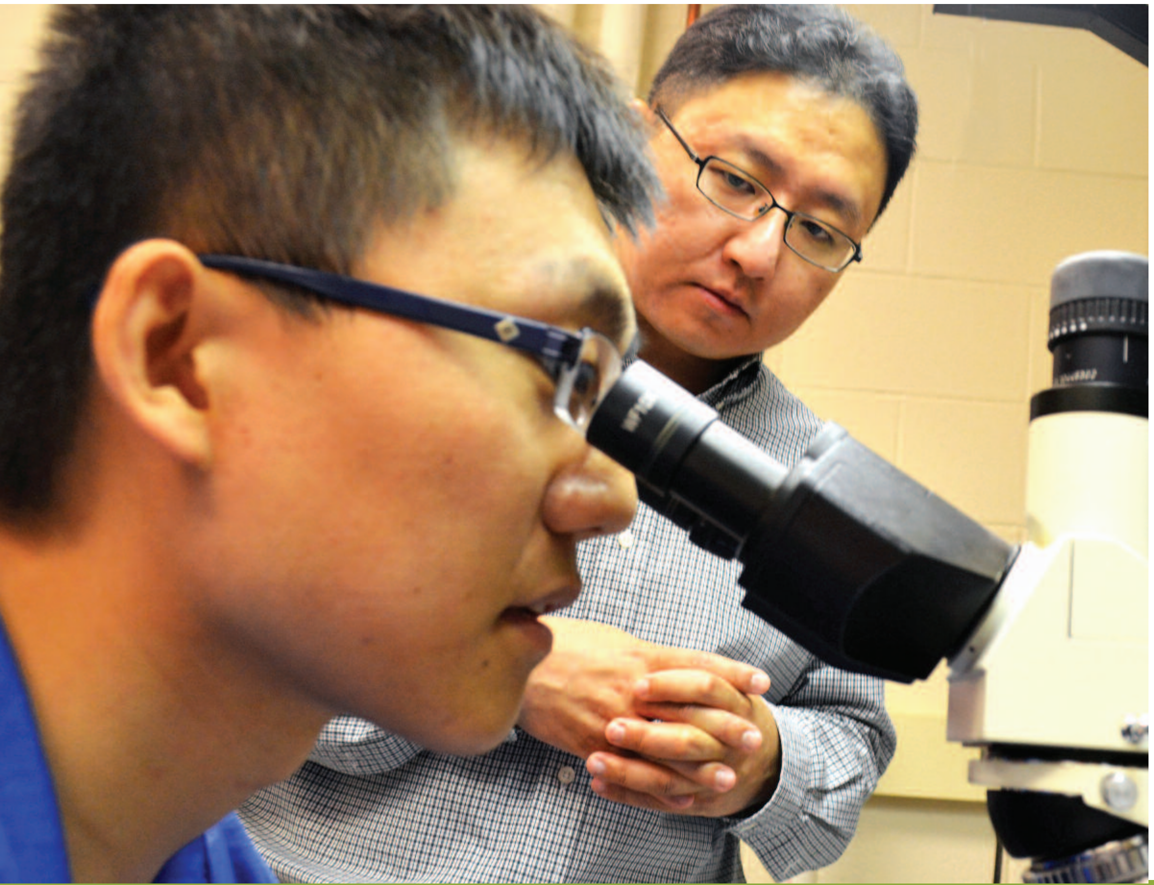
None of his work involves cutting or milling or drilling; the group works only on additive processes. They seek to have as much control as possible over where material is placed to build up a complex structure. This process can be more flexible than cutting out parts and finding ways to put them together, and can result in a more heterogeneous product.

Alleyne's work is intentionally multidisciplinary. He uses pen-and-paper calculations to find the algorithms he needs, simulates it on a computer to make sure it works and to hammer out fine details, and then puts it into the hardware of the machines and runs tests. He said learning this process has proven beneficial to his students.

"I think it does very well for the students after they graduate because they're able to see a wide range of challenges from concept to implementation," Alleyne said. "So when they go out, they're so well-versed they can take very different types of jobs, and they have experience with the theoretical and the experimental."

While the algorithms and software governing manufacturing machines are impossible to touch, the effects of their quality are tangible. Imprecision in machine controls can lead to many problems in manufacturing.

"The parts are going to be very sloppy; there's going to be a lot of variation, and that's very problematic," Alleyne said. "How do you maintain tight control? Part of it is with tool design, the machine design, the big computer numerically controlled machines, but a lot of it also is in the software, the algorithms, that go into making sure that system is monitoring what it's doing and doing exactly the right thing at exactly the right time."



Assistant Professor Seok Kim and graduate student Zining Yang study the features of their nanoscale donor and receiver substrates through an optical microscope prior to assembling them in the cleanroom. After each step in the substrate manufacturing process, the samples are checked to ensure a clean, smooth pattern with no particles adhering to them, which can result in distorted patterns. Kim has developed a process he termed "micro masonry" that involves transfer printing from one substrate to another in order to manipulate and assemble small-scale materials. The unique process allows him to build more complex 3D micro and nano devices that cannot be accomplished with traditional microfabrication techniques.

### New "micro-masonry" process creates complex microscale structures

At its core, there are two kinds of manufacturing: additive, where material is put together to make a structure; and subtractive, where making a structure involves etching away material. Assistant Professor **Seok Kim** works in additive manufacturing with micro/nanoscale systems, and he has designed a new method of additive manufacturing that may provide advantages over subtractive manufacturing in certain contexts.

Monolithic microfabrication is a common manufacturing method for devices that are made in one substrate, such as a silicon wafer. To make a transistor, for example, silicon dioxide is electrochemically deposited onto a silicon substrate to form a thin layer. The silicon dioxide layer is then patterned and mostly etched away in the desired pattern. There are two main disadvantages to this method. It is very challenging to create three-dimensional structures; deposition can only be made up to a micrometer in thickness. Depositing the material to 10 or 100 micrometers is prohibitively difficult and expensive. Second, it is inherently wasteful, as most of the material layered onto the surface is etched away.

As an alternative to monolithic microfabrication, Kim has created an additive manufacturing process that involves less waste and has more flexibility. Instead of etching a pattern out of a material, a pattern is created by placing individual units of the material onto the substrate to create structures.

"This approach is inspired by LEGO®s, or traditional masonry," Kim said. "We make units of the material we need in a donor substrate, like making bricks in a brickyard, and place them one at a time on the receiver substrate. The bricklayer uses mortar to bind bricks together; we just do some annealing to bind a silicon unit to other silicon units. So we are making standardized units somewhere and bringing them to another location and then we assemble them, exactly the same as LEGO® or the mason. That's why we call our process micro-masonry."

The process is very flexible. Many different types of structures can be made using the same tools. It also does not require a vacuum or plasma; it can be done at room temperature and atmospheric pressure. There are also some materials that do not electrochemically bind very well—such as silicon and gold. For monolithic microfabrication, the solution is usually to apply an adhesive layer of chrome between the silicon and gold. With micro-masonry, the two materials can be directly combined without that additional layer.

Kim said the process is not universally applicable. In the manufacture of LED displays, for example, the surface is one large and very repetitive planar pattern, usually with many pixels. Monolithic microfabrication works better for this kind of application, because it patterns over larger areas simultaneously, taking much less energy than it would to lay down each pixel one at a time.

However, there are a lot of devices for which micro-masonry is a much better approach than monolithic microfabrication. For devices whose structures are largely three-dimensional, or have delicate complex geometries, or require the integration of multiple materials, micro-masonry is much more efficient and far less expensive and wasteful. Kim believes it will be a revolutionary addition to micro/nanoscale manufacturing processes.

"There are many, many different manufacturing approaches," Kim said. "And all of them are complementary to each other. So ours has our own pros and cons, others have their pros and cons. But when we can combine them, we have a lot of options, and we can make better things. That's the whole idea."

## Alumni in Manufacturing: Mark Karasek

**Mark Karasek** (BSEM '84, MSME '86) is the executive vice president of engineering and chief technology officer of The Chamberlain Group, Inc., a global leader in access control products that manufactures residential and commercial garage door openers, gate operators, motion control security lighting, and door chimes. Karasek joined The Chamberlain Group in 1994 as a senior design engineer in the garage door opener engineering group.

### Manufacturing research for nanomaterials integration

Assistant Professor **Sameh Tawfick** and his research group are investigating how to translate nanomaterials like carbon nanotubes (CNTs) into large scale production to be used in transportation and construction materials.

"In 2013, the Government Accountability Office report on nanomanufacturing detailed the economic aspects of the valley of death, or the missing middle, of the transition of nanotechnology from R&D to industry," Tawfick said. "It is our role as manufacturing scholars to identify and overcome the technical hurdles of the valley of death."

Tawfick's research shapes nanomaterials into forms attractive to the composite industries, and possibly the consumers themselves, in a

*(continued on page 12)*

## Alumni in Manufacturing: Stanley Weiss

**Stanley Weiss** (PhDTAM '49), after 29 years with the Lockheed Corporation, started his academic career at MIT in 1991, where he spent nine years as a visiting professor. At Lockheed, he began in space systems manufacturing, then moved to the missile division on his way to the position of corporate vice president of engineering, and finally vice president for research and development. His book, *Product and Systems Development: A Value Approach,* written during his most recent activity as consulting professor at Stanford, incorporates lessons from these experiences and from his five years in the Department of Energy and as chief engineer at NASA.



# **First national manufacturing lab** will have distinct MechSE flavor

MechSE professor **William King** and other representatives from the University of Illinois stood alongside President Obama in February 2014 as he announced a new Chicago-based public-private partnership called the Digital Manufacturing and Design Innovation Institute (DMDII).

"We've got to make sure we're on the cutting edge of new manufacturing techniques and technologies," Obama said. "That's why we're here today: To take new action to put America at the forefront of 21st-century manufacturing."

The DMDII is an applied research institute that will develop digital manufacturing technologies and commercialize them within key industries. These technologies will be used to make everything from consumer products to heavy machinery to equipment for the military.

"Manufacturers who can adapt, retool, get something out, change for a particular spec of a particular customer—they're going to win the competition every time," Obama said. "And we want that country that is specialized in that to be us."

The DMDII will launch with $70 million from the U.S. Department of Defense. More than $250 million in additional funding will come from industry, academic, government, and community partners. The University of Illinois at Urbana-Champaign's Top 5 College of Engineering and its world-renowned National Center for Supercomputing Applications (NCSA) are central to DMDII.

King is the DMDII's principal investigator and will serve as its Chief Technology Officer.

"The challenges for manufacturing are virtually unchanged since the Industrial Revolution," King said. "How do you make a high-quality product and get it to your customer quickly? How do you most efficiently use materials and energy?"

Today's computing and data technologies, however, mean that companies generate huge amounts of data about the design, fabrication, assembly, quality, shipping, delivery, and use of their products. But that data is not aggregated. In fact, it is often thrown away.

The DMDII will develop data-integration technologies for the manufacturing industry. Companies will use the resulting "Digital Manufacturing Commons" to collect all of the data generated in a product's life cycle, analyze that data, and unlock its value. Developed by GE, this software will be made open-source through the DMDII for all its partners.

"Think of it as Facebook for manufacturing—a digital platform that will link innovators, factories, and computing," King said.

With MechSE department head **Placid Ferreira** and professor **Shiv Kapoor** also holding key roles at the DMDII, the department will play a vital part in its implementation and success.

"MechSE has played a central role in the Digital Lab, particularly through Bill King," Ferreira said. "Our faculty members have played a defining role in realizing the vision of a future in which digital technologies become an integral part of our manufacturing infrastructure."

Sensors will provide data on every aspect of the product. New tools will be created to model, prototype, and manufacture products. Machines on the factory floor will talk to each other. Entire factories will talk to each other.

All of that data and all of those digital conversations will be internet-based. Illinois' computer scientists and engineers will help make the conversation possible, and the Illinois cybersecurity experts will help keep it safe.

The Digital Manufacturing Commons will also link companies to supercomputing resources at NCSA and the experts who can make the most of them.

Ultimately, the challenges are complex, but the mission is simple. The DMDII will reduce costs for manufacturing, transform the way work is done, and spur economic growth.

"Digital manufacturing requires world-changing, research-driven innovation—the sort of innovation that has always been at the heart of pre-eminence at Illinois," Chancellor **Phyllis Wise** said. "Some might find that mandate intimidating; we find it exhilarating. We're proud to take on such a leading role."

"The size of our award in total is $320 million," said Professor William King. "We have the most competitive manufacturing companies in the world as our partners. Six of the top 20 engineering schools in the nation are part of our consortium, generating 12% of the engineering and computer science graduates every year in the United States. So we have massive financial power, massive brain power, and a focus on competitiveness in the manufacturing sector on new business growth."


Rendering from Skidmore Owings and Merrill.

A 94,000-square-foot facility on Goose Island in Chicago will soon be the home of the Digital Manufacturing and Design Innovation Institute (DMDII). Goose Island is a unique, heavily industrial area just northwest of downtown and surrounded by the Chicago River.

## Lab receives first additional funding

Months before its official opening, the DMDII has received its first major contract.

The federal government's Defense Advanced Research Projects Agency has granted $10 million in funds to speed the development of military vehicles.

"The digital lab is establishing itself as an economic driver in Chicago even before its doors are open," U.S. Senator Dick Durbin said. "We worked so hard to bring the lab to Illinois precisely in order to attract cutting-edge research and design like the adaptive-vehicle-maker funding announced today."

The project entails using digital technology to produce better and more reliable planes, trucks, and other vehicles, and to produce them more quickly.

"It is a huge win for the new digital manufacturing lab," Chicago mayor Rahm Emanuel said. "It shows that our efforts to establish key industries here and create opportunities for future growth in manufacturing are already paying off."



"do-it-yourself" approach. His group creates synergy between nano processes, such as self-assembly, and standard manufacturing technologies (large area/high rate), such as forming and machining.

"When incredibly small structures—with diameters that can be a thousand times smaller than that of a human hair—are manufactured in bulk, their collective properties change dramatically," Tawfick said.

He seeks to understand how these properties scale with different amounts of nanostructures. His goal will be to make strong, conductive, and low-density CNT composites, and to apply them on surfaces as efficient non-wetting, wear-resistant coatings.

"The future of materials is multi-functionality, meaning that the same material will be carrying a mechanical load, dissipating heat, and possibly even conducting electrical current," Tawfick said.

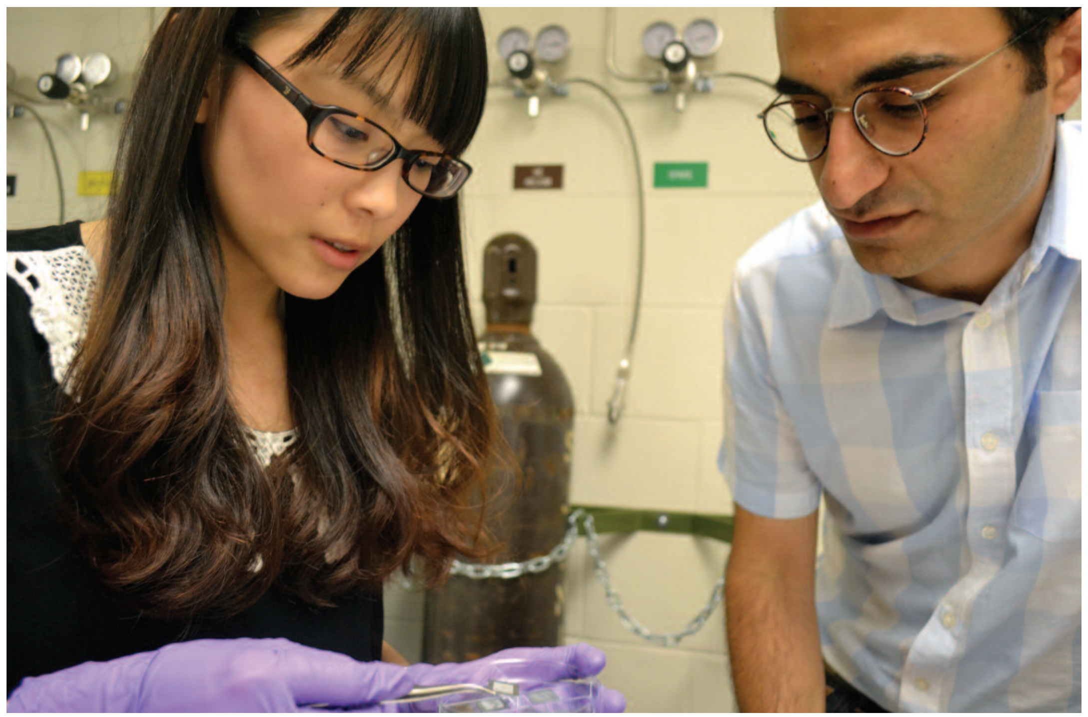
While the current materials, including CNTs, have these multi-functional properties, a clear framework for professional engineers to design multi-functional parts and products is still lacking, Tawfick said.

One of the specific areas targeted by Tawfick's team is making nanomaterials available for customers in challenging health applications. Printing objects and tools for health-related applications is rising. His goal is to print nanomaterials using a 3D printer in a DIY approach—so that consumers or medical personnel can create tools with specific multi-functional abilities as they need them, in situ. The parts can then be used in building a customized prosthetic device or in a tool inserted into a human body during a surgery.

"This is beyond the current perception of 3D printing," Tawfick said. "We want to print a multi-functional part, a sensor or an actuator, so you can print your own little machine. We hope to enable everyone to design and fabricate functional objects and devices for their specific needs."

The technology to do this, to scale up the manufacturing of these materials so that they can be created out of a desktop 3D printer, is multidisciplinary, as it involves mechanical engineering as well as computer science and materials science. Tawfick and his research group have already begun experiments on this project after completing a preliminary analysis, but he said they have a long road ahead.

"You won't see a final version of these in FDA-approved applications for many years," Tawfick said. "But the results are incredibly promising, and we are hopeful."



Graduate student Ping-Ju Chen and Assistant Professor Sam Tawfick are investigating a new manufacturing technology to integrate carbon nanotubes (CNT) into flexible surfaces with shape-changing roughness to enable the active tuning of the CNT wetting properties. In this photo, Chen shows Tawfick a silicon stamp she fabricated in the Micro-Nano Mechanical Systems (MNMS) cleanroom at MechSE. They are discussing how to use it to continuously mold rubber surfaces with re-entrant micro-architectures—a long-standing challenge in scalable small-scale fabrication technologies.

## Alumni in Manufacturing: Sue Brasmer

**Sue Brasmer** (BSME '79, MSME '88) is a technical advisor in the engineering department of Cummins, Inc., where she has worked for more than 25 years. She has served on the MechSE Department's alumni board and has returned to campus as a guest lecturer for the mechanical engineering seminar course, ME 390.

## Consortium brings academia, industry together to optimize steel manufacturing processes

Steel is one of the most utilized materials in the world; about 1.5 billion tons of it are produced every year. This high level of production can only come with efficient manufacturing processes, and that is exactly what Professor **Brian Thomas** and his Continuous Casting Consortium (CCC) work to ensure.

The CCC is a cooperative research effort that works to understand and improve the important solidification process in the making of steel. The CCC involves some of the biggest names in the steel industry, including members from Sweden, China, Japan, the Netherlands, and Korea, in addition to the United States.

"What most people don't realize," said **Seid Koric**, Thomas' colleague and an adjunct assistant professor in MechSE, "is that Brian Thomas is the go-to guru for the steel industry. Everybody in the world comes to CCC and the University of Illinois to solve their problems, not just the producers in the United States."

Continuous casting is the manufacturing method that produces over 96% of the steel in the U.S. The process begins with molten steel being poured into an open-ended, water-cooled mold, which allows the steel touching the walls of the mold to cool faster and create a shell for the molten steel inside. As the shell is pulled from the mold, it is supported, straightened, and rolled until the steel cools all the way to the center. The steel is then cut and sent for processing.

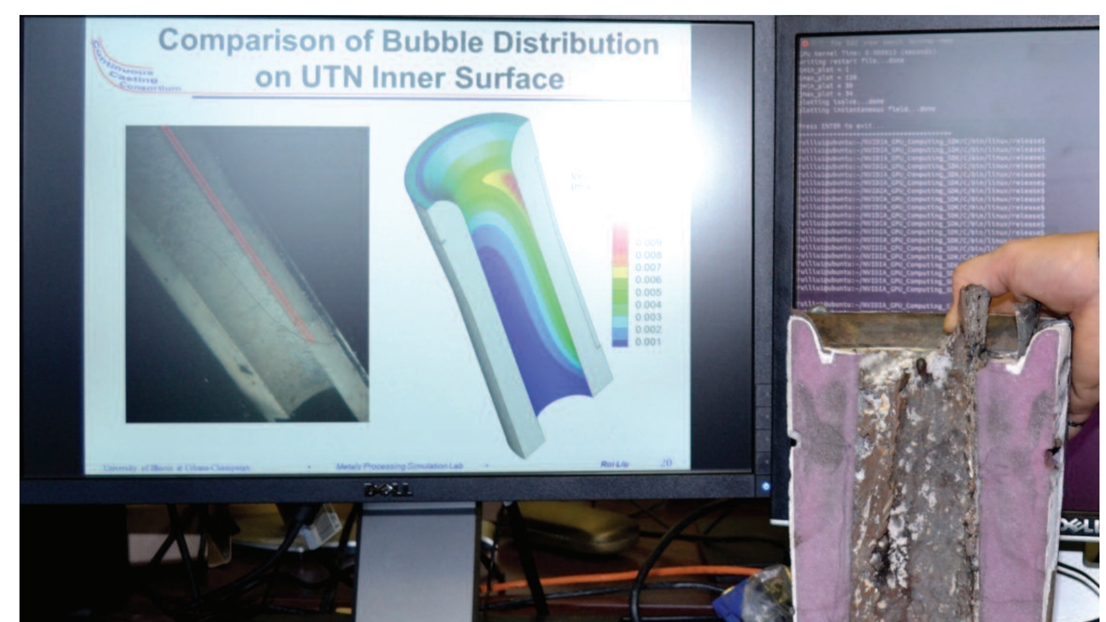
"If you can get the whole process to run a steady state, that's how you make your highest quality steel. You don't want things to deviate," Thomas said. "Everyone worries about random failures, because they can cause serious calamities in the real world. But it's not really random if you look at steel parts in detail. It's most likely some little inclusion or some problem with the steel, and most of those problems go right back to the casting process. So that is why we are looking at improving the casting process."

Thomas and his group develop comprehensive mathematical models of the continuous casting process in order to make it more efficient and to minimize weaknesses and defects in the final product. They solve specific practical problems for the steel industry through the involvement of steel corporations in the CCC. The member companies of the CCC invest funding and interest into his work, as his achievements can directly improve their processes.

"They are interested in an improved understanding of the process and things that they can do to make the process better," he said. "Rather than tell them, 'Do this and your defects go away'—that might work for one specific case, if we get

## Alumni in Manufacturing: Mike Vogler

**Mike Vogler** (PhDME '03) is an engineering manager in machining and metrology research and development at Caterpillar Inc. Before coming to Caterpillar, he worked on machine tool alignment procedures for Cincinnati Milacron and then became a senior research engineer at Delphi, where he worked on improving the cost and quality of machining and grinding processes. He is an active member of Chapter 31 of the Society of Manufacturing Engineers and served as the chapter chair from 2010 to 2012.




Professor Brian Thomas and his research group concentrate on the core level of steel production. Here, the computer screen compares a computer simulation of the argon gas bubble distribution entering a continuous steel-casting nozzle alongside a photo of a water model of the process. The example in the foreground, a nozzle taken from a commercial operation, shows how without proper argon injection the nozzle can become clogged with solidified steel and inclusions.



lucky—I think the better way we do it is to explain: here is exactly how this defect occurs. By getting all the details nailed down, we can find out the most optimal way of fixing the problem."

And the problems tend to be complicated, due to the coupled and multi-physics nature of the process. Thomas said he often has to collaborate with controls experts, fluid flow experts, and researchers with experience in stress analysis from the University of Illinois and other groups around the world.

"Recently, we have been working on understanding the effects of applying electromagnetic forces on the flow pattern in the molten steel," Thomas said. "Computational models are likely the best way to determine how to optimize the use of electromagnetics in the plant. Our model predictions match surprisingly well with measurements of surface velocity conducted in several different commercial steel casters, using a method that one of my PhD students, **Rui Liu**, helped to pioneer."

## King's digital manufacturing expertise to be leveraged on national scale

Professor **William King** and his research group work across the technical areas of manufacturing, thermal energy, nanotechnology, and materials science. Taking a broad view toward aligning their work across the domains of science, technology, and business, researchers join his team to develop their skills for understanding scientific fundamentals, advancing state-of-the-art technology, and seeking translational impact.

The director of the National Science Foundation-funded Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing (Nano-CEMMS) in MechSE from 2012 until its recent ramp-down, King's expertise and numerous advancements in digital manufacturing made him the ideal selection for his latest undertaking. He is the Chief Technology Officer at the new Digital Manufacturing and Design Innovation Institute, or DMDII (see page 10), which was created to address many of the same manufacturing challenges on which King has worked for years.

"We have rising costs for raw materials and all kinds of constraints throughout the supply chain, especially as we think about global supply chains," said King, the College of Engineering Bliss Professor. "We have global over-capacity, which has reduced profitability for industry worldwide, coupled with rising labor costs even in low-wage markets. So what is happening is that industry is paying more and more for the kind of productivity that does not meet industry's standards."

When King talks about manufacturing, he refers to the huge leap forward made a century ago with Henry Ford's assembly line, with its economies of scale and its commoditization of materials and labor.

"We need a new formula to move the American manufacturing industry forward," King said. "More than a decade of outsourcing and offshoring of manufacturing has separated designers and makers, and our current way of doing things will simply not produce the kind of competitiveness that America needs."

In fact, outsourcing to other countries has limited many vital facets of the manufacturing process, such as data sharing, communication, and innovation.

"The future of manufacturing will look more like a complex system," King said. "So, instead of a linear chain through design-make-deliver, there will be a complex system that has all of the opportunities and challenges of a complex system. Specifically, there will be a digital link between designers and makers. We will have machines and factory-supply chains that are all digitally connected and networked together."

The result: a massive aggregation of data across the life cycle of the product, allowing advanced analysis that can result in rapid improvement and innovation. King notes that recent revolutions in other sectors can give us a clue as to what will happen when digital technologies and online networking fully integrate with manufacturing.

"We know what it looks like when digital technologies hit a sector of the economy—it has changed the way we consume movies and television and music," King said. "It has changed the news media, the finance industry, the travel industry. We have seen this happen again and again across the different sectors of the U.S. economy—what it looks like when digital and online hits. Manufacturing is the next sector. It will be completely transformed by online and digital technologies."

As CTO of the DMDII, King will turn his attention more than ever to three key areas: 1. information systems applied across the manufacturing enterprise, including "smart" factory and supply-chain management that provide digital links between different parts of the product life cycle; 2. intelligent machines—self-aware manufacturing tools on the factory shop floor—that have sensors and computing embedded within them, are linked to the cloud, and are able to do analytics in real time to improve quality and speed of manufacture; and 3. advanced algorithms that analyze the data and turn it into information and then turn information into value.

"Over the last 20 years, the manufacturing sector of the U.S. economy has not received massive new investments from the public sector or the private sector," King said. "This is changing. The pendulum is swinging the other way in a significant and meaningful way, and we are looking at a decade or more of new business growth in the manufacturing sector. We are thrilled that one of the first major investments will be in Illinois, at the Digital Manufacturing and Design Innovation Institute."

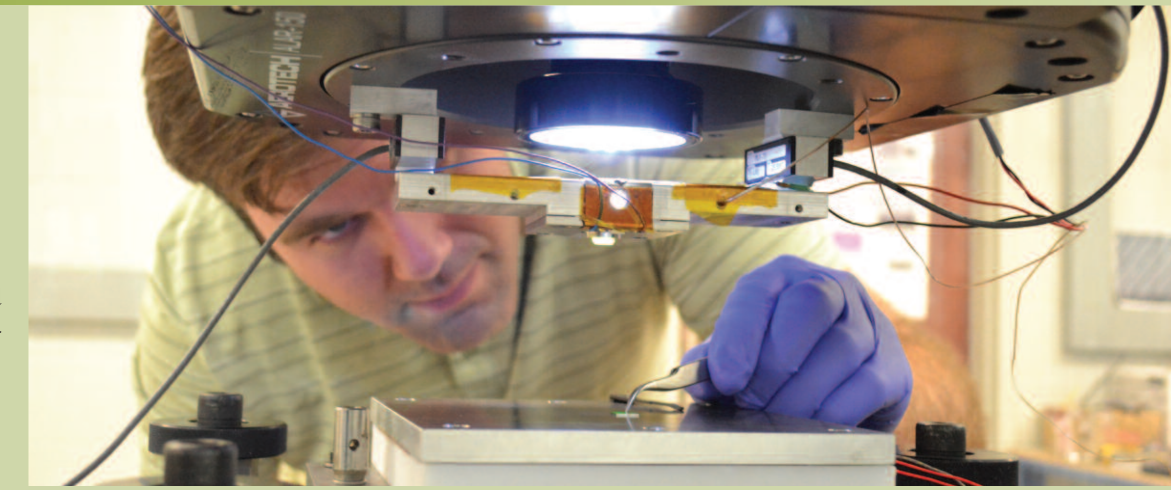
## Alumni in Manufacturing: Kira Barton

**Kira Barton** (MSME '06, PhDME '10), an assistant professor in mechanical engineering at the University of Michigan, has recently won a National Science Foundation CAREER Award. With the accompanying grant, she will investigate the next generation micro-additive fabrication science and technology to enable high-fidelity, 3D printing at the micro-scale. The educational goal of this work is to introduce students, teachers, and parents to the intellectually diverse field of manufacturing with emphasis on the cross-disciplinary nature of the advanced manufacturing paradigm.

## Alumni in Manufacturing: Frank Topel

**Frank Topel** (BSME '72, MSME '73) was recently promoted to vice president of MWH Americas, Inc. Topel has been with MWH for nearly 40 years. His career has been in the planning and design of mechanical equipment and systems for construction surveillance, commissioning of navigation locks, pumping stations, water supply projects, flood control projects, hydroelectric power, and pumped-storage projects. His work has taken him to Japan, Canada, Germany, Austria, Egypt, India, Turkey, Ethiopia, China, Honduras, and Peru.

## Nanomanufacturing center advancing research, educating students



Graduate student Kyle Jacobs works with the S4 machine during the stamp manufacturing process. On the hot plate is a silicon mold with nano-scale patterns. Above is the glass S4 stamp that has been imprinted at about 100°C to transfer the pattern to the stamp. The next step in the process would be to press the stamp against a silver film and apply a small voltage, etching the silver and leaving behind replicas of the nano-scale patterns.

There exists powerful potential for new technology at the nanoscale; this is the belief that drove the Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS) since it was founded in 2003. The essential problem in the field of nanotechnology today is how to create, assemble, and manipulate structures at a scale that is approximately one-thousandth the width of a human hair. A reliable and cost-effective nanomanufacturing system could change the trajectory of human technological development, and it is this kind of system that the Nano-CEMMS Center worked to create.

Now ramping down after an incredibly productive and successful decade, the NSF-funded Nano-CEMMS brought together collaborators from the University of Illinois; Stanford University; North Carolina Agricultural and Technical State University; University of California, Irvine; University of Notre Dame; and Northwestern University. Each partner contributed researchers, facilities, and funding to the work of the center. The center's directors have been MechSE professors **Placid Ferreira** and **William King** and Materials Science and Engineering professor **John Rogers**.

Nano-CEMMS also had a strong presence in the scientific outreach community. Over the years, its wide range of programs targeted students from K-12 to the graduate level, exposing them to cutting-edge research and awareness about the importance of nanotechnology while promoting the recruitment of students from underserved groups. The location of Nano-CEMMS at Illinois has been immensely advantageous for MechSE faculty and their research. The center and its resources were indispensable for the research of Assistant Professor **Seok Kim**.

"One of the major research thrusts in my group was initiated with the financial support and the equipment of Nano-CEMMS," Kim said. "I believe that having the center here on campus absolutely expedited my research activities."

Nano-CEMMS had a great impact on research in MechSE and science education in the community, and every success was a vital step forward for the future of nanomanufacturing.



### Ferreira adapts research as manufacturing goes smaller and smaller

Through his many years in manufacturing research, Professor **Placid Ferreira** has watched the field develop and grow.

"When I started work in this area, we were just beginning to use computers in manufacturing," Ferreira said. "My initial work was about how you build these computer-controlled machine tools, how you create programming languages for them, and then how you assess the accuracy or the fidelity with which they execute those programs. Communications were growing, too, and the notion of being able to tie a bunch of machines together in a factory and make them behave in a coordinated manner in the factory became important. These things are called flexible manufacturing systems."

Ferreira has decades of experience in the field of manufacturing, ranging from large-scale machinery to nanoscale structures. His research now is more concentrated on micro- and nano-scales, looking at how to make manufacturing machines more and more accurate.

"As you go down into precision engineering, you start asking questions as to the limit of manufacturing precision," Ferreira said. "How far can we go? When I started work, ten microns was a big deal. Today, people get down to ten nanometers on a regular basis. How you design these incredibly complex machines that are accurate to within a few nanometers is part of my work."

To be able to manufacture products at high levels of accuracy, the machine-tools that make them must be calibrated to even greater levels of accuracy. The smallest error in calibration can lead to very large flaws in the final product. But what if machines didn't have to be calibrated using an external object or process? Ferreira also researches the possibility of a self-calibrating system.

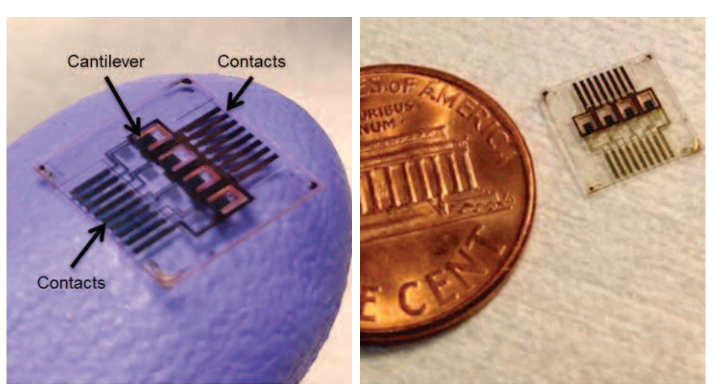
"The notion of transferable length standards and transferable calibration is very important in manufacturing," Ferreira said. "What if we had systems that are self-calibrating? Rather than having to bring in external artifacts and performing lengthy calibrations with them, our work looks at techniques that, with the input of a single piece of calibrated information (for example, a calibrated inch), there is some information that is resonant in the machine, and the machine uses that to calibrate itself periodically, which might be a better method of calibration."

Parallel to his studies on the accuracy and calibration of manufacturing machinery, Ferreira is also working on the development of new processes to make nanoscale structures that are repeatable and cheap. Many nanoscale manufacturing processes require ultra-high vacuum, perfectly controlled conditions, and pure materials, making the manufacture of nanostructures extremely expensive and hard to repeat within a certain level of accuracy. A new set of manufacturing processes that reduce the cost and increase the repeatability of making nanostructures could revolutionize nanoscale research.

Ferreira has seen the growth and development in the field of manufacturing and believes that the past trajectory is indicative of things to come.

"When we start thinking about manufacturing today, our ability to control either the composition or the shape has grown tremendously," Ferreira said. "And it has just continued to grow. Manufacturing is also becoming very information-intensive. You're not only capturing information about the artifact, but you can get information about all the signals, such as the vibrations, temperatures, forces, and others that were monitored while the part was being made. So if the part fails, you can go back and mine all that data and know exactly what manufacturing event might have contributed to the failure.

"The other way manufacturing is changing is in the way we organize it. We went through a phase where the manufacturing meant big, dirty factories that were very large, and everybody had to go to the factory to make things. But today, we have really good logistical and information networks that connect everybody, so parts can be made in small quantities exactly where they will be consumed and precisely to the specifications of the end user. The next generation of manufacturing is going to be much more distributed and hopefully much more sustainable and clean."




These are images of released active membrane stamp dies showing the completed device. Each die has a 4 x 1 array of instrumented active composite cantilevers.

## Alumni in Manufacturing: Johnson Samuel

**Johnson Samuel** (MSIE '03, PhDME '09) recently won a CAREER Award from the National Science Foundation. A material design and advanced manufacturing expert, and assistant professor in the Department of Mechanical Aerospace and Nuclear Engineering at Rensselaer Polytechnic Institute, Samuel will use the grant to advance his research. His work concentrates on developing new surgical tools and techniques for cutting and drilling bone that take into account both the age of individual patients as well as the particular microstructure of their bone.

## Alumni in Manufacturing: Sidney Lu

**Sidney Lu** (BSME '81) is the chairman and CEO of Foxconn Interconnect Technology. He has worked for Foxconn for more than 20 years, and the company is now in the top 5 companies in the connector industry. "I'm grateful to Illinois," Lu said. "I learned hard work here, and I learned how to learn." He is now planning to open a satellite office in the University of Illinois Research Park.

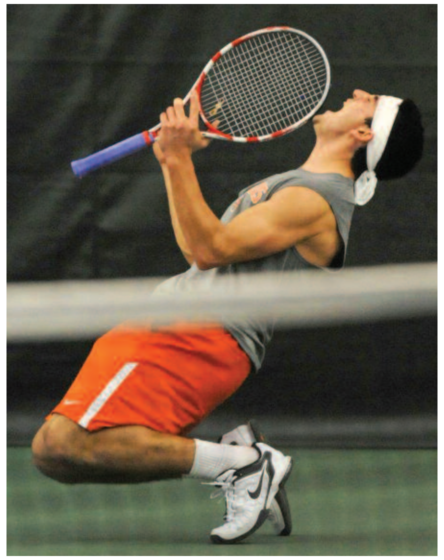
## Alumni in Manufacturing: Alexander Rankin V

**Alexander Rankin V** (BSME '57) founded Vulcan Spring in his basement in 1967, and through it pioneered constant-force and variable-force spring technologies as well as the Vulcan Pullbox, a retail display security tether that allows products such as cell phones to be handled by customers without risk of theft. Vulcan now ships over 30% of its products to customers outside the U.S. He received the Spring Manufacturers Institute Lifetime Achievement Award in 2008.

The image below is a silver film patterned on silicon with S4. It shows a variety of features including lines of silver, holes in silver, and demonstrates the ability to make complex shapes like the university logo.


Graduate student Kyle Jacobs holds a piece of AgIAgPO3 glass on the left, a solid state superionic conductor of silver ions. On the right is the same glass manufactured into a usable stamp with nanoscale features for solid state superionic stamping (S4). When pressed against a thin silver film, and applying a few hundred millivolts between the stamp and the silver, the stamp will etch away the silver and pull it into the stamp as silver ions—resulting in a replication of the stamp patterns on the silver film. Professor Ferreira's group is researching this process as a way to cheaply make small metallic features, which can be used for interconnects, surface-enhanced Raman spectroscopy (SERS), and plasmonic structures.

# MechSE student-athletes win both Big Ten postgrad scholarships



Abdelnour celebrates a victory over Texas A&M.

Abdelnour hopes to work for a year before heading to grad school.

During his junior season, Abdelnour finished 25-15 in singles and received the NCAA's Elite 89 Award for posting the highest GPA among all sophomores, juniors, and seniors in the NCAA round of 16.

A freestyle sprinter, Goering said competitive swimming in Alaska is a very new development.

Goering's senior design team completed a project for Alaska Center for Energy and Power, an agency from her home state.

Goering will return to MechSE in Fall 2014 to begin graduate school.

Each year, the Big Ten Conference awards postgraduate scholarships to two student-athletes from each university in the conference. For 2014, both of the University of Illinois scholarship winners are MechSE students.

Tennis player **Bruno Abdelnour** (BSME '14), an Academic All-American, and swimmer **Anne Goering** (BSME '14)—varsity athletes who reached high academic standing and demonstrated strong leadership qualities—each received a monetary scholarship to continue their education in graduate school.

We sat down with Abdelnour and Goering to talk about their scholarship achievements.

**How did you end up at Illinois?**

**Goering:** When I was selecting undergraduate schools, I looked up the top 25 engineering schools and then looked at which ones I could possibly swim at, and just went down the list and cross-referenced them. I had never been to Illinois before in my life, and I came here on a four-hour recruiting trip. I liked it here, I liked the swimming coach, everything. I met with Dr. **Jim Phillips**, from MechSE, and he walked me through the curriculum, but he also took me around to see the concrete crusher and Talbot Lab, and all of that. Illinois made me feel like the people here really cared if I came to school here. Coming from Alaska, I would go on several college visits at a time. So I had visited another school right before visiting Illinois, and at the other school it felt like they didn't really care whether I was there or not. I received scholarships from Illinois, too, so both swimming and engineering is really what got me here.

**Abdelnour:** I grew up in Syria until I was 15. Syria is a really poor country and tennis is not popular at all. I got really good at tennis, but there was no one for me to practice with. My dad could hit with me, but I eventually got to be better than him. I had to go somewhere else in order to keep improving, so my parents sent me to France by myself to go to an academy for three years. I did pretty well tennis-wise, and I got recruited by a lot of schools—not Illinois—but schools like Berkeley, Texas, Texas A&M, and Georgia Tech. I was really looking at both engineering and tennis. Berkeley wasn't as good at tennis that year, and Illinois was ranked in the top ten. So I contacted the coach, **Brad Dancer,** who was looking for players that year. I got lucky and he took me in.

**Have you always been interested in engineering? How was that interest fostered?**

**Goering:** My father is a mechanical engineer. I've always been really good at math and science. I looked at some of the really good engineering schools, and I actually visited some business schools as well, because I thought about going to school for business. During my senior year of high school, I was on the robotics team, and I loved the whole concept—getting a problem and having only a certain set of constraints that I could solve the problem with. I knew then that I wanted to apply to a mechanical engineering program.

**Abdelnour:** My dad is a doctor and I always thought I would be a doctor. Even coming into school I thought there might be a chance for me to do mechanical engineering, take a few biology classes, then switch to a pre-med major and go to medical school later. I really thought I would do that, but I liked engineering better. I liked the excitement of it better than medicine.

**What area of engineering are you hoping to pursue?**

**Goering:** I'd like to work in renewable energy. I'm hoping that after grad school I can work for the National Labs or the Department of Energy. For now, that's my goal. It might change!

**Abdelnour:** I'm pretty open to a lot of things, but I've done some research here with nanotechnology, energy transfer, and heat transfer at the small scale, and it seems really interesting to me. I'm most interested in the energy industry right now, whether it's renewable energies, or small-scale nanotechnology, or innovative energy systems.

**Do you have favorite memories of your ME classes or professors?**

**Goering:** My senior design project was one that I brought back from Alaska. For two different summers, I did research at the University of Alaska Fairbanks. The research I did was designing an innovative hydrokinetic device. I was looking for a senior design project and the device had been developed into a testbed, but we hadn't figured out what we were going to do with it yet. The people who were working on it with me were leaving for the year, so the University of Alaska decided it would fund my senior design project so I could continue working on it.

**Abdelnour:** In ME 371 this semester, we had to get a ball up in the air two feet, then get it in a down-track and repeat that process in a cycle. We were working a lot on our design, and the day before it was due, we tested it and it just didn't end up working at all. It was a really innovative design, but the setup didn't work. So we decided we would just build something really big. Our design was six feet tall compared to everyone else's designs, which were about three feet tall. We figured if it wasn't going to be as innovative, it would at least be big! We ended up getting an A+ on that project, after pulling an all-nighter. I was proud of that moment.

# **MechSE students** win NSF research fellowships

In April 2014, five MechSE students were named recipients of National Science Foundation fellowships. In an unusual twist, two MechSE seniors won fellowships for their future work in grad school, in addition to three graduate students.

**Nathan Dostart** said his research could contribute to the development of a microchip for a scanner that reads blood samples to find out what is going on in the user's body.

"You take a blood sample, you put it in, and five seconds later you get a reading and figure out what is going on in your body," the MechSE senior said about the potential device.

Dostart works with MechSE assistant professor **Gaurav Bahl** to research how to amplify and enhance sound signals. He uses glass capillaries, hollow glass tubes that are 300 microns in diameter, and a laser that travels around the outer edge of the tube, enabling him to interact with sound waves in the material.

"So, the way these capillaries fit into the scanner application is that if you run blood through it, you can start figuring out what's different from what you expect," Dostart said. "It's really fast and you can run a lot of samples, because you are continuously running it through."

The interaction between the first laser and the glass capillary results in a secondary laser beam that allows Dostart to adjust and investigate the frequency and amplitude of the signal, among other variables.

"You can tell its acoustic properties, the physical properties of this glass tube," Dostart said. "You can basically find out the density or the speed of sound in fluid, so it's a very good way of figuring out what fluid you have."

While Dostart's NSF research proposal suggested he would continue his work on finding methods to reduce and enhance the sound signal, he decided to take his research one step further with funding.

"The research I've been doing is just figuring out—based on these few different shapes, some very simple shapes that almost everyone uses—how to change the size and how to pick the shape of the laser we're shooting to get the best signal out," Dostart said.

MechSE graduate student **Ritu Raman** is partaking in bioengineering efforts to generate tissue and organ replacements using a high-resolution 3D printer.

"You can do that using this kind of 3D printing apparatus, which you can't do using other types of machines," she said.

But this is only half of Raman's research. After developing the device, which can pattern single cells reliably, she began working on using the medium to build biological robotics.

She advances her research with advising from Bioengineering professor and department head **Rashid Bashir** and MechSE professor **Taher Saif**. Her decision to pursue multidisciplinary research emerged when she was looking at graduate schools, she said.

"I felt like all of my application interests were in biomedical," Raman said. "But at the same time, I feel like the strengths that I was able to bring to biomedical research were all because of my mechanical engineering background, and I wanted to build on the MechSE strengths and use those to apply to biomedical applications."

Since constructing a high-resolution 3D printing apparatus, Raman works on patterning single cells to create tissue replacements and design biological systems.

"We've created these simple, 3D-printed soft robotic devices that basically have this strip of skeletal muscle between two legs, and if you apply an electrical stimulus to them, they will start to walk," Raman said.

Next, she hopes to change the DNA of the cells in the devices to trigger a response to non-invasive signals, including lights, and to make the robots turn and rotate. Other applications of Raman's research include regenerative medicine.

To future NSF fellowship applicants, Raman emphasized how important dedication is in deciding on a research topic.

"I think finding something that you care about that much is almost sure to guarantee you success, whether you win the fellowship or not."

A recent project for MechSE grad student **Rishi Bal Singh** entailed developing a new method to generate organized germ layers, a collection of cells usually assembled as an embryo forms, using a single embryotic stem cell. If successful, the method would provide researchers with a way to study the developing embryo, he said.

"Right now, if you want to study the organization of three germ layers, or the initial formation of cells in vivo, which is inside the body, it would be really difficult because you would have to somehow extract that and look at it outside the body," Singh said.

His research, which he does as a member of MechSE professor **Ning Wang**'s group, aims to study binary and single cells via embryotic stem cells and cancer cell projects.

"Most of the research we do isn't necessarily application-based, it's more fundamental biology, where we try to understand different facets of biology," Singh said.

In his NSF application, Singh proposed to research whether the mechanical sensitivity of patterned cells differs depending on what direction they are pulled in.

"I combined some ideas that we had from previous papers in our lab that basically show, when cells are really soft, they tend to be more sensitive to mechanical signals," he said.

He merged these ideas with micropatterning, which can be used to control the geometry of a cell.

When micropatterning cells into long, elongated shapes, they develop anisotropy and possess different mechanical properties and varying directions. That is, the cells could be stiffer in one direction and softer in another.

With the research, he wanted to learn about the developing embryo and the transition from a single cell to creation of tissues.

"This may elucidate some new insights into how differentiation of organization of these cells depends on their shape and the pattern that they're in during development," Singh said.

As an undergraduate student, **Nicolas Tobin** began researching wind energy with MechSE assistant professor **Leo Chamorro** at the University of Minnesota. When Chamorro pursued a position at the University of Illinois, Tobin followed his advisor to MechSE to continue their work on the fluid dynamics of wind energy.

"I've always thought it is important to advance renewable energy technologies," Tobin said. "During my junior year, I got interested in fluid mechanics and thought it was a good way to apply my skills and interests."

Tobin researches how topology can be used to increase energy output for a wind farm. With the fellowship, he will work on experiments with a fleet of turbines and use the wind tunnel at Talbot Laboratory.

In the future, the fellowship recipient would like to work on experiments with a wind farm operator. He also wants to run wind farm simulations on supercomputers to perform computations to compare to his previous experimental work.

For now, Tobin's studies focus on how turbulence affects power output fluctuations. He hopes others can use his research for control schemes.

Senior **Marc Deetjen** also won an NSF Fellowship. To read about it, see the article on page 22.

# **MechSE graduate student** runs half-marathon as a guide

MechSE grad student and 2012 NSF Fellowship winner **Elizabeth Jones** had run an ultra-marathon, a marathon, and four half-marathons. After reaching her personal goal of a time less than two hours for a half-marathon, she decided she wanted to help someone else as a running guide.

"Once I broke two hours, I thought I was in a good position to run (as a guide) because I didn't have anything in particular I was doing for myself. You have to make the decision you're running for the person you're a guide for," Jones said.

Jones ran the Christie Clinic Illinois Half-Marathon this past April as a guide for high school senior **Ashley Eisenmenger**, who has been legally blind since birth. Eisenmenger has been running for five years, and once she decided she wanted to run this year's Illinois half-marathon, she sent out a message to the local running club, Second Wind. Jones, a club member, jumped at the chance, the two clicked as runners, and the partnership began.

During the race, Jones and Eisenmenger ran with Jones' sister and another friend, who both helped get water and Gatorade at the water stops along the route, and offered moral support and encouragement. Eisenmenger's goal was to complete the race in 2:30. She and Jones finished in 2:18.

"It was a great race," Jones said.

Jones noted that running as a guide is definitely different from running with a sighted partner.

"Unlike running with other people, I couldn't skip a training run with Ashley, because she couldn't make it up later on her own," Jones said. "There was a lot more accountability than I've had in the past. The other big difference is the responsibility that I had. Ashley was counting on me to 'be her eyes,' as she says. I had to pay attention to every rock, bump, and pothole in the road, as well as the bigger issues like people, traffic, and the overall route."

However, she says, at the core, they really are just two fellow runners.

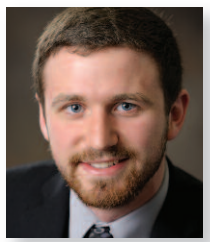
"In a lot of ways, running with Ashley wasn't much different than running with any person or group. We had a training schedule, we met up, did our runs, talked about whatever to pass the time, and then repeated the next day," Jones said. "I guess the take-away thought is that being a guide runner does require some extra effort, but at the end of the day, Ashley and I are just two people who enjoy running. I was glad that I could help make that possible for her."

Jones, a doctoral candidate in theoretical and applied mechanics, was recently named one of six Graduate Fellows at the Beckman Institute for Advanced Science and Technology.

MechSE's Elizabeth Jones (right) trains with Ashley Eisenmenger.

# Graduation now behind them, **new grads head to work**

Each year, approximately 200 MechSE students graduate, and nearly all of them have impressive plans arranged for entering industry or attending graduate school. Here is a snapshot look at the plans of six of this year's graduating seniors.

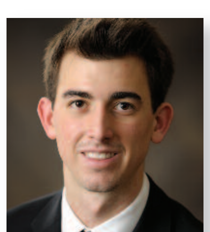


**Matt Carmody** likes learning how things function.

"I feel you cannot truly appreciate a product or infrastructure that benefits your life until you wrap your head around how it works and what it took to develop it," Carmody said.

He is most proud of his senior design project, a specialty paper dispenser. Carmody's responsibilities for the project included scheduling work time and meetings with sponsors and faculty as well as designing the conversion of energy from electrical power into motion for the paper roll. The project won the Senior Design Outstanding Achievement Award for Excellence in Engineering Design and the Bayne Award for Outstanding Senior Design Project Award.

He has spent the past two summers working with Panduit Corporation, an infrastructure provider based in Tinley Park, Illinois. After graduating in May, Carmody joined Panduit's pre-configured solutions team, which tests products and integrates them into value-added solutions. He works at the Burr Ridge facility. He also has plans to take night classes in pursuit of a master's degree in mechanical engineering and hopes to tutor high school kids in math and science in his spare time.



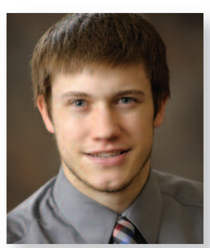
One of the highlights of **Matt Condon**'s senior year was serving as president of the American Society of Mechanical Engineers (ASME). Involved with ASME since his freshman year, he said he is proud of ASME because it "serves as an inclusive society geared towards social, academic, and professional development of its members through a diverse set of opportunities."

Thanks to ASME, he had the unique experience of attending a barbecue at the home of professors **Harley Johnson** and **Amy Wagoner Johnson**. The society hosts an annual "Professor Auction," with the profits going to Relay for Life.

"It is one of my favorite memories of my time here," Condon said.

His contributions to the College of Engineering and his leadership earned him the honor of Knight of St. Patrick in 2014. He also was awarded the Patrick B. and Janet A. Flanagan Award, which is given to a senior in ASME who has shown outstanding leadership.

After graduation, he will be working as a mechanical engineer for Microsoft in Seattle, as part of the new product integration team for Xbox.



Hoping to find biological flight techniques that could be applied to man-made aircraft, May graduate **Marc Deetjen** plans to pursue bird flight research in graduate school at Stanford University.

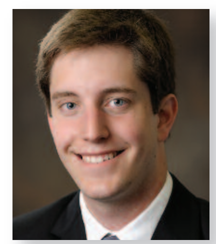
"This research interested me because I think on so many levels, nature has still got us beat," Deetjen said.

Being awarded a National Science Foundation fellowship is a rare accomplishment for an undergraduate. Exploring bird flight was not the proposed research in his NSF fellowship application; he originally planned to study surface tension and yield-stress fluids that act as solids at low stresses, such as toothpaste.

"Stanford is very flexible, so I could end up in a couple different routes and try them out," Deetjen said.

"I want to understand yield-stress fluids a little bit better and create a method for finding the surface tension of them."

To tackle the issue, he plans to analyze differently sized yield-stress fluid droplets in order to identify the size below which all droplets become spherical. Then the surface tension of the fluid can be determined by finding this lengthscale at which surface tension stresses exceed the yield stresses.



**Jon Hutchings** came to the U of I with only a mild interest in cars. Through his involvement with the Off-Road Illini Baja SAE team, this interest was cultivated into a passion. It started on Quad Day of his freshman year.

"I talked to the captain of the Baja team who told me I could turn a wrench on the car that very weekend," Hutchings said. "And I never turned back."

He served as team captain and lead chassis designer during his senior year. One of his accomplishments was changing the geometry of the chassis to conform to new rules while increasing the driver space and making the frame easy to assemble. He said he was also proud of being able to teach younger members various skills that are not taught in class, such as machining techniques. Hutchings's work in the area of safety engineering won him the George W. Harper Safety Award.

"I wanted to become an engineer because I have the mindset to constantly improve the safety and function of everyday things," Hutchings said.

He will now be working full-time at Chrysler in Auburn Hills, Michigan, as a chassis engineer for the suspension, steering, and mounts group.

"I look back fondly on the sense of belonging and comfort that I felt being part of the engineering community and the moment I felt 'at home' when I walked onto the Engineering Quad," **Valeria Laguna** said.

Her desire to give back led her to become very involved with the College of Engineering's recruiting and retention efforts. During her time on campus she served for three years as an Engineering Learning Assistant (ELA) and, in her senior year, as the lead ELA for MechSE and Undeclared Engineering. She also coordinated the Women in Engineering freshmen camp and worked as an engineering tour guide for prospective and admitted students.

Laguna graduated in December 2013 and now works as a process engineer in chemicals and surfactants for Procter & Gamble at the company's Kansas City plant. She is in charge of keeping her sector's process running and finding ways to make it more efficient while sustaining its quality.

"I am an engineer because I love the idea of possibilities and flexibility," Laguna said. "Engineering tells you that there is always a way to create something of value to solve a problem, further knowledge, or make life more efficient."

Mahatma Ghandi's quote, "Be the change you wish to see in the world," holds strong meaning for **Katie Neville**.

"It is this call to action that encouraged me to become an engineer and also reaffirmed my decision throughout college," Neville said. "I am an engineer because the problems of this world are not yet all solved."

Neville served this year as the vice president external for Engineers Without Borders (EWB). She worked to help EWB gain members and corporate sponsors. She has been involved with EWB since her freshman year, when she started as a team member on the Solar Cooker Design Project.

"I have been so proud of my various roles within EWB because I know that my work is having a huge impact in the lives of those in impoverished villages," Neville said.

Now that she has graduated, she will be working for the Boeing Company in Seattle within their engineering career foundations program, a program in which engineers serve six four-month rotations. Neville hopes to have rotations in the human factors lab, which studies how people interact with products, and the tool liaison group, which focuses on designing tools to improve the manufacturability of Boeing's planes.


## **Condon a hitter—**and not just of books

One of the reasons for the national prominence of the Fighting Illini women's volleyball team over the past few years can be found at their practices. It is, in a word, men. These men are practice players, helping the women hone their skills. The men serve as hitters, blockers, and motivators.

The 2013-14 male practice players were all engineering students, including MechSE's **Matt Condon**. At first, Condon thought the lower net and the fact that his opponents were women would give him an unstoppable advantage.

"When I came in for the first time, I thought, oh, I'm going to be so much better, so much stronger, so much smarter about it," he said. "But they proved me wrong right on the first day."

Condon has played volleyball since he was in the sixth grade. Many of his family and friends played volleyball and he was on the club team at Illinois.

Coach Kevin Hambly likes the spirit the men bring to the game.

"I like what it brought just with the vibe in the gym with those guys, just how competitive they are and the energy that they bring," he said. "That's been very positive."

Although the men and women are always on opposing sides during practices, they have developed a nice camaraderie.

"When I was a sophomore I was pretty intimidated by the girls on the team, but they welcomed me," Condon said. "I liked that."

And the women are grateful for the time the men put in, a commitment of three hours, one or two days a week, all semester long.

"I know that they take a lot of time out of their day to be there and help us out, which is really awesome of them," sophomore player **Jocelynn Birks** said.

# Eight students **honored for entrepreneurship**


**Left:** Grad students Samantha Knoll and Brian McGuigan of AVriculture enjoy praise from MechSE professor Taher Saif during the 2014 Cozad Competition judging.

**Above:** 2014 Cozad winner and Illinois Innovation Prize finalist Adam Tilton shows off his Rithmio technology during the 2014 Cozad Competition judging.

The MechSE Department's success in student entrepreneurship continued in Spring 2014 as seven PhD students and recent alumni were recognized for their engineering initiatives.

Data analytics software company Rithmio won the grand prize in the university-funded category of the 2014 Cozad New Venture Competition. **Adam Tilton** (BSME '10), a PhD candidate in mechanical engineering, co-founded Rithmio with MechSE associate professor **Prashant Mehta**. The company's first focus is on a gesture-recognition software system for wearable devices. The prize included $20,000 for further product development.

In the commercially funded Cozad category, Inscites Research, Inc. took home the second-place prize, which included $7,000 plus acceptance into the I-Start Program at EnterpriseWorks in the U of I Research Park. One Inscites team member is **Ben Blaiszik** (PhD TAM '09). Inscites is a National Science Foundation-funded cloud-sharing startup developed to integrate into a researcher's workflow and allows real-time, secure knowledge management and collaboration.

The company AVriculture won the EnterpriseWorks Incubator Prize, which includes incubation space and resources in the Research Park, as well as taking fourth place in the commercially funded Cozad category. The AVriculture team includes **Samantha Knoll** (BSEM '11, MSTAM '13), and **Brian McGuigan** (BS/MSME '13), both PhD candidates in mechanical engineering. Through autonomous aerial vehicles integrated with advanced imaging technology, AVriculture creates a continuous data link between farm owners, operators, and the land, allowing farm operators to be in "many places at once."

Mechanical engineering PhD candidate **Nishana Ismail**'s (MSME '13) company won the Student Startup Award at Champaign-Urbana's ninth annual Innovation Celebration. Together with alumnus **Tim Deppen** (BSME '09, MSME '09, PhDME '13), Ismail founded the company Servabo around their invention "Shadow." It is a one-click device that interfaces with a smartphone via Bluetooth to provide personalized life-saving features, such as sending text, email, and phone messages to emergency contacts and services. Servabo also won the top prize at the 2013 Cozad New Venture Competition.

Of the six finalists for the 2014 Illinois Innovation Prize, established by the Technology Entrepreneur Center (TEC) in the College of Engineering, two were MechSE grad students. One of them was Mechanical engineering PhD candidate **James Pikul** (BSME '09, MSME '11). He makes microbatteries that are 100 times more powerful than conventional batteries and 2,000 times more powerful than other microbatteries. For his work, he recently won the Materials Research Society Gold Award. In his spare time, Pikul developed a company, JáD Naturals, that produces 100% natural skin care to treat conditions such as rosacea and psoriasis.

The second MechSE finalist was Tilton, who has developed a new approach for pattern recognition and classification in machine learning, which led to the creation of Rithmio. The company's software has two features that set it apart from the current state-of-the-art. It can be trained by the user for new, user-defined gestures, and once trained, it can accurately distinguish the gesture being performed and provide precise analysis of how that gesture compares to a baseline.

## MechSE Graduate Awards

**David Hinde Memorial Award**
Ling Yan Jiang

**Hassan Aref Memorial Award for Theoretical and Applied Mechanics**
Venkatarama Bhargav Rallabandi

**James O. Smith Memorial Award**
Aaron Anderson

**Outstanding PhD Graduate in Mechanical Engineering**
Curtis Johnson

**Outstanding Teaching Assistant**
Cai Michael Wang

**Stanley I. Weiss Outstanding Thesis Award**
Fernando Viegas Stump

## MechSE Undergraduate Awards

**A.G. Friederich Memorial Award**
Anthony Bruno
Marc Deetjen

**ASME Junior Leadership Award**
Danielle Tene

**Bei Tse & May Chao Award**
Kathryn Neville

**Caterpillar Award**
Nicholas Kuhajda

**Clarence L. & Harriette Johnson Award**
Nathan Zimmerer

**Fred B. Seely Award**
Kendall Rak

**George W. Harper Award**
Jonathan Hutchings
Michael Lynch
Paul Mondi

**GM / Philip W. Leistra Jr. Society of Automotive Engineers Award**
Michael Bastanipour

**Helmut H. Korst Award**
Bruno Abdelnour
Justin Tan

**James W. Bayne Award for Outstanding Senior in Pi Tau Sigma**
Quinton Ford

**James W. Bayne Award for Outstanding Senior Design Project**
Carl Bohm
Matthew Carmody
Marc Deetjen
Brad Hemmingsen
Ian Moses
Brett Munkres
Douglas Rylander
Xiaohang Zhang

**John C. & Elizabeth J. Chato Award in Bioengineering**
Muyun Cai
Samuel Zschack

**Kenneth J. Trigger Award**
Robert Donahue
Nathan Dostart

**Konzo/ASHRAE Engineers Award**
Jesus Sotelo

**Materials Processing Award**
Cassidy Warning

**O.A. Leutwiler Award**
Shivani Parekh
D.J. Podgorny

**Patrick B. & Janet A. Flanagan ASME Senior Leadership Award**
Matthew Condon

**Pi Tau Sigma Sophomore Award**
Da Yae Frail

**Student Outreach Award**
Julia Huynh

**Swanson Environmental Sustainability Award**
Nicholas Dornik

**T & AM Merit Award**
Arik Avagyan

**T.A. Peebles Award**
Roy Lee

## College of Engineering Awards

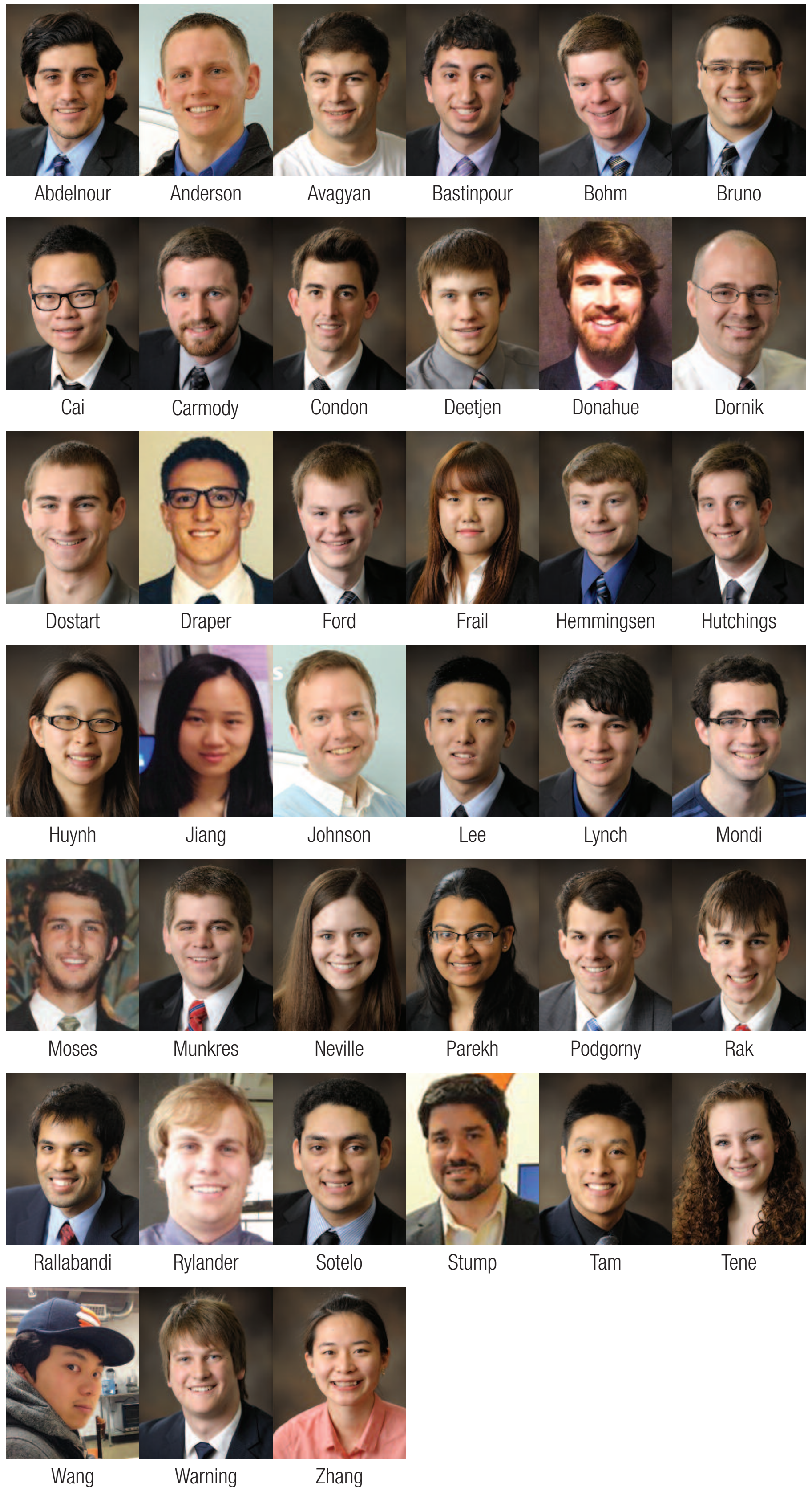
**Harvey H. Jordan Award**
Kathryn Neville

**Knights of St. Patrick**
Matthew Condon
D.J. Podgorny

**C.S. Larson Transfer Student Award**
Kye Draper

## University Honors

**Bronze Tablet**
Marc Deetjen
Julia Huynh
Christopher Johnson
Kathryn Neville
Zachary Renwick
Justin Tan



# MechSE honors **2014 distinguished alumni**


Lawrence Ziemba talks about embracing challenges at MechSE's awards banquet in April 2014.

The department recognized four distinguished alumni at its annual awards banquet in April 2014. Each of the four took the podium to address the MechSE students who were in attendance.

**Richard E. Furkert**

**"Their first question would always be, 'When and where should my next move be?'" said Richard E. Furkert (BSME '70, MSTAM '72), speaking about young colleagues seeking career advice. "I always try to turn the question around. The good question is, 'What and where should I invest next?' And what I was looking for was if they had an investment strategy in their skills, knowledge, and so forth. Your clear strategy is to expand your universe, and your investment strategy should be a strong portfolio to invest in the basic skills. That means don't just jump into your next opportunity blind; grow into your next opportunity."**

After completing his graduate study at Illinois, Furkert embarked on a 38-year career at Caterpillar Inc. Early on he held positions at the R&D Technical Center for developing and deploying design analysis and product simulation software. This included the improvement and expansion of Finite Element Analysis into the product development process during the early 1970s.

He and his family then relocated to a Caterpillar near Kobe, Japan, where he became vice manager of the Vehicle Design Department. There he was responsible for the Computer Aided Engineering and Engineering Standards & Releasing divisions. He was also a liaison for design technology exchange, and he assumed unexpected responsibility in the wake of Kobe's Great Hanshin Earthquake in 1995. Furkert retired in 2011.

Furkert served on the TAM Alumni Board from 2000 until 2006, and as president from 2004 to 2006. He then served on the MechSE Alumni Board and as president from 2008 to 2010. He and M&IE Board president **Kent Schien** received the 2008 UIAA Constituent Leadership award in conjunction with the merger of TAM and M&IE into today's MechSE Department.

**William C. Jackson**

**"I was working under Chuck Tucker when I was getting my master's degree, and he told me I had to take a certain polymer processing class. So I took it, but I got so frustrated because I really had no understanding of it," said William C. Jackson (BSME '82, MSME '83). "And now I run one of the largest injection-molding businesses in the world. So the important thing is even though you can get frustrated, your education here lays a great foundation, you work hard, and it pays off."**

Jackson is executive vice president and president of Interiors, Electronics and Corporate Development at Johnson Controls. He is responsible for running the Interiors and Electronics businesses. He holds a corporate responsibility for leading strategy, business unit transformations, and pricing across the company.

Prior to joining Johnson Controls, Jackson worked for 20 years as a consultant. He served as senior vice president and board member of Booz Allen Hamilton and Booz & Company. He led the firm's global automotive, transportation, and industrials practice. Early in his career, Jackson worked as an engineer and program manager for Lockheed (formerly General Dynamics), researching composite materials for fighter aircraft applications.

Jackson holds an MBA from the University of Chicago and is a board member of Metaldyne Corporation. He was formerly a board member of the Milcron Corporation. He also serves on the College of Engineering Board of Visitors at the U of I and has served on the board of directors for the Lyric Opera and Chicago Public Education Fund.

**Susan E. Shimoyama**

**"My education here really gave me solid technical competencies and really taught me about problem-solving skills, which is probably the most key part of how you collaborate with a team to bring solutions to the marketplace," said Susan E. Shimoyama (BSME '84). "If you would have told me when I graduated as a mechanical engineer, that I'd be working on IT business systems and implementing them globally, I'd have said 'No way.' But it shows you, in your career, there are a lot of opportunities. Take on those challenges, even as unusual and weird as they may seem. They're great experiences to build on, and the challenges will continue to develop you. The key is to always learn and continue to be challenged."**

Shimoyama is vice president of global sales and marketing operations at Rockwell Automation. She is responsible for maximizing the performance of the sales force to support the company's growth and performance strategy through improved efficiency and effectiveness. Her organization is focused on integrated sales and marketing processes, sales force effectiveness and enablement, accelerating process transformation and business readiness for enterprise systems, global customer information, and business intelligence for both Rockwell Automation and their partners.

Since joining the company, Shimoyama has served in multiple positions of increasing responsibility in technical solution sales, commercial marketing, product marketing, industry initiatives, market development and market access/channel operations. She is active on the company's diversity and inclusion leadership team, and employee engagement council. She serves as the executive sponsor for the Rockwell Automation Society of Women Engineers, and is on the board for the Society of Manufacturing Engineers Education Foundation.

Shimoyama has received awards and recognition from Milwaukee Business Journal Women of Influence, Manufacturing Institute—STEP (Science, Technology, Engineering and Production) award, and Rockwell Automation Professional Women Outstanding Mentor.

**Lawrence Ziemba**

**"Good education, hard work, and ambition will take you anywhere you want to go, and maybe places you never dreamed of," Lawrence M. Ziemba (BSME '77) told MechSE students. "You've got a great education from a great institution. I know you know how to work hard. What I would advise you to do is keep an open mind and embrace the challenges ahead of you, including the challenges that maybe others in your organizations don't want. If you do that, you'll do great things, and you might end up somewhere that surprises you."**

Ziemba is executive vice president of refining for Phillips 66 and has spent 35 years in the oil and gas industry. Before assuming his current role in 2012, Ziemba worked for ConocoPhillips as president of global refining. He first joined Phillips Petroleum in 2001 after its acquisition of Tosco.

He started his career at Unocal's Chicago refinery in 1977. In 1988, he moved to Unocal's Los Angeles corporate headquarters as manager of planning/business development for downstream business. In 1991, he managed the acquisition of Shell's Carson refinery and subsequently integrated this asset into the Los Angeles operations. In 1997, Ziemba joined Tosco as they acquired Unocal's downstream business. In 1999, he was named vice president of Tosco's three San Francisco area refineries. In 2000, he was assigned to handle the acquisition and take-over of the Wood River refinery.

Ziemba has held a number of industry and community leadership positions.

## From the **MechSE Alumni Board**

**We want to reach out to all MechSE alumni through this magazine, so that we can communicate to you any topics that gain our attention in our meetings with the current faculty, staff, and students of the MechSE Department. Coming out of our most recent meeting in April 2014, there is indeed a topic that not only has our attention, but also our full support: the Engineering Visionary Scholarship Initiative.**

**You can read further details about this initiative on page 35, but we'll give you our take as fellow alumni. The MechSE program continues to rank near the top in the country. A significant and ongoing goal and challenge is to maintain this high ranking. To do so, we need to continue to be financially attractive to the best students in Illinois and in the country.**

**The Engineering Visionary Scholarship Initiative hopes to raise a $100 million endowment to bring the nation's best students here by making college more affordable. Large, renewable undergraduate scholarships are a key to Engineering at Illinois' ongoing success. By supporting the Engineering Visionary Scholarship Initiative, you'll help Engineering at Illinois:**

- **Ensure that the best students can come to Illinois, regardless of their financial situation.**
- **Make Engineering at Illinois as diverse as our state and our country.**
- **Bring even more of the very best students to Engineering at Illinois.**
- **Create world-changing technologies and insights—just like we have for almost 150 years.**

**You are a world-class engineer with a degree from a world-class engineering school. Giving back ensures that the MechSE Department can continue to impress the world.**

**Very truly yours,**

**The Alumni Board of the Department of Mechanical Science and Engineering**

**Hugh Abrams** (BSME '81, JD '84) joined MechSE's alumni board in Spring 2014. A partner at Sidley Austin in Chicago, he applies his nearly 30 years of litigation, prosecution, and counseling experience in analysis of complex litigation, clearance, and transactional issues. He has served as lead trial counsel in several cases as well as part of a larger trial team in dozens of litigated patent matters. He has successfully tried patent cases to juries, district court judges, arbitrators, and administrative law judges involving diverse technologies such as medical devices, pharmaceutical products, metallurgical processes, chemical processes, automotive technology, and complex electronics. He has also successfully argued appeals before the Court of Appeals for the Federal Circuit. Although his current practice focuses on litigation work, Abrams has written and prosecuted several hundred patent applications, as well as handled complex reissues, reexaminations, and appeals in the Patent and Trademark Office. He has spent substantial time in Japan working on matters on behalf of and adverse to Japanese companies and has a working knowledge of the Japanese language.

**Paul Poorman** (BSME '79) recently retired from Hewlitt-Packard Company after 34 years of employment. During his career with HP, Poorman developed recording heads for disk and tape storage products. He earned 24 patents and participated in the development of over a dozen of HP's data storage products. In his retirement, he will be developing and installing backcountry weather products for remote Idaho airstrips for his new company, Eye-n-Sky, LLC (www.eye-n-sky.com) and building a cabin near Cambridge, Idaho. He and his wife, Gayle, are also working with the Nature Conservancy to preserve their 550-acre ranch near Cambridge as a wildlife habitat and a demonstration of how a native high-desert landscape can flourish.

**Carol Regalbuto** (BSME '11) is currently pursuing a PhD in mechanical engineering at Stanford University with an emphasis on energy systems and thermodynamics. Her work in the Advanced Energy Systems Lab under Professor Chris Edwards includes building a high-temperature PEM fuel cell from scratch for use in a combined cycle with an internal combustion engine. With this combined cycle, she and her colleagues are hoping to realize a system thermal efficiency of 70%. She is also interested in finding viable, cost-effective energy solutions for the developing world as well as implementing policies in the U.S. to support energy systems that will reduce global greenhouse gas emissions. When not thinking about energy, she enjoys taking advantage of all the Bay Area and California have to offer by cycling, hiking, and snowboarding as much as she can.

**Marina Tharayil** (MSME '01, PhD ME '05) is currently a research competency manager and program manager at the Xerox Research Center in Webster, New York. She manages the systems, design, and controls group at Xerox Research. Her group works on services innovation in multiple domains such as healthcare, transportation, and education. In addition, she has recently taken on a transportation program management role, which includes managing multiple projects in the transportation innovation pipeline at Xerox. She was the recipient of the 2009 Rochester Business Journal's 40 under 40 Award and a finalist for Rochester Engineering Society's 2012 Young Engineer of the Year Award. She is currently serving as the Technical Liaison for The Women's Alliance group at Xerox.

**Karen Thole** (BSME '82, MSME '84) joined MechSE's alumni board in Spring 2014. After receiving her PhD from the University of Texas at Austin, she spent two years as a post-doctoral researcher at the Institute for Thermal Turbomachinery at the Karlsruhe Institute of Technology in Germany. Her academic career began in 1994 when she became an assistant professor at the University of Wisconsin-Madison. In 1999, she accepted a position in the mechanical engineering department at Virginia Tech, where she was promoted to professor in 2003 and was recognized as the William S. Cross Professor of Mechanical Engineering in 2005. In 2006, she was appointed and continues to hold the position of head of the Department of Mechanical and Nuclear Engineering at Penn State University. She has been recognized by the U.S. White House as a Champion of Change for recruitment efforts in STEM and as a recipient of Penn State's Rosemary Schraer Mentoring Award.

**David Wright** (BSME '82) joined MechSE's alumni board in Spring 2014. He is a registered professional engineer with more than 30 years of nuclear power engineering experience. He is an owner of Sargent & Lundy LLC (S&L) and a senior vice president in the nuclear power technology group. His career with S&L began in 1982 when he was assigned to work on the final design of two midwest nuclear power plants. In the mid-1980s, he shifted from new plant design to support the development of S&L's emerging nuclear services business. Today, he is responsible for the direction of S&L's nuclear power fleet support services for the northeast region of the U.S.

**Carol Patterson** (BSME '87, MD '99 UIC) has recently been named a Professor of Medicine at the Universidad de Panama Facultad de Medicina (University of Panama School of Medicine) in Panama City, Panama. In this role, she teaches internal medicine to the students at this university during their last year of medical school. Formerly, she held the position of an assistant professor of medicine at Dartmouth Medical School and at Rush University. Patterson practices internal medicine at various hospitals across the Midwest as well. She and her family currently live in Panama City, Panama.


**Bill Bahnfleth** (BSME '79, MSME '80, PhDME '89, BA Instrumental Music '88) was in Urbana-Champaign in February 2014 taking tours around campus, the Research Park, and the MechSE Department, in particular the Air Conditioning and Refrigeration Center (ACRC). As the current president of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE), he was an esteemed visitor for the department, and he was able to spend time with several MechSE faculty members, including **Anthony Jacobi**, **Predrag Hrnjak**, and **Ty Newell**. In addition to his ASHRAE leadership, Bahnfleth is also a professor of architectural engineering and director of the Indoor Environment Center at Penn State University.

When asked what message he would give current MechSE students in regard to their time here, he said, "I'd probably tell them to pursue their interests, not grades. I think the best students often worry so much about whether they'll get a good grade or not that they might avoid things that appear to be difficult. I wish I'd just taken more lumps and more engineering classes that might have interested me and broadened my horizons." (Bahnfleth did receive a music degree in the pipe organ and served as president of the Illinois Track Club while here, so one could argue his horizons were not exactly narrow.)

Every ASHRAE president comes up with a theme to motivate and direct the society for a year and hopefully longer. For his theme, Bahnfleth said, "We're emphasizing indoor environmental quality, taking care of people's basic needs in buildings, making them safe, healthy, comfortable, and productive. And ASHRAE serves the whole world, so that means developing economies and being more effective than we've been in residential markets, and also continuing to be good environmental stewards because this industry has a lot to say about things like atmospheric pollution and consumption of water."

**We'd like to hear from you!**
If you have news you'd like to share with us and your fellow alumni, please contact Betsy Powers at epowers2@illinois.edu. Thanks!

## **MechSE professor coaxes** stem cell breakthrough

The gap between stem cell research and regenerative medicine just became a lot narrower, thanks to a new technique that coaxes stem cells, with potential to become any tissue type, to take the first step to specialization. It is the first time this critical step has been demonstrated in a laboratory.

University of Illinois researchers, in collaboration with scientists at the University of Notre Dame and the Huazhong University of Science and Technology in China, published their results in the journal *Nature Communications.*

"Everybody knows that for an embryo to form, somehow a single cell has a way to self-organize into multiple cells, but the in vivo microenvironment is not well understood," said study leader and MechSE professor **Ning Wang**. "We want to know how they develop into organized structures and organs. It doesn't happen by random chance. There are biological rules that we don't yet understand."

During fetal development, all the specialized tissues and organs of the body form out of a small ball of stem cells. First, the ball of generalized cells separates into three different cell lines, called germ layers, which will become different systems of the body. This crucial first step has eluded researchers in the lab.

No one has yet been able to induce the cells to form the three distinct germ layers, in the correct order: endoderm on the inside, mesoderm in the middle, and ectoderm on the outside. This represents a major hurdle in the application of stem cells to regenerative medicine, since researchers need to understand how tissues develop before they can reliably recreate the process.

MechSE professor Ning Wang led a team that found the precise combination of mechanical forces, chemistry, and timing to help stem cells differentiate into three germ layers, the first step toward developing specialized tissues and organs.

"It's very hard to generate tissues or organs, and the reason is that we don't know how they form in vivo," Wang said. "The problem, fundamentally, is that the biological process is not clear. What is the biological environment that controls this, so they can become more organized and specialized?"

Wang's team demonstrated that not only is it possible for mouse embryonic stem cells to form three distinct germ layers in the lab, but also that achieving the separation requires a careful combination of correct timing, chemical factors, and mechanical environment. The team uses cell lines that fluoresce in different colors when they become part of a germ layer, which allows the researchers to monitor the process dynamically.

The researchers deposited the stem cells in a very soft gel matrix, attempting to recreate the properties of the womb. They found that several mechanical forces played a role in how the cells organized and differentiated—the stiffness of the gel, the forces each cell exerts on its neighbors, and the matrix of proteins that the cells themselves deposit as a scaffolding to give the developing embryo structure.

By adjusting the mechanical environment, the researchers were able to observe how the forces affected the developing cells, and found the particular combination that yielded the three germ layers. They also found that they could direct layer development by changing the mechanics, even creating an environment that caused the layers to form in reverse order.

Now, Wang's group is working to improve their technique for greater efficiency. He hopes that other researchers will be able to use the technique to bridge the gap between stem cells and tissue engineering.

"It's the first time we've had the correct three-germ-layer organization in mammalian cells," Wang said. "The potential is huge. Now we can push it even further and generate specific organs and tissues. It opens the door for regenerative medicine."

## **Tiny swimming bio-bots** boldly go where no bot has swum before

The alien world of aquatic micro-organisms just got new residents: synthetic self-propelled swimming bio-bots.

A team of engineers has developed a class of tiny bio-hybrid machines that swim like sperm, the first synthetic structures that can traverse the viscous fluids of biological environments on their own. Led by **Taher Saif**, the University of Illinois Gutgsell Professor of Mechanical Science and Engineering, the team published its work in the journal *Nature Communications.*

"Micro-organisms have a whole world that we only glimpse through the microscope," Saif said. "This is the first time that an engineered system has reached this underworld."

The bio-bots are modeled after single-celled creatures with long tails called flagella. The researchers begin by creating the body of the bio-bot from a flexible polymer. Then they culture heart cells near the junction of the head and the tail. The cells self-align and synchronize to beat together, sending a wave down the tail that propels the bio-bot forward.

This self-organization is a remarkable emergent phenomenon, Saif said, and how the cells communicate with each other on the flexible polymer tail is yet to be fully understood. But the cells must beat together, in the right direction, for the tail to move.

"It's the minimal amount of engineering—just a head and a wire," Saif said. "Then the cells come in, interact with the structure, and make it functional."

The team also built two-tailed bots, which they found can swim even faster. Having multiple tails also opens up the possibility of navigation. The researchers envision future bots that could sense chemicals or light and navigate toward a target for medical or environmental applications.

"The long-term vision is simple," said Saif. "Could we make elementary structures and seed them with stem cells that would differentiate into smart structures to deliver drugs, perform minimally invasive surgery, or target cancer?"

The swimming bio-bot project is part of a larger National Science Foundation-supported Science and Technology Center on Emergent Behaviors in Integrated Cellular Systems, which also produced the walking bio-bots developed at Illinois in 2012.

"The most intriguing aspect of this work is that it demonstrates the capability to use computational modeling in conjunction with biological design to optimize performance, or design entirely different types of swimming bio-bots," said center director **Roger Kamm,** a professor of biological and mechanical engineering at the Massachusetts Institute of Technology. "This opens the field up to a tremendous diversity of possibilities. Truly an exciting advance."

Led by MechSE professor Taher Saif, engineers have developed the first tiny, synthetic machines that can swim by themselves, powered by beating heart cells.

## Alleyne takes lead of MechSE undergrad programs

The MechSE Department has named a new Associate Head for Undergraduate Programs: **Andrew Alleyne**, the College of Engineering Ralph M. and Catherine V. Fisher Professor.

"Andrew is well-known for his many efforts on behalf of the department's Faculty Recruiting Committee and other critical committees within the department, college, and on campus," said **Placid Ferreira**, MechSE's Department Head. "We look forward to his dedicated service in his new role as associate head."

Alleyne joined the department in 1994 as an assistant professor, and then became an associate professor in 2000 and a full professor in 2004. He served as the College of Engineering's Associate Dean for Research from 2008 to 2012.

"He has been the recipient of notable research and teaching awards and is an outstanding mentor to his students," Ferreira said.

This latter trait played a large part in Alleyne's decision to take on his new role.

"What appealed to me, at the core, are the students," he said. "We have excellent students. If you go to IBM, GE, or any other organization, large or small, what's your most important resource? If you ask CEOs, they'll tell you 'Our most important resource is our people.' And we have such good people here in MechSE."

He looks forward to helping guide MechSE students as they learn, mature, and position themselves to launch their careers and make their impact in the world.

"We are now influencing the next generation of people who are going to build the future on a global scale," Alleyne said. "That's a very attractive proposition."

Alleyne takes over the undergraduate office from Professor **Kenneth Christensen**, whose action-packed tenure as associate head included the 2013 ABET review. Thanks in large part to the preparation efforts of Christensen and Director of Undergraduate Programs **Emad Jassim**, this in-depth review of MechSE's programs went extremely well.

"Ken did an excellent job of assembling a crack staff of folks who do a great job of directing our programs," Alleyne said. "Everything that's being done is working very well. We have a very tight ship."

Taking over an already top-ranked office means there are no immediate crises to address, Alleyne said. But that does not mean he will not strive to improve the educational experience students receive in MechSE.

"The big-picture strategy is trying to see how we can take an already excellent product and, if possible, improve it," Alleyne said. "We might try to see how we can increase the global perspective of our student body as a whole. That's global geographically but also global in terms of the types of ways that they can have an impact.

"Many of our students, when they leave here, will have an ability to influence the world in ways they really didn't think about coming in. We are living in very exciting times."

**Narayana Aluru** is on two interdisciplinary teams that were awarded Beckman Institute seed grants to foster novel research. His NanoStrong team will study ultra-strong nanostructured carbon-based materials. The Engineered 3D Breast Tumors team focuses on the basic science and biomedical use of the innovation.

**Gaurav Bahl** made the list of Top 30 Breakthroughs, as named by *Optics & Photonics News*. It was the second consecutive year Bahl made this prestigious list.

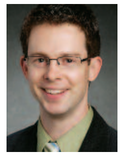
**Armand Beaudoin** retired from the MechSE Department in May 2014. Specializing in solid mechanics and materials, specifically in simulation and biomechanics, process modeling, and metal plasticity, Beaudoin joined the department as an associate professor in 1997 and was named a full professor in 2005. He holds a B.S. degree in mathematics from Virginia Commonwealth University, an M.M.S. degree in materials science from the University of Virginia, and M.S. and Ph.D. degrees in mechanical engineering from Cornell University. Among his many awards and honors, Beaudoin received an NSF CAREER Award in 1999, was a Willett Faculty Scholar in the College of Engineering from 2002 to 2009, and was many times included on the List of Teachers Ranked as Excellent by Their Students. He has been a Fellow of the Institute of Physics since 2004. Beaudoin will continue his research at the University of Illinois as well as participate in various departmental activities.

**Joseph Bentsman** was awarded the 2014 Achievement Award from the Instrumentation, Systems, and Automation Society's Power Industry Division.

**Harry Dankowicz** is the principal investigator for National Science Foundation-funded research on how coordination emerges in leaderless complex societies, such as a bee hive. This team has designed controlled situations to study how groups of humans manage to coordinate efforts and get things done even in challenging situations in which there is no leader.

**Stephen Downing** received the two-year Alumni Effective Teaching Award. Alumni who graduated two years ago named Downing as the faculty member who had the greatest impact on their career.

**Debasish Dutta** has left his post as associate provost and dean of the Graduate College at Illinois. He has been announced as the new provost at Purdue University in West Lafayette, Indiana.



**Randy Ewoldt** received a CAREER Award from the National Science Foundation. The CAREER Award is given to faculty members at the beginning of their academic careers and is one of NSF's most competitive awards, placing emphasis on high-quality research and novel education initiatives. He received a 3M Nontenured Faculty Award, and he was awarded the 2014 Arthur B. Metzner Early Career Award by the Society of Rheology. Ewoldt also was named one of 10 faculty members from around the world to the DuPont 2014 Class of Young Professors.

**Placid Ferreira** received the ASME William T. Ennor Manufacturing Technology Award for his contributions to innovative manufacturing technologies.

**Jonathan Freund** was invited to serve on the editorial board of the *Annual Review of Fluid Mechanics*.

**Naira Hovakimyan** won the Humboldt Prize. According to the foundation, the recipients are "academics whose fundamental discoveries, new theories or insights have had a significant impact on their own discipline and who are expected to continue producing cutting-edge academic achievements in the future." Hovakimyan's work supports safety-critical applications in various industries, including aerospace, marine, health care, oil production, and many others. Hovakimyan was also invited as plenary speaker in ICUAS 2014.

**Iwona Jasiuk** is the co-principal investigator for the Center for Novel High Voltage/Temperature Materials and Structures. The National Science Foundation announced the funding of this center in March 2014. She was also selected for funding by the NCSA Faculty Fellows Program to conduct multiscale modeling of bone fracture and strength and by the Illinois Applied Research Institute Seed Funding Program to investigate novel metal-carbon nanomaterials for energy transfer.

**Harley Johnson** will receive a Fulbright U.S. Scholar Award to support his research while on sabbatical at the French energy agency CEA and the Université de Grenoble in France in the 2014-2015 academic year. His project relates to understanding defects in semiconductor materials for photovoltaic applications.

**Shiv Kapoor** received the Outstanding Lifetime Service Award for his long-term dedication and contributions to the North American Manufacturing Research Institution (NAMRI)/Society of Manufacturing Engineers (SME).

**Seok Kim** received a CAREER Award from the National Science Foundation. The CAREER Award is given to faculty members at the beginning of their academic careers and is one of NSF's most competitive awards, placing emphasis on high-quality research and novel education initiatives.

**William King** was named Chief Technology Officer of the Digital Manufacturing and Design Innovation Institute (see page 10). He was also named a Fellow of the American Association for the Advancement of Science (AAAS).

**Seid Koric** led a team that collaborated to scale the Barcelona Supercomputing Center's Alya multi-physics code to a previously unprecedented 100,000 cores of NCSA's Blue Waters supercomputer, simulating complex engineering problems such as airflow in the human body, contraction of the heart, and combustion in a kiln furnace.

**SungWoo Nam** received a Young Investigator Grant by the Korean-American Scientists and Engineers Association. The award recognizes those who have demonstrated outstanding early career development in the areas of science and technology, and Nam was one of only two recipients in the U.S. He is also part of an interdisciplinary NanoStrong team that was awarded a Beckman Institute seed grant to study ultra-strong nanostructured carbon-based materials.

**Chandra Nath** won the Outstanding Young Manufacturing Engineer Award from the Society of Manufacturing Engineers.

**Martin Ostoja-Starzewski** is the co-principal investigator for the Center for Novel High Voltage/ Temperature Materials and Structures. The National Science Foundation announced the funding of this center in March 2014.

**James Phillips** received the five-year Alumni Effective Teaching Award. Alumni who graduated five years ago named Phillips as the faculty member who had the greatest impact on their career.

**Taher Saif**'s lab developed, for the first time, an autonomous flagellar soft biobot that swims in viscous fluids (see page 31). The work was published in the journal *Nature Communications* and was highlighted by media around the world, including CNN and *The Wall Street Journal*.

**Huseyin Sehitoglu** has been named editor-in-chief of the new journal *Shape Memory and Superelasticity*. It is the official journal of the International Organization on Shape Memory and Superelastic Technologies, an affiliate society of ASM International. It will publish original peer-reviewed papers that focus on shape memory materials research, with contributions from materials science, experimental and theoretical mechanics, and physics, with cognizance of the chemistry, underlying phases, and crystallography. He also has joined the editorial board of *Materials at High Temperatures*.

**Mariana Silva Sohn** received the Engineering Council Outstanding Advising Award, which recognizes the top 10% of engineering advisors on campus.

**Dan Tortorelli** completed a sabbatical leave in which he spent the Fall 2013 semester as the Melchor Visiting Professor of Engineering at the University of Notre Dame Du Lac and the Spring 2014 semester as a visiting scientist at Lawrence Livermore National Laboratory.

**Kimani Toussaint** has been awarded an appointment as a Dr. Martin Luther King, Jr. Visiting Associate Professor at MIT for the 2014-2015 academic year. According to the appointment letter, "MLK visitors are chosen for the contributions they have made to their profession, and for their potential contributions to the intellectual life of MIT." He will be hosted by Dr. Peter So in the Mechanical Engineering Department and will spend his time exploring the potentially biologically relevant quantitative information that can be extracted from the application of harmonic imaging. He has also received a Carl Storm Underrepresented Minority Fellowship to support attendance at the first Gordon Research Conference on Imaging Science.

**Amy Wagoner Johnson** received the Chair of Excellence from the NanoScience Foundation in Grenoble, France. The objective of Wagoner Johnson's project is to engineer novel 3D microenvironments to better understand cell-cell and cell-material interactions and to enhance cell differentiation and tissue formation, particularly in bone tissue. She will spend 13 months in Grenoble, beginning in June 2014.

**Ning Wang** has been named the Leonard C. and Mary Lou Hoeft Endowed Chair in Engineering.

**Matthew West** has been named a University Distinguished Teacher-Scholar for 2014-2015 for his efforts to incorporate project-based, active learning and increase student engagement in TAM 200-level courses. The honor is the university's premier recognition for excellence in teaching and for a commitment to activities that enhance student learning at Illinois.

# Another great **EOH performance!**

The MechSE Department had another successful, educational, and entertaining showing at Engineering Open House in 2014—thanks in part to our incredible students and their dedication! The College of Engineering recognized them with first-place awards in several judging categories, including Class Projects (Illini Motorsports), Most Innovative Project (Illini Formula Electric), and Best Collaboration (Guatemala Water Project).

## **Message from the Advancement Office:** A Vision of the Future

In May 2014, I was fortunate to be among those representating the College of Engineering at Lincoln Park Zoo's Cafe Brauer in Chicago. This unusual—and very fun!—location was where we announced the Engineering Visionary Scholarship (EVS) Initiative to a group of engineering alumni and friends. Their reaction was overwhelmingly positive, as they all believed strongly in the goal of this initiative: great students deserve a great education.

The EVS Initiative will raise a $100 million endowment to bring the nation's best students to Engineering at Illinois by making college more affordable. This endowment—starting with a $30 million gift from The Grainger Foundation—will give a vibrant new generation of engineers the skills they need to improve our world in ways we can only imagine. Scholarships work. They bring amazing young engineers to Illinois. They change lives, and that changes the world.

To find out more, please do not hesitate to contact me at the email address or phone number listed below. Our online giving option is at **www.mechse.illinois.edu/giving.** As always, thank you so much for your generosity in supporting the MechSE Department and all of our students.

Robert E. Coverdill
Director of Advancement and Outreach Activities
coverdil@illinois.edu
217-333-4109

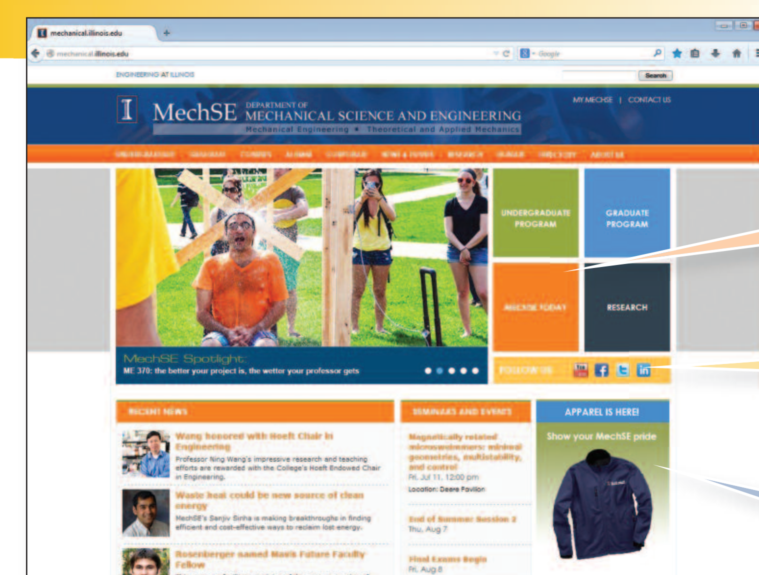
### **Thanks to some great alumni for** their Time, Talent, and Treasure

Our ME 390 course is just one way alumni share their valuable time to enrich MechSE students' experience and help prepare them for the future. We would like to thank the following alumni for returning to campus to address our students during the Spring 2014 semester:

- **Eric Bartsch** (MSEM '95)
- **Sunil Bean** (BSEM '12)
- **Sue Brasmer** (MSME '79. MSME '88 )
- **Dana Coldren** (MSME '90)
- **Scott Daigle** (BSME '09, MSME '11)
- **Ken Frankel** (BSME '77)
- **Don Gall** (BSME '56)
- **Jess Perschbacher** (BSME '02, MSME '04)
- **Paul Predick** (BSAE '72, MSME '73 )
- **David Raske** (MSTAM '71, TAM PhD '72)
- **Kevin Traeger** (BSME '02, MSME '05)
- **David Wright** (BSME '82)
- **Ann Zuzuly** (BSME '13)

Any other alumni who would like to volunteer their time can email us at **mechse-alumni@illinois.edu.**

## Get in the know at mechse.illinois.edu!




The MechSE website is a great source of information about one of the top engineering departments in the U.S. In case you haven't visited us online recently, here are three features you should know about:

**MechSE Today:** contains a feed of all of our news stories and blog posts. And in case you didn't know, we have several MechSE students who have been blogging about life on campus and studying overseas—it's a great inside look!

**Social networks:** quick links to our YouTube, Facebook, Twitter, and LinkedIn pages can be found on every page of the MechSE website. Following our social media pages is a great way to network and stay in the loop with the department.

**MechSE Store:** purchase everything from jackets, dress shirts, and sweatshirts to coffee mugs and koozies. Declare your love for MechSE—all at very reasonable prices.

Visit **mechse.illinois.edu** soon—and often!

**Join our social networks—just go to mechse.illinois.edu!**

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The Alma Mater, looking fresh and renewed, returned to its home at Green and Wright on April 9, 2014. The landmark statue had been removed to undergo extensive repairs for water damage and corrosion. One of the most recognizable symbols on campus, the sculpture was created by alumnus Lorado Taft and originally installed in 1929.