

2013  
NEWS

*The Department of*

# Mechanical Engineering

inside

Featured research:

composites & nanotechnology

robotics & control

fuel cells

Distinguished Career Awards | pg 32

MARK YOUR CALENDAR:

APRIL 26

Mechanical Engineering  
Career Celebration

See page 31 for details.

UNIVERSITY OF  
DELAWARE

College of Engineering

**ON THE COVER:** Prof. Tsu-Wei Chou's carbon nanotube research, which was recently featured on the cover of *Advanced Functional Materials*. Learn more on pg 10.



## MESSAGE FROM THE CHAIR

Welcome to the 2013 Mechanical Engineering news magazine.

Welcome to the 2013 Mechanical Engineering news magazine. It is my pleasure to share with you many exciting events and activities from the last year in the pages that follow.

In particular, I am proud to report that UD's mechanical engineering program ranked 85th worldwide in the 2012 Performance Ranking of Scientific Papers for World Universities, released Oct. 9 by National Taiwan University. The ranking is based on statistics of scientific papers that reflect three major performance criteria: research productivity, research impact and research. UD ranked 298th overall, with three departments (including ME) listed in the top 100 by subject.

This objective study attests to the scholarship of our faculty members, who not only work in technologically important areas of energy, biomedical and materials but whose impact also extends to innovative research publications. Last year, our 21 faculty published 157 papers in archival journals and departmental research funding increased by 12 percent. Learn more about some important and stimulating research frontiers emerging from Spencer Lab on page 8.

Students are integral to our department. The senior design capstone course—where students work with industry sponsors to design, fabricate and test a prototype in four months—is a unique and memorable experience for our many undergraduates. One of my goals is to enhance undergraduate learning by providing students with open access design and fabrication space, multi-use laboratory workstations and informal teaching and demonstration areas.

With the help of UD ME alumna and faculty member Jenni Buckley, the department has launched a campaign to develop a new Design Studio—a learning environment where students, faculty, alumni and industry sponsors can collaborate in hands-on learning proficiencies that transcend the classroom. We are particularly excited about bringing this concept from idea to reality and positioning UD mechanical engineering as a thought leader in engineering education. (read more on page 34)

In a fresh twist on two popular UD events, the department will host a joint Career Celebration and Senior Appreciation event Friday, April 26. This new event combines the student Senior Appreciation dinner and the alumni Career Celebration into one exciting afternoon and evening. I encourage you to join us—to learn more, read the article on page 31.

Many of the initiatives list above are only possible thanks to the generous contributions of alumni, friends, faculty and staff. Your support enables educational programming improvements, top student awards and graduate fellowships. Thank you for supporting our department.

As always, please do not hesitate to contact us. We welcome your questions, concerns and suggestions.

Best regards,  
Suresh Advani

## IN THIS ISSUE...

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*Looking for an old friend? Want to share your latest news? Searching for information on upcoming alumni events such as Homecoming? Now you can do it all in one place, [www.UDconnection.com](http://www.UDconnection.com). UD and the UD Alumni Association (UDAA) have collaborated to bring alumni a vibrant online community—so register and get active! The online community allows you to search the alumni directory, post class notes, update your contact information and see if there are any upcoming alumni events in your area. You can also take advantage of networking opportunities and volunteer opportunities to get involved with your alma mater!*

Visit [www.UDconnection.com](http://www.UDconnection.com) today!



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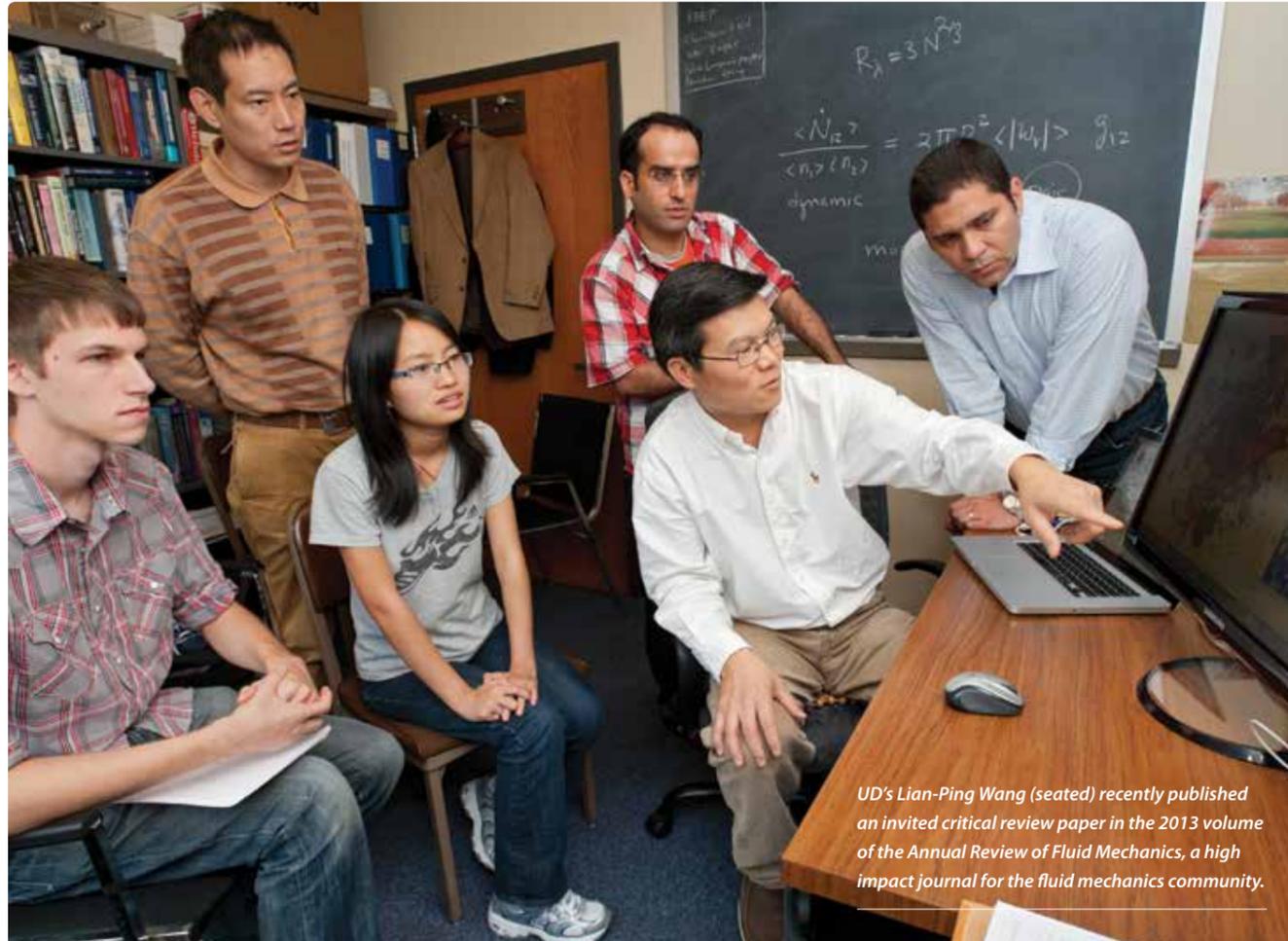
Be sure to like the *University of Delaware* and the *Department of Mechanical Engineering* on Facebook!

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UD's Lian-Ping Wang (seated) recently published an invited critical review paper in the 2013 volume of the Annual Review of Fluid Mechanics, a high impact journal for the fluid mechanics community.

**Tiny cloud droplets: UD's Wang contributes invited paper on cloud microphysics**

ME professor Lian-Ping Wang, also a joint professor of physical ocean science and engineering, co-authored an invited critical paper in the 2013 volume of the *Annual Review of Fluid Mechanics*.

"Growth of Cloud Droplets in a Turbulent Environment" addresses a classic cloud physics problem of how cloud turbulence affects the growth of tiny cloud droplets.

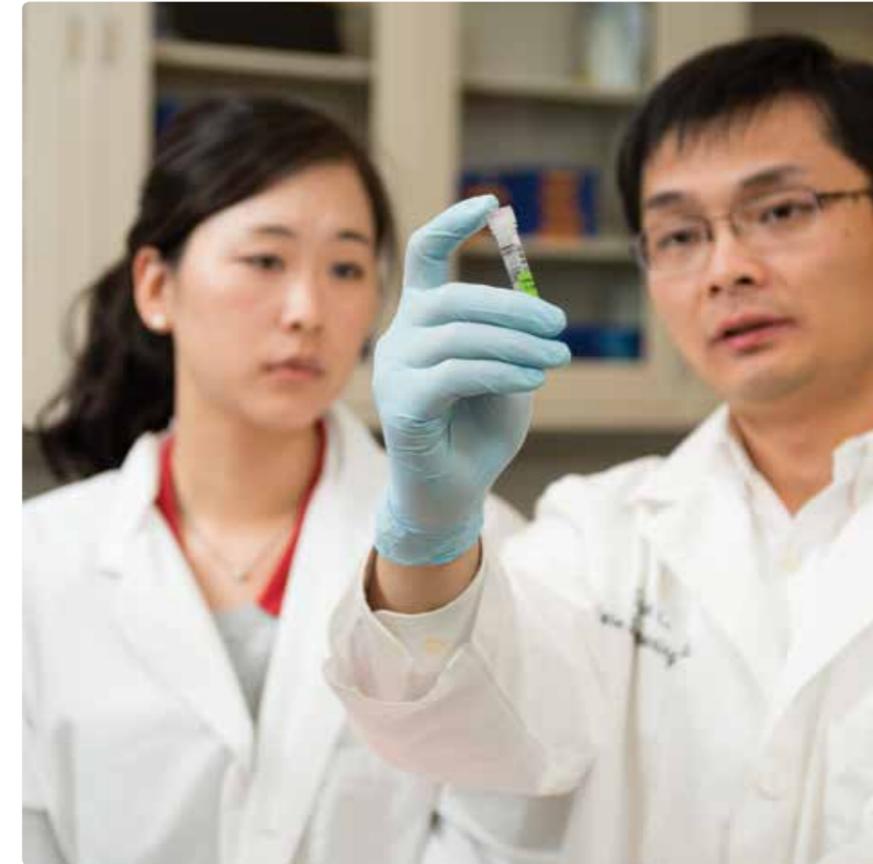
The paper summarizes convincing evidence that air turbulence can significantly enhance the growth of cloud droplets by collision-coalescence, the merging of two droplets into one larger droplet. More importantly, it points to a large number of open issues where further research is needed to understand the formation and dynamics of cloud droplets central to the water cycle, regional weather and global climate.

Wang began studying these complex multiscale and multiphase problems more than a decade ago, prior to the cloud physics community's broad

acceptance of the quantitative impact of cloud turbulence on warm rain formation.

"With expected advances in the area of extreme-scale computing and possibilities to measure processes at the cloud microscales, we are optimistic that a more complete quantitative understanding will emerge in the near future and allow increasingly refined simulation of weather and the climate at regional and global scales," Wang says.

*Adapted from article by Karen Roberts*



**X. Lucas Lu awarded UDRF research grant for early detection of osteoarthritis**

X. Lucas Lu, assistant professor, was one of 11 UD faculty to receive funding from the University of Delaware Research Foundation (UDRF) last year. Lu's work aims to develop a non-invasive mechanical technique for the early detection of osteoarthritis, the most common joint disorder. He will use proteoglycan, the second most abundant component in cartilage, as a biomarker for arthritis diagnosis. The ultimate goal is to develop an arthroscope that can provide a precise quantitative evaluation of cartilage in clinical practice.

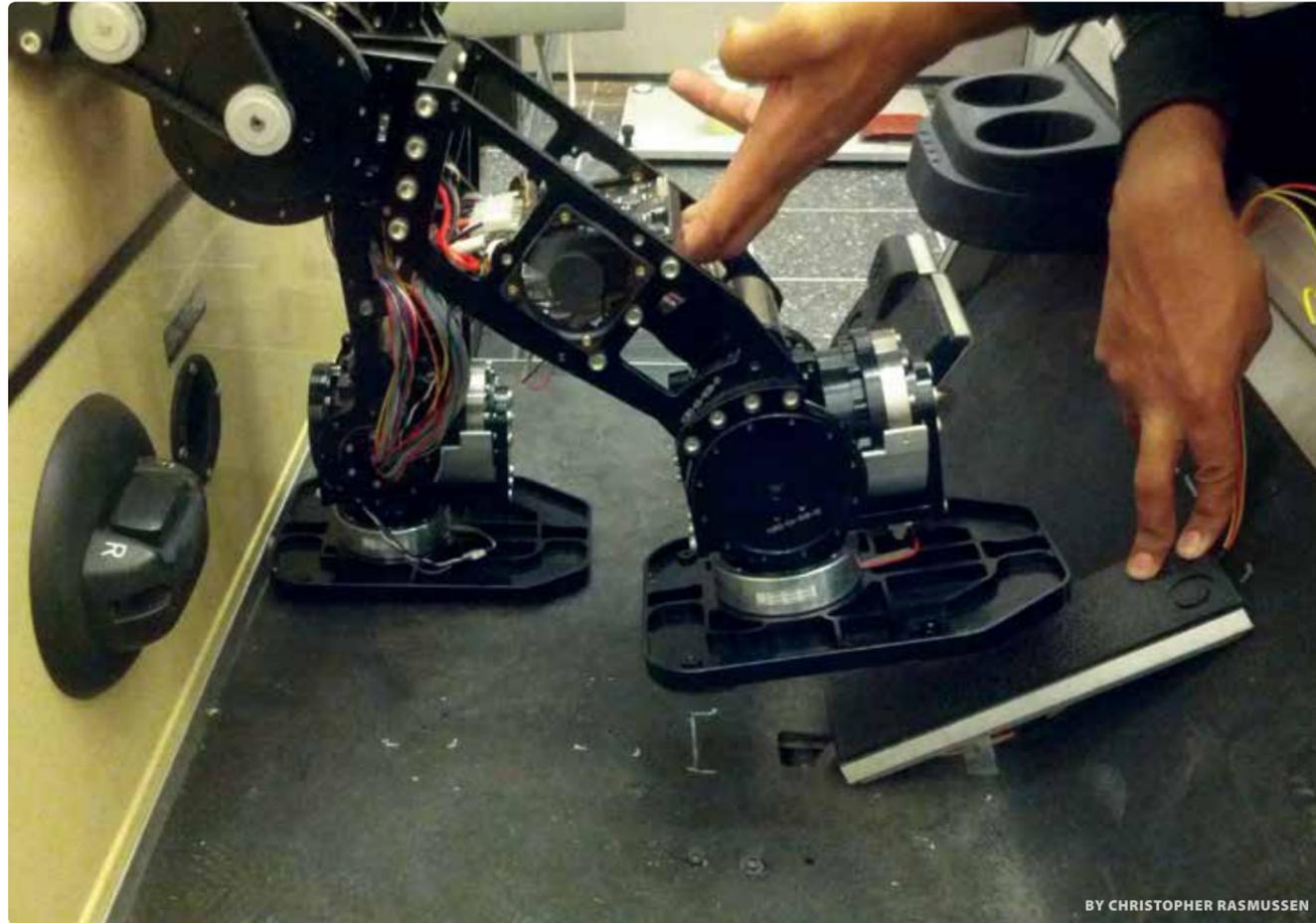
*Adapted from article by Tracey Bryant*



**Chou lectures on three continents in 2012**

Tsu-Wei Chou, Pierre S. du Pont Chair of Engineering, delivered three invited plenary lectures last summer on his research team's work on carbon nanotube-based continuous fibers. Their recent experimental characterization and analysis/modeling research has gained significant fundamental understanding of the electromechanical behavior of this novel nanomaterial for multifunctional composite applications.

Chou shared his group's findings at the International Conference on Mechanics of Nano, Micro and Macro Composite Structures, Politecnico di Torino, Italy, in June; at the 2nd International Conference on Advanced Polymer Matrix Composites, Harbin Institute of Technology, Harbin, China, in July; and at the 2012 International Symposium on Materials for Enabling Nanodevices, UCLA, Los Angeles, in August.



BY CHRISTOPHER RASMUSSEN

### Driver's Ed for robots: UD joins research team training robots for emergency disaster response

Assistant professor Ioannis Poulakakis and associate professor Herbert Tanner, both of mechanical engineering, along with



associate professor Christopher Rasmussen of computer and information sciences, are part of a 10-school team, led by Drexel University, competing in a new U.S. Defense Advanced Research Projects Agency (DARPA) Challenge to design and deploy a robot capable of disaster response in radioactive- or bio-contaminated areas. The robot must drive vehicles, navigate environments, use tools and manipulate equipment.

Poulakakis and Tanner are programming the robot to get in and out of a vehicle. Rasmussen is teaching the robot to drive

*Christopher Rasmussen (left), Herbert Tanner (center) and Ioannis Poulakakis are part of a research team that is teaching robots to respond in disaster emergencies.*

the vehicle factoring in dicey conditions including obstacles, uneven terrain, weather and poor visibility. The challenge roughly mimics the situation created inside a Japanese nuclear energy plant after the 2011 earthquake and tsunami.

Teams will work toward reaching goals by two target points during the 27-month competition that began in October. Phase 1 will last 15 months and culminate with a competitive challenge testing the robot's ability to complete the eight events. DARPA will then select teams to continue into Phase 2 for another head-to-head competition in early 2015.

*Adapted from an article by Andrea Boyle Tippet and Karen Roberts*

### Thostenson earns prestigious NSF award for novel approach to processing multi-scale hybrid composites

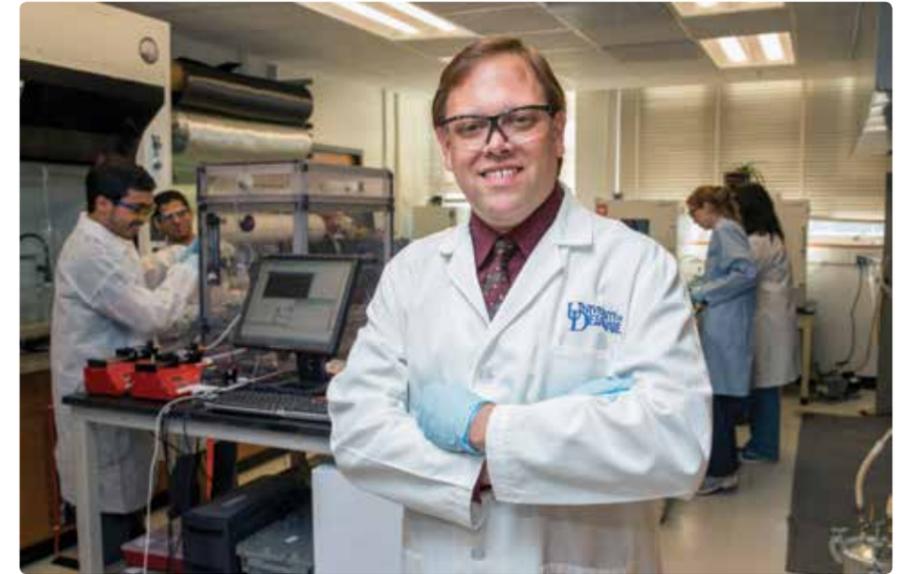
*Erik Thostenson's fascination with composite materials grew out of his love for downhill skiing.*

"I was intrigued that the performance characteristics of various skis could be remarkably different, yet the skis themselves could look identical," he says. "The same basic materials—graphite, carbon and Kevlar—are used in most high-tech skis, but advanced composite technology enables mogul skis to be flexible, while racing skis are stiff."

Now two decades later, the assistant ME professor is still fascinated with these high-tech materials and their almost limitless potential to be tailored for applications far beyond high-performance skis.

*"Our work is paving the way for integrating adaptive, sensory and energy storage capabilities into structural composite materials."*

Thostenson, who also holds a secondary appointment in the Department of Materials Science and Engineering and is an affiliated faculty member in UD's Center for Composite Materials, has received a prestigious five-year \$400,000 Faculty



Early Career Development Award from the National Science Foundation to investigate a new processing approach for novel multi-scale hybrid composites with functionally graded material properties.

"Because nanotubes are so small, they can penetrate the polymer-rich area between the fibers of individual yarn bundles, as well as the spaces between the plies of a fiber composite," he explains. "The nanotubes become completely integrated into advanced fiber composite systems, adding functionality without altering the microstructure of the composite."

Thostenson plans to study an environmentally friendly water-based processing technique as an alternative to current energy-intensive approaches for integrating carbon nanotubes within fibrous structures.

"Our preliminary research has established an efficient technique for producing very stable aqueous suspensions of highly dispersed carbon nanotubes in a single processing step," he says. "The technique enables the nanotubes to fully penetrate fiber bundles and form chemical bonds with the fiber surface."

The proposed approach is carried out under ambient conditions and is industrially scalable for future applications.

*UD's Erik Thostenson has received a National Science Foundation Career Award to investigate a new processing approach for novel multi-scale hybrid composites with functionally graded material properties.*

"This is important for the future use of these hybrid materials, which offer remarkable improvements in shear strength, fracture toughness and electrical conductivity over traditional fiber-reinforced composites," Thostenson says. "Our work is paving the way for integrating adaptive, sensory and energy storage capabilities into structural composite materials."

Thostenson devised an innovative education plan for his Career Award: a junior-level research and design project to develop a lab-scale pilot facility for continuous deposition, with a working pilot facility constructed as a follow-on senior research project. He also plans to develop a nanotechnology course module for high school students to help to build the pipeline of engineers interested in careers in materials and nanotechnology.

*Article by Diane Kukich*

# RESEARCH

Research underpins every engineering innovation. It is the scientific foundation that transforms intellectually exciting ideas into pioneering discoveries.

UD researchers investigate problems from a variety of angles in order to develop viable solutions to problems impacting society.

In the pages that follow, we offer a closer look at research within our department destined to help redefine and reshape our world.

Suresh Advani  
Chair

## Mechanical Engineering Faculty Research

		Biomedical Engineering	Clean Energy and Environment	Composites and Advanced Materials	Nanotechnology	Robotics and Controls
Suresh Advani			•	•		
Thomas Buchanan		•				
Jenni Buckley		•				
David Burris		•	•	•	•	
Tsu-Wei Chou				•	•	
James Glancey				•		
Joshua Hertz			•		•	
Jill Higginson		•				
Michael Keefe				•		
X. Lucas Lu		•				
Kurt Manal		•				
Ioannis Poulakakis						•
Ajay Prasad		•	•		•	
Valery Roy			•			•
Michael Santare			•	•		
Leonard Schwartz			•			
Jonghwan Suhr				•	•	
Herbert Tanner						•
Erik Thostenson				•	•	
Lian-Ping Wang		•	•		•	
Liyun Wang		•				
Bingqing Wei			•	•	•	



## Composites & Nanotechnology

### Multifunctional Composites

#### Lighter, smarter and renewable

Multifunctional nanotechnology composites add strength and function while driving energy and fuel cell research.

UD nanotechnology researchers are working on lightweight multifunctional composite structures to make advanced military aerospace and vehicles lighter and smarter while their colleagues working with electrochemical capacitors (supercapacitors) offer renewable power sources for electric vehicles and the portable electronic devices and satellites found on board.

#### Bring in the reinforcement

Both light and strong, carbon nanotubes (CNTs) are a revolutionary material with excellent mechanical, electrical and thermal properties. Motivated by the high electrical conductivity and ability of continuous CNT

fibers to kink without cracking, **TSU-WEI CHOU**, Pierre S. du Pont Chair of Engineering, and his research team, created a flexible composite that can withstand repeated stretching-and-releasing cycles up to a prestrain level of 40 percent with little variation in electrical resistance. Their findings in *Advanced Functional Materials* demonstrate the flexible fibers' potential to reinforce ultra-light-weight multifunctional composites.

#### Sensitive skin

Assistant professor **ERIK THOSTENSON** is investigating the use of carbon nanotube composites as a kind of "smart skin" for structures. An expert in materials processing and characterization or sensor applications, he's collaborating with assistant professor **THOMAS SCHUMACHER**, who studies structural health monitoring of large-scale infrastructures. The two found that a carbon nanotube hybrid glass-fiber composite attached to small-scale concrete beams formed a continuous conductive skin that is exceptionally sensitive to changes in strain. This sensor can be structural, where the layer

*From left, Hyung-ick Kim, James Sargianis and Jonghwan Suhr*

of the fiber composite adds reinforcement to a deficient or damaged structure, or nonstructural, where it acts merely as a sensing skin.

Thostenson incorporates nanotubes into the polymer-rich area between the fibers of individual yarn bundles, as well as in the spaces between the plies of a fiber composite. The nanotubes become completely integrated into advanced fiber composite systems, imparting new functionality without altering the composite's microstructure. A key advantage of this innovative sensor is that it can be bonded to existing structures of any shape or built into new structures during the fabrication and construction processes.

#### Silence, please

Carbon fiber composites are the strongest structural materials available, and are

often used for their superior mechanical performance. Compared to metallic structures, they are also light-weight. However, because they radiate noise at low frequencies, they provide poor acoustic performance, requiring expensive and heavy materials to mitigate noise.

By marrying carbon fiber composites with natural cork, assistant professor **JONGHWAN SUHR** created a noise-free sandwich composite structure without the sacrifice of mechanical performance or weight. Cork-core sandwich composites offer damping properties 250 percent greater than their synthetic foam core counterparts, and provide increased durability and lifetime operation.

The transition from synthetic foam cores to natural cork cores could provide unprecedented improvements in acoustic and vibrational performance in applications such as aircraft cabins, wind turbine blades and automobiles (see related story, page 28).

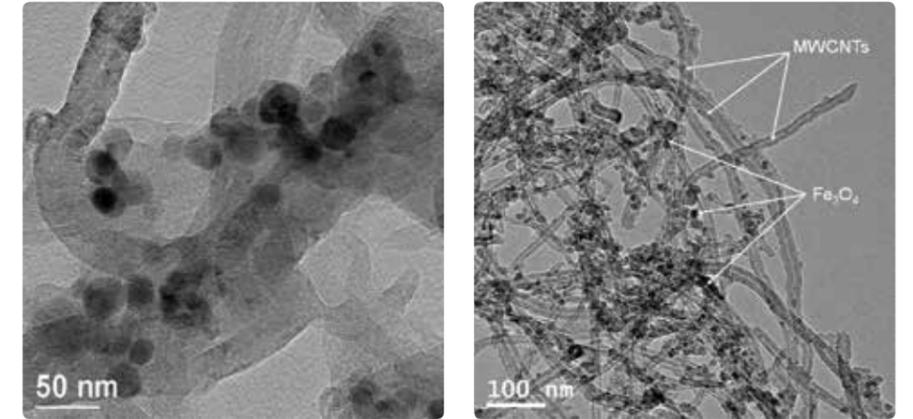
#### Bring on the power

Now that nanotechnology is making aircraft and vehicles lighter and smarter, equally advanced power sources are needed to power them. Once again, nanotechnology steps in as researchers develop rechargeable batteries and supercapacitors as primary power sources for portable electronic devices, satellites and electric vehicles.

The single-walled carbon nanotube/manganese oxide nanocomposites created by Professor **BINGQING WEI** and his team for both supercapacitors and lithium-ion battery applications have exhibited excellent electrochemical performance. They chose manganese oxide for its excellent electrochemical activity, cost effectiveness and environmentally benign nature. Their work was recently published on *Nano Energy*.

#### Composites in 3D

Wei and Suhr have also joined forces to demonstrate that single walled carbon nanotube (SWNT) films can be prepared on a macroscopic scale and easily laminated between carbon fiber prepregs to fabricate



*TEM micrographs showing the presence of iron oxide (Fe<sub>3</sub>O<sub>4</sub>) spheres on the surface of MWCNTs.*

3D composites. The controllable pore size of the SWNT films—ranging from tens of nanometers to hundreds of microns—provide tunable pathways for engineering the interfacial properties of 3D composites, as well as easy penetration of resin during the infiltration. Researchers believe that composites built from 3D SWNT films will exceed the electrical/mechanical/thermal properties of carbon fiber composites, yet still be extremely lightweight, flexible and both mechanically and thermally robust.

#### Enhancing strength and stability

Professors **AJAY PRASAD** and **SURESH ADVANI**, George W. Laird Professor and department chair, have incorporated carbon nanotubes within the Nafion polymer electrolyte membrane (PEM) to create composite membranes with enhanced mechanical strength and dimensional stability. At low carbon nanotube (CNT) loadings, their composite membranes provide electrical performance similar to Nafion, but with better durability. Higher CNT loadings would improve strength, but CNTs are electrically conducting, which would increase the membrane's electrical conductivity to an undesirable extent. So, the team is exploring two novel ideas to maintain the electrically-insulating nature of the membrane while incorporating CNTs.

The first uses wet-chemistry techniques to coat the CNTs with a thin layer of silica, which absorbs water under wet conditions, and releases it back to the membrane under dry conditions. The resulting membrane is strong, electrically insulating and tolerant to humidity fluctuations during fuel cell operation.

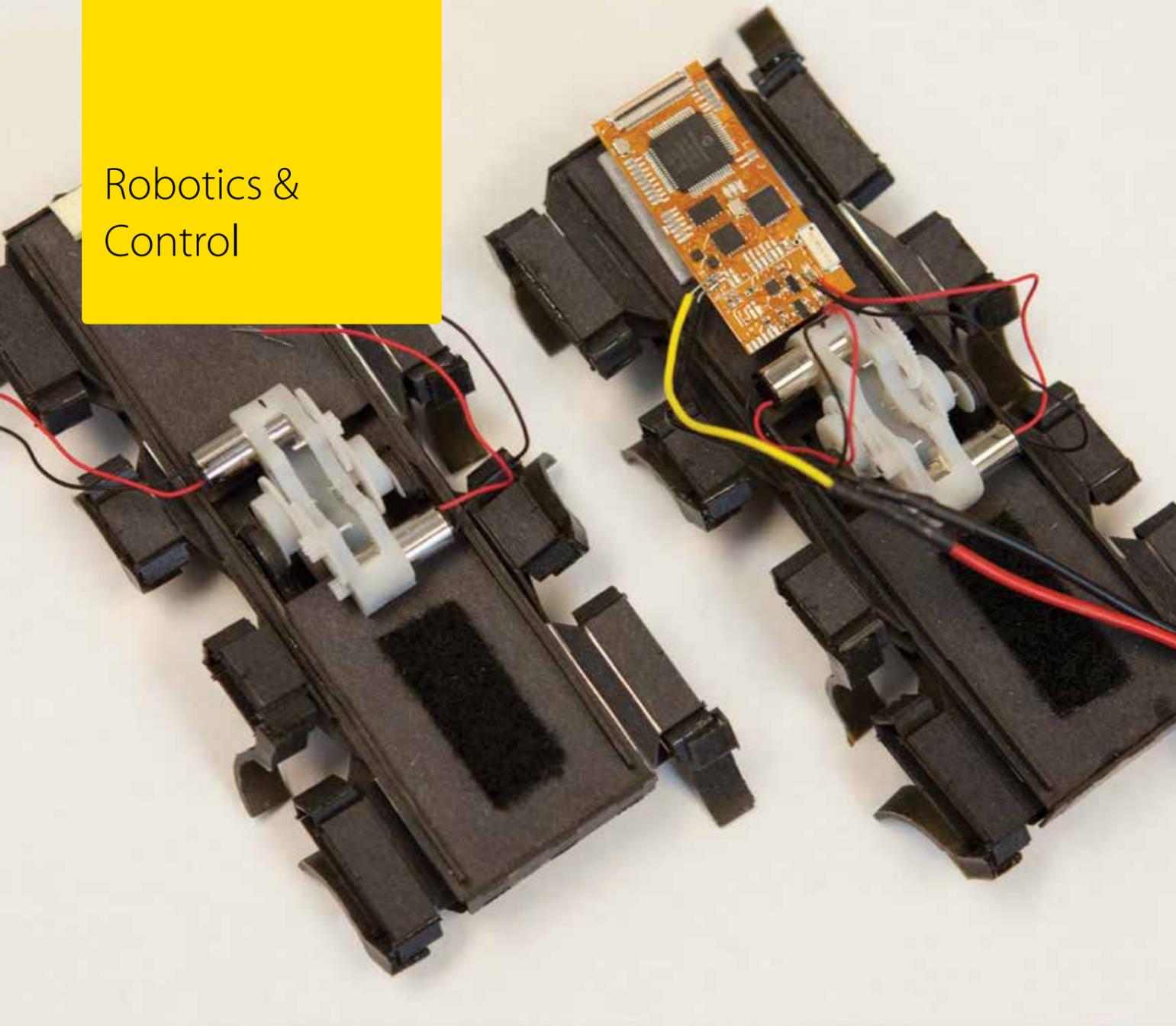
The team also functionalized the CNTs with iron oxide (Fe<sub>3</sub>O<sub>4</sub>) before incorporating them in the Nafion resin. A strong magnetic field draws the CNTs to one side of the membrane, creating both a CNT-rich layer and a Nafion-rich layer. The CNTs enhance the membrane's strength and durability, while the Nafion-rich layer preserves its electrical resistance.

#### Removing barriers to acceptance

PEM fuel cell durability represents one of the main barriers to commercialization. The Nafion/CNT composite membranes created at UD show good durability and resistance to mechanical and chemical degradation under accelerated stress testing protocols. Researchers hope the findings contribute to widespread acceptance of fuel cells in the coming years.

*Article by Jonghwan Suhr*

## Robotics & Control



### Pushing the envelope

#### Making robots useful in the real-world

Human-centered robotic technologies offer the prospect of replacing humans in what are considered dull, dirty and dangerous jobs. They can push the envelope in a variety of real-life applications, including search-and-rescue missions, building inspection, transportation over rough terrain, remote or hostile environment exploration, and entertainment.

#### Palm-scale crawlers

As part of their work, Associate Professor **HERBERT TANNER** and Assistant Professor **IOANNIS POULAKAKIS** concentrate on palm-sized legged robots—specifically the octapedal robot OctoRoACH. OctoRoACH was developed at University of California Berkeley, as part of a collaborative project in which UD is involved and is funded by the Army Research Laboratory, in an effort to build a robotic platform with enhanced

*UD researchers are working to address a critical missing link in the advance of robots such as the OctoRoACH, a palm-sized legged robot.*

locomotion capabilities fit for urban and complex terrain.

There are many motivations for exploring the use of legs for locomotion, but one, in particular, stands out: mobility. Walking robots fit the bill to travel over rough terrain

where wheeled or tracked vehicles cannot traverse and creep into crevices where larger machines cannot go. For example, crawling robots could search for survivors buried under rubble from a devastating natural disaster, such as an earthquake or tornado. Successfully deploying such systems in real-world missions demands tight integration between platform-specific locomotion control strategies and universal high-level motion planning algorithms.

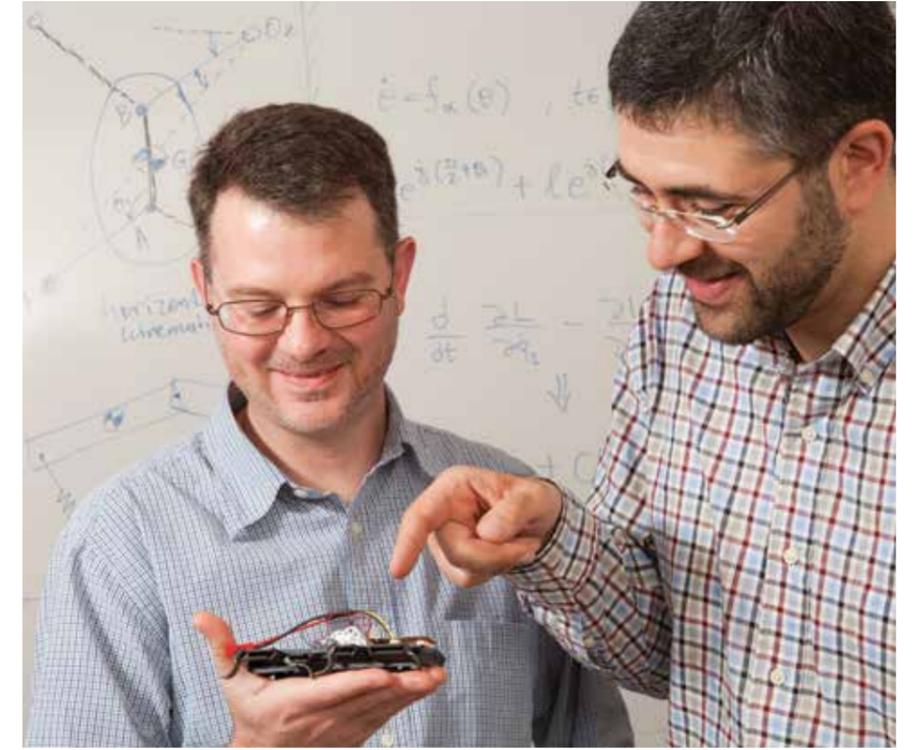
Existing approaches on low-level locomotion control aim primarily at achieving locomotion stability, and have been developed largely in isolation from high-level, task-specific requirements. General motion-planning methods, by contrast, typically include simplified systems, and may produce paths and trajectories that cannot be realized by fast-moving, palm-sized legged robots, such as the OctoRoACH.

Tanner and Poulakakis are working to address a critical missing link in the advance of such robots—a framework that combines high-level motion-planning specifications with low-level locomotion controllers in a functionally integrated manner that fully exploits the capacity of the ground platforms in collectively accomplishing a mission.

#### Networked robots for radiation detection

Along a different direction, the team is working to increase their understanding of how networked machines can make decisions about a process they collectively observe. Ultimately, they hope to develop dynamic, responsive reconfiguration and coordination algorithms for these machines to support collective decision making.

Current safeguards are not as tight as necessary to guard against the possibility of a clandestine nuclear or radiological attack. The professors believe collective decision making by autonomous, possibly mobile, robotic sensors could push the state of the art in methods for nuclear nonproliferation, and also possibly impact optical communications and radar-based detection. In addition, the proposed research could benefit other areas where sensor networks have the potential to



improve timely signal detection, including early detection of earthquakes and tsunamis.

Their research applies principles from statistical analysis, sensor networks and robot control to the specific problem of detecting weak radioactive sources in transit, using a network of stationary and mobile sensors. They are investigating new theoretical tools that enable this network to decide, in a fixed time interval, whether a passing target is radioactive, using sensor mobility, adaptive networking architectures, and local data processing for decision making.

For example, the robotic network could be deployed along border crossings where humans either don't have the capability to search every vehicle, or where doing so would impose a severe burden on the free movement of people or goods.

The envisioned robotic sensor networks can interpret, on their own, what they are sensing. They would exploit their mobility to position themselves better and improve error and detection rates. They could

*Herbert Tanner and Ioannis Poulakakis are part of a research team that is teaching robots to respond in disaster emergencies.*

exchange information to decide which of them is in the best position to make the final decision, and the chosen decision-maker bases its decision on compressed information received from its group-mates. Perhaps more importantly, they could allow us to make timely decisions regarding threats, opportunities or time-critical requirements, without constant time- and labor-intensive human supervision.

These technologies, jointly developed by the two faculty, are envisioned to have applications in the fields of search and rescue, autonomous inspection, national security and environmental monitoring.

*Article by Herbert Tanner and Ioannis Poulakakis*



## Jill Higginson

Associate Professor of Mechanical Engineering

Jill Higginson took the first step on her career path to biomechanics when she was just a high school student touring a facility that manufactured artificial hips. The tour was part of a summer camp designed to get girls interested in science and engineering.

Now an associate professor of mechanical engineering at UD, Higginson is a firm believer in the value of such programs, and she views outreach as an important part of her job.

Her path to UD as a faculty member—via Cornell, Penn State and Stanford—exposed her to both the hands-on and simulation sides of the field, and her current research is aimed at improving the understanding of muscle coordination in normal and pathological movement through coupled experimental and simulation studies.

Specifically, her research group's ongoing projects focus on progressive knee osteoarthritis (OA) and gait issues in stroke patients.

Her OA work has been supported largely by an NIH COBRE grant that included an interdisciplinary team of researchers from UD's colleges of Health Sciences, Engineering, and Arts and Sciences. Higginson's particular area of interest is modeling of muscle forces.

An NIH R01 grant has enabled Higginson and her team to collect data from more than 40 stroke patients, which are used to build subject-specific simulations to identify an individual's deficits and design strategies to help them recover function. She is currently seeking funding to support follow-on work in this area that will help determine which interventions will work best for which patients.

Higginson is also director of UD's Center for Biomedical Engineering Research (CBER), an interdisciplinary center whose mission is to reduce the impact of disease on the everyday life of individuals through engineering science and clinical technology.

Housed in the Department of Mechanical Engineering, CBER builds on a history of interaction between ME and the UD departments of Physical Therapy, Biological Sciences, and Kinesiology and Applied Physiology.

"The center mirrors my own background," Higginson says. "I'm a mechanical engineer first, and everything I do starts from that foundation." The three classes Higginson taught during the 2012 fall semester exemplify that philosophy, providing a foundation in mechanical engineering concepts but with a biological spin.

With the field of biomechanics changing rapidly, Higginson is aware of the need to find new ways to teach, collaborate and reach out to the community and the K-12 population.

This year, she is planning some new directions for CBER, including sponsorship of students with UD's Undergraduate Research Program through its Science and Engineering Scholars Program. She would also like to increase partnerships with industry to open up internship opportunities for students and joint research programs for faculty. Finally, she wants to expand outreach with tours and hands-on demonstrations.

"This is so important in attracting young people to the field, especially girls and other underrepresented groups," she says. "I really appreciate the work one of our newest faculty members, Jenni Buckley, is doing in this area. She is great at making biomechanical concepts fun and engaging."

Higginson herself is well aware of the importance of STEM outreach. If it weren't for that tour more than 20 years ago, she might not have found her way into the field of mechanical engineering.

Article by Diane Kukich



## David Burris

Assistant Professor of Mechanical Engineering

When David Burris saw a McLaren at the recent Philadelphia Auto Show, he remembered why he had gotten into mechanical engineering in the first place.

When David Burris saw a McLaren at the recent Philadelphia auto show, he remembered why he had gotten into mechanical engineering in the first place.

"I was really into cars," he says, "and I got excited all over again, seeing that high-end sports car stripped down to just the chassis and the engine."

The path to his current interest in tribology—the science and technology of such phenomena as friction, wear, and lubrication—wasn't quite so direct, but it left Burris with a lasting impression of the impact one person can have on another's life.

"In my sophomore year at the University of Florida, I heard about internships where they spent all summer doing CAD modeling or optimizing a single airplane part. Most of it sounded dreadfully monotonous and boring to me."

So when his fluids professor approached him about doing undergraduate research instead of interning with a company, Burris jumped at the chance. It turned out to be a perfect fit.

"This professor wasn't the type to pigeon-hole himself into doing just one thing,"

Burris says. "In his lab, we did it all—from designing instruments to making materials to developing the software to controlling the instruments."

Although he had never considered a career in academia, Burris stayed on at Florida for graduate work. His Ph.D. research focused on lubrication for space applications, which led to a seemingly unrelated interest in cartilage.

"You can't use lubricants in space," he explains, "because they evaporate, so surfaces just tend to bond to each other. My goal was to design composite or nanocomposite materials that provide low friction and wear without lubrication. One of the materials I patented for this application was licensed for joint replacement, another application where wear resistance is a technological barrier. I began to wonder if we could make bigger impacts in orthopaedics by mimicking cartilage, a material with a unique structure that self-lubricates when pressure is applied by the joint."

The work in Burris's lab now focuses on cartilage lubrication. Although the subject has been studied extensively since the 1930s, his group has made extraordinary progress in just the past three years due to another lesson he learned from his fluids professor at Florida—integrating the engineering with the research.

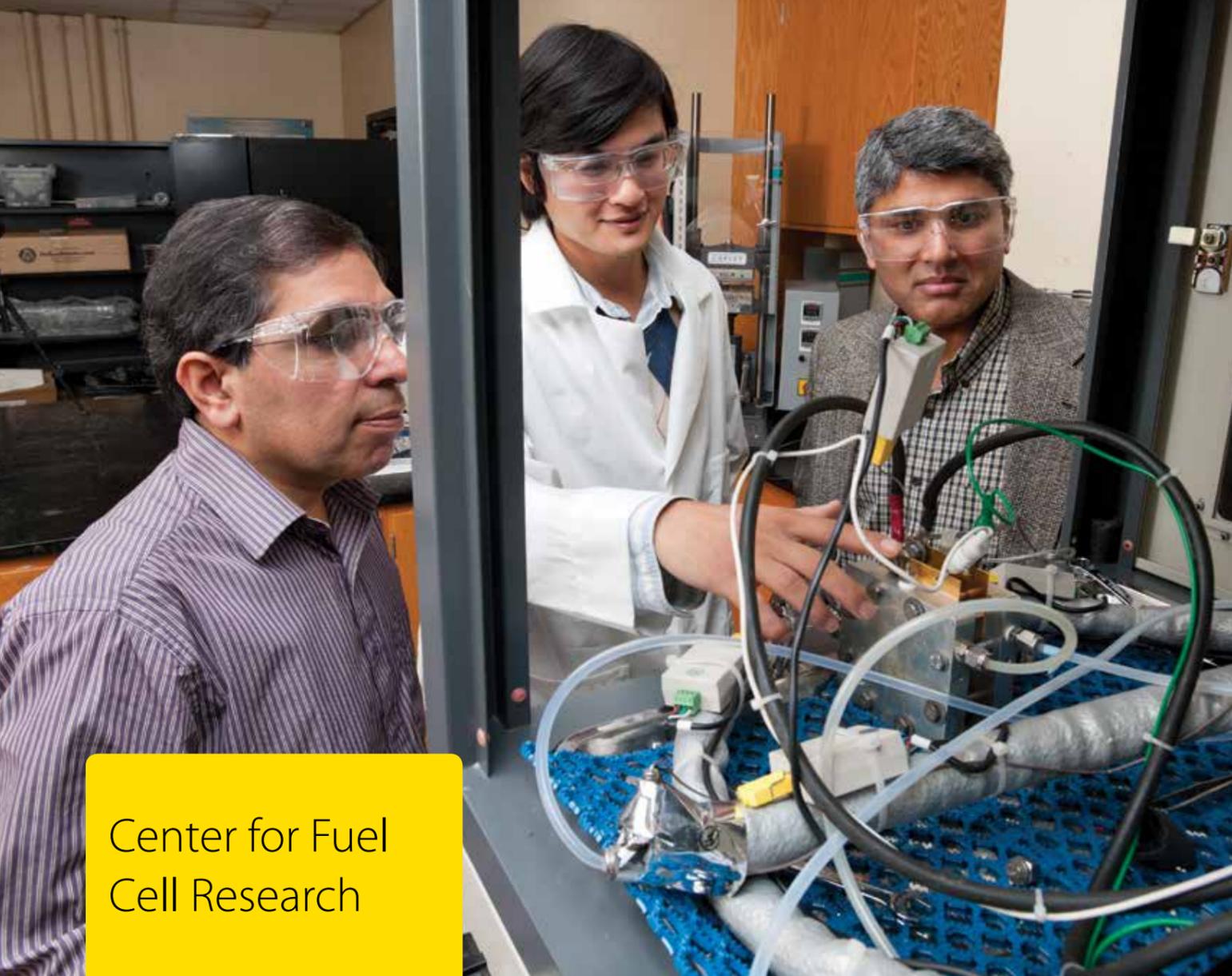
"Just as we did in the lab where I worked as a student, we're making our own instruments to take the measurements we need so we can better understand how cartilage works," he says. "We're in the process of publishing the first cartilage model that actually predicts its tribological response and using it to design new cartilage repair and replacement materials."

Burris explains that achieving low wear rates is critical for these applications because wear can cause failure of the implant. In addition, the body can attack wear debris, causing bone resorption, implant loosening and infection.

Most recently, Burris has become interested in wind energy. He is contributing his expertise in tribology to study turbine drive-train failure, another technology barrier, in research led by Willett Kempton in UD's College of Earth, Ocean, and Environment.

Burris is grateful to the professor who helped him find his way. "I came awfully close to becoming a ski bum," he admits. "I'm really glad I was offered the opportunity to work in a lab that meshed so well with my own interests and need for variety."

Article by Diane Kukich



## Center for Fuel Cell Research

### Fueling a hydrogen economy: Center for Fuel Cell Research enters 5th year

Fuel cells have long been considered a green power source destined to re-define how consumers use energy. Research in this area typically centers around three main applications: automotive, stationary power and portable power.

World leading industry corporations in the region such as DuPont, Gore, Bloom Energy and Air Liquide, among others, are focused

on developing key fuel cell technologies. The University of Delaware is located at the epicenter of this activity, which gives the Center for Fuel Cell Research, founded in 2009, a unique opportunity to drive critical science and technology efforts to bring fuel cells into widespread use.

There are major challenges to widespread adoption of fuel cells, however, including their cost, limited durability and the lack of hydrogen infrastructure. At the component level, the Center serves as a resource for materials development research to create novel and more durable membranes and cost-effective catalysts. At the system level, the Center is conducting several projects aimed at gaining operational experience with fuel cell/battery hybrid vehicles,

*Postdoctoral researcher Liang Wang (center) with help from his advisors Suresh Advani (left) and Ajay Prasad (right) is working to increase the durability and performance of fuel cell membranes.*

hydrogen storage and the generation of hydrogen from renewable sources.

According to **AJAY PRASAD**, the Center's director, major automotive companies are expected to introduce fuel cell cars in the showroom by 2015. Hybrid fuel cell powered vehicles provide a fuel economy that is two to three times higher than conventional combustion engines. Equally important, they produce zero emissions, emitting only water vapor into the environment.

"Unfortunately, right now, there is no economy-of-scale for the manufacture and wide-spread implementation of fuel cells," explains Prasad. "One way to address this challenge is by developing novel membranes and catalysts that exhibit greater durability and cost efficiency."

In collaboration with industry, government and academic partners, the Center seeks to address barriers to commercialization. Among the mechanical engineering faculty conducting noteworthy work in this area are Prasad and his longtime colleague **SURESH ADVANI**, professor of mechanical engineering and chair of the department. **MICHAEL SANTARE**, professor of mechanical engineering, investigates issues surrounding fuel cell membrane and electrode durability. Other key interdisciplinary researchers are **YUSHAN YAN**, Distinguished Professor of Engineering, who has dual responsibilities in chemical and biomolecular engineering and UD's Energy Institute, and **DION VLACHOS**, Elizabeth Inez Kelley Professor of Chemical and Biomolecular Engineering.

Bloom Energy, a leader in developing high temperature fuel cells for stationary power applications, broke ground in April 2012 for its new manufacturing plant on UD's Science, Technology and Advanced Research (STAR) Campus. It's a development that Prasad calls a "fantastic addition" that holds great promise for future partnerships.

"Several UD faculty members are working in exactly the area that Bloom is interested in," explains Prasad. For example, **JOSHUA HERTZ**, assistant professor in mechanical engineering, and **DOUGLAS BUTTREY**, professor of chemical and biomolecular engineering, are researching solid oxide fuel cells used in stationary power applications.

UD is also a leader in adopting fuel cell technologies. One example is the growing number of hydrogen fuel cell buses on UD's Newark campus. The Center currently operates two fuel cell buses, and plans to double its fleet in 2013, with a third bus arriving on campus this spring and the fourth by year's end.



"One of the principal challenges right now is that the catalyst currently used in proton exchange membrane fuel cells is platinum, an expensive resource. We would like to create a paradigm shift and move away from using platinum all together. To do that successfully, there must also be a paradigm shift to a new type of fuel cell membrane," explains Prasad. Prasad is currently collaborating with Yan, who is known for his work in developing hydroxide exchange membranes, a promising alternative to traditional proton exchange membranes typically used in fuel cells.

Equally important is the Center's efforts toward a long-term vision for hydrogen production and storage. Current work includes the potential use of metal hydrides to improve the density and safety of hydrogen storage. Generating hydrogen renewably from concentrated sunlight through thermochemical cycles is another ongoing effort for a sustainable pathway towards the hydrogen economy.

*Article by Karen Roberts*

### Symposium highlights fuel cell advances

More than 40 industry, government and academic researchers gathered at UD in October to discuss the important role of fuel cells in clean energy technology.

Sponsored by the University of Delaware Energy Institute (UDEI) and organized by the Center for Fuel Cell Research (CFCR), the event covered research aimed at improving the performance and durability of fuel cells, reducing their costs and exploring new methods to produce hydrogen renewably from sunlight.

Talks focused on two types of fuel cells: polymer electrolyte membrane fuel cells, applicable in the automotive sector; and solid oxide fuel cells, best suited for stationary power.

According to Ajay Prasad, ME professor and CFCR founder-director, fuel cells offer the potential to reduce the nation's dependence on fossil fuels, reduce greenhouse gas emissions and improve urban air quality.

UD faculty are actively improving fuel cell performance and helping commercialize them; work that Prasad believes aligns with UD's "Initiative for the Planet," a major theme in the Path to Prominence strategic plan.

*Adapted from an article by Megan Marshall*

# Outstanding Students



Study Abroad took **ANNA D'ALESSIO** to Italy where she studied Materials science and history. The following year, she traveled to Australia to learn about fluid mechanics and transportation engineering. "They were some of the best experiences of my life," she recalls.

As part of her sustainable energy technology minor, D'Alessio worked for the National Institute of Standards and Technology. "I worked on the sustainability standards portal, which helps stakeholders determine whether a specific standard or regulation applies to them," she explains. Her work was so impressive that she published a paper, "Modeling Gaps and Overlaps of Sustainability Standards."

After graduation, D'Alessio plans to earn a doctoral degree in mechanical engineering, concentrating in sustainability.

**MICHAEL PFEIFFER** enjoys mentoring younger students and is a peer mentoring officer for the Mechanical Engineering Student Squad, as well as a member of the American Society of Mechanical Engineers. In his free time, he helps his former high school's robotics team.

Over the past few years, Pfeiffer interned at the Navy Yard in Philadelphia working on control systems and vibrations analysis. He also did hardware engineering with Lockheed Martin.

He chose UD for the great engineering program, and is currently retrofitting a recumbent bicycle for people with disabilities. After graduation, Pfeiffer plans to work as a design engineer while earning his master's degree.

**CHRISTINE GREGG**, who worked at the Aeromechanics branch of NASA Ames Research Center with the U.S. Army Aeroflightdynamics Directorate analyzing rotocraft wind tunnel test data, wishes to pursue a career with NASA after attending graduate school.

As an Honors student in mechanical engineering, she researches nanocomposites, specifically damage detection using carbon nanotube networks and self-healing composites.

Gregg is the president of Tau Beta Pi, a member of the Arnold Air Society—a part of Air Force ROTC—and involved in Science, Technology, Engineering and Mathematics (STEM) outreach programs for the local Girl Scout Council with the Society of Women Engineers.



Honors student **DHARA AMIN** is the winner of multiple awards and scholarships, including the General Honors Award, the Alumni Award for Outstanding Junior in Mechanical Engineering, a scholarship from the Society of Women Engineers (SWE) and a scholarship from the American Association of University Women.

Active on campus and in the community, Amin is the project manager of the Guatemala Bridge Project for Engineers Without Borders; conference chair for the SWE; and a member of Tau Beta Pi, Phi Delta Epsilon and the American Society of Mechanical Engineers.

Amin, who is interested in biomedical engineering and conducted research with a doctoral graduate student on spinal disc fatigue, plans to become an orthopaedic surgeon.

Honors student **MATTHEW DURST** studies mechanical engineering with minors in mathematics, biomedical engineering and economics. He's also a UD athlete, running for men's cross country and track club.

A TA for three mechanical engineering courses, Durst enjoys being on both sides of the classroom. Last year, he studied knee cartilage to better understand osteoarthritis.

Durst interned with United Technologies Corporation Aerospace Systems working on NASA and Boeing projects for the past three summers, and has a job lined up in the Operations Leadership Program after graduation. Eventually, he plans to get his PE license and earn a master's degree.

Robotics enthusiast and Honors student **BENJAMIN HOCKMAN**, who helped kick start the new UD Robotics Club, has worked in the Cooperative Robotics Lab on a research project since his sophomore year. The project's focus is to improve detection of hazardous radioactive materials with mobile robotics sensors. Since freshman year, he's represented UD at the American Society of Civil Engineer's steel bridge competition, bringing knowledge of SolidWorks as the team's only mechanical engineer.

Hockman designed a conveyor belt system for X-ray baggage scanning machines for Smiths Detection, helping the company increase production.

He hopes to pursue robotics research as a professor.



## Student Community Projects

Mechanical Engineering students are involved in a multitude of community outreach programs at the local, national, and international level. Here's a sampling of their recent activities:

**THE MECHANICAL ENGINEERING STUDENT SQUAD (MESS)** is a new student group focused on peer mentoring, outreach

and advancing young mechanical engineers. This year, members introduced students to careers in engineering at local schools; helped students from a local

polytech high school test their structural bridge designs; and hosted the department Chair's Council meeting.

**THE SOCIETY OF WOMEN ENGINEERS (SWE)** encourages young women to consider careers in engineering and provides members with developmental and professional opportunities. Members of UD's SWE chapter are currently helping with plans for the regional SWE conference scheduled in March.



**ENGINEERS WITHOUT BORDERS (EWB)** is a non-profit dedicated to developing sustainable solutions for underdeveloped communities around the world. Over the past few years, EWB-UD students traveled to Bamendjou, Cameroon to install a water distribution system that will deliver large amounts of clean water to the Bakang and Balatsit villages. Returning this winter to ensure the community had ownership of the installation, the students made small repairs and taught the villagers how to maintain the water system.

In 2012, EWB members traveled to San Jose, Guatemala, to build a bridge linking villagers to their crops during the rainy season when the local river is too dangerous to cross by other means. During winter session 2013,



the team was proud to find that their bridge survived a 7.4-magnitude earthquake and was still serving as a lifeline for many of the locals.

**Undergrads take third in Rowan University Pumpkin Chunkin' event**

Growing up, Janty Shoga, now a senior mechanical engineering student, watched the national Punkin' Chunkin' competitions in Bridgeville, Del., where contestants competed to launch pumpkins the farthest using homemade catapults.

So last fall, when the opportunity arose to compete in the 2012 American Society of Mechanical Engineers (ASME) Pumpkin Chunkin' event at Rowan University in Glassboro, N.J., Shoga knew he had to participate.

He teamed up with Honors senior mechanical engineering student Anna D'Alessio to design a wooden catapult using their combined knowledge of fatigue and material analyses learned in solid mechanics and machine design at UD. Using the 3D mechanical computer-aided design (CAD) program, SolidWorks, the duo ran computer simulations as they researched, designed and tested their product prior to the competition.

"Building the trebuchet attracted interest from several faculty members and students,

which really made me feel like a part of the mechanical engineering department," Shoga said.

Hosted by the Rowan University chapter of the ASME, the competition pitted six teams against one another to launch five-pound pumpkins 100 feet toward a target. Shoga and D'Alessio placed second in the first round, advancing to the final round where they placed third overall.

"Our design was made out of wood, and when it began to warp, things became slightly misaligned," the team explained.

Despite these challenges, the pair enjoyed their experience working together and felt they learned a lot, saying, "Through this journey, we have gained knowledge about testing devices, compiling research and designing a product."

*Article by Megan Marschall*

# Senior Design

## Ideas to reality

Students gain experience; sponsors benefit from fresh ideas

When mechanical engineering alumni reflect on their UD experience, Senior Design is often among their most revered memories. For many, the course was their first experience addressing a real-world problem for an actual company. The sense of accomplishment earned from taking idea to prototype to proof of concept is second to none for preparing a young engineer to enter the workforce, while the teamwork involved often leads to lifelong friendships.

Sponsoring companies also benefit. Al Frattarola, director of global engineering and technology for Concordville, Penn.-based Southco, manufacturer of engineered access hardware solutions, likes the idea of

giving a design or production problem to students whose fresh approach, he says, will sometimes surprise you. "They aren't tainted by 'it can't be done.' I've been impressed by their creativity."

The price is also right, he acknowledges. In return for a \$5,000 sponsorship, a team of young engineers focuses on finding a workable solution before semester's end—an estimated 1,200 hours of enthusiastic engineering brainpower.

Southco has several UD mechanical engineering alumni among its employee base, and is always looking for new local talent. "It opens the students' eyes to realize that we design, develop and manufacture products right here in the tri-state area," Frattarola says. "It gives me a chance to see the students at work and recruit the best to come work for us."

Is your company interested in building relationships with some of the brightest young minds in the industry? Contact [NATE CLOUD](mailto:NATE.CLOUD@UDEP.EDU) about Senior Design Sponsorship opportunities at [CLOUDN@UDEP.EDU](mailto:CLOUDN@UDEP.EDU).

# Meet the teams

(continued on page 26)



**TEAM ALCORE // JET ENGINE INNER FIXED STRUCTURE**  
Michael Wherry, Adrian Sawyer, Justin Keller, Charles Jackson



**TEAM AMSAA // SHAFT TWIST DETECTION TOOL**  
Jianhua Su, David Broadwater, Zachary Sniffen, Evan Phillips, Matthew Sinnott



**TEAM ASHLAND // PAINT ROLLER APPLICATION FEEL SYSTEM**  
Matthew Durst, Stephen Weathers, Daniel Wilkins, Brian Owens



**TEAM CHESAPEAKE TESTING // HELMET COMPRESSION FEATURE**  
Parker Wright, Marcus Whitchett, Ryan Hilker, Peter Lessik



**TEAM DOW ELECTRONIC MATERIALS // AEROSPACE COMPOSITE TOOLING**  
Daniel Greene, Francis Heil III, Jacob Hersh, Prasant Muralidhar



**TEAM ESCO // JET BLAST RESISTANT TRAY TEST SYSTEM**  
Nathaniel Martin, William Moreland, Janty Shoga, Andrew Gay



**TEAM HELIOCENTRIC // SOLAR THERMAL ENERGY SYSTEM**  
Christopher Gray, Sven Ellefson, Michael Powers, Chelsea Trotter



**TEAM ILC // APPARATUS FOR SOFTGOODS TESTING**  
Justin Chambers, Christine Gregg, Hilary Pieper, Sean Naughton



**TEAM LITECURE // UTILITY CART FOR DEEP TISSUE THERAPY LASER SYSTEM**  
Dhara Amin, Eric DiBlasi, Andrew Smith, Michael Brennan



**TEAM PRECISION AIRCONVEY // RELIABILITY IMPROVEMENT OF AIR CONVEYOR SYSTEM**  
Robert Rex, Alejandro Londono, Stephen MacPherson, Justin Janelli



**TEAM SCHILLER GROUNDS CARE // EDGER ATTACHMENT**  
David Hegenbarth, Kevin Murphy, Garrett Rugen, Daniel Baumzweig



**TEAM SENSING DEVICES // RTD ADJUSTING OPERATIONS RE-DESIGN**  
Joseph Iannacci, Kathryn Yovanovich, Rebecca Creighton, Todd Toso



**TEAM SMITHS DETECTION // X-RAY CONVEYOR**  
Gerard Lieb, Benjamin Hockman, Luke Walmer, Gregory Ohnemus



**TEAM SOUTHCO // HEAVY DUTY LATCH TEST SYSTEM**  
Gregory Burgess, Ryan Lagano, Anna D'Alessio, Lawrence Rosello



Team Highlight

**Team Schiller**  
Schiller Grounds Care, of Southampton, Penn., sponsored a senior design team in creating an edger attachment that cleanly separates the lawn from a surface. The attachment improves Schiller's internationally recognized tiller, Mantis, known as the first lightweight and convertible cultivation tool for commercial and consumer use.

The students created a prototype with an improved gearbox, increasing both the RPMs of the transmission and the depth the blade will cut. Schiller is currently testing the new gearbox for durability and implementing some design revisions suggested by the UD team.



Team Highlight

**Team Sensing Devices**  
Sensing Devices Inc., from Lancaster, Penn., sought a redesign of the adjusting station used in the production of resistance temperature detectors (RTD). By creating a more stable environment for the electrical adjustment of the .0007"OD platinum coiled helix, the RTD will be closer to the ideal ohmic value, enabling a more accurate measure of temperature.

The team successfully created a cost-effective workstation with uniform airflow at a particular velocity, leading to a greater yield of high precision RTDs. Sensing Devices Inc. plans to implement the students' redesign in the trimming stage of RTD production.



**TEAM SPEAKMAN I // LOW FLOW 'GREEN' SHOWERHEAD**  
John Sheridan, Kevin Mathews, Jason Troyer, Andrew Beauchemin, Timothy Williamson



**TEAM SPEAKMAN II // HANDS-FREE ACTIVATING FAUCET**  
Jiajun Wu, Charles Small, Derek Herr, Lindsay Rennie



**SUPERIOR TUBE // TUBE BLOWOUT SYSTEM**  
James Buckmann, Ravi Sharma, Ryan Heelan, Sean Pologruto



**TEAM SURVIVE // ROBOT END EFFECTOR FOR AIRFRAME MAINTENANCE**  
Michael Kase, Jay Patel, Rajorshee Nath, Edward Skolnick



**TEAM WEST PHARMACEUTICAL // NEW PHARMACEUTICAL COMPONENT PACKAGE**  
Dylan Dartnell, Phillip Schweiger, Benjamin Lavallee, Jennifer Moyer



**TEAM WHITE OPTICS // SPRAY COAT SYSTEM AUTOMATION**  
Scott Wroten, Colleen Cannatelli, Lauren Resch, Benjamin Natrin



**TEAM W.L. GORE // DENOX TEST SYSTEM**  
Tonilynn Yavorski, Robert McGrath, Michael Marando, Michael Pfeiffer



**TEAM YES-U-CAN // HANDS-FREE BICYCLE STEERING SYSTEM FOR THE DISABLED**  
Devin Prate, Christopher Leonard, Daniel Evans, Matthew Klixbull



**Team Highlight**

### Team Yes You Can

Joining the Senior Design lineup this year is the Yes You Can Foundation, a nonprofit that promotes inclusion and physical fitness for those with limited mobility and disabilities. Students were tasked with retrofitting a recumbent bicycle with a steering system intended for someone with limited mobility.

The team constructed a joystick steering system with a stepper motor, making it possible for the rider to independently maneuver the bicycle. Power is generated when an incorporated Functional Electrical Stimulation (FES) system jumpstarts the muscles in the user's legs.



*Front row: Shawn Riley, Dina Riley, Don Hallam, Bill Lotter and Yogendra Chadda. Back row: Bob Hartman, Ken Paulsell, Bill Fagerstrom, Peter Cloud and Ed Gargiulo.*

## Engineering Advisory Panelists:

**YOGENDRA CHADDA**  
Retired professor and chairman, Department of Mechanical Engineering, University of Detroit; Fulbright Professor: Univ. of Botswana, & Tribhuvan University of Kathmandu, Nepal; former vice-dean of Engineering, University of Singapore; and engineer for both Martin Marietta Aerospace, and Ford; ASME life member

**PETER CLOUD, ME65**  
Former president/general manager of several Astra Zeneca specialty chemical businesses

**BILL FAGERSTROM, PE**  
Former machine dynamic senior consultant with Dupont; UD manufacturing course and past Senior Design advisor (2011); ASME life member and SME member

**ED GARGIULO**  
Senior staff mechanical engineer, Siemens Healthcare Diagnostics, UD adjunct professor and ASME life member

**DON HALLAM, EE51**  
Retired senior engineering associate with DuPont Engineering Development Laboratory

**BOB HARTMAN, PE, PHDME88**  
Retired professor in charge; Engineering, Penn State Great Valley; UDME faculty/Senior Design advisor (2006–2010)

**BILL LOTTER, ME56**  
Retired from leadership positions in the paper, plastics and steel industries; a founding director and CEO of DEMEP (1999–2001)

**KEN PAULSELL**  
Former mechanical systems development manager for Dupont; consultant for new product business processes

**DINA RILEY, ME98, MBA03**  
Manufacturing engineering manager, Agilent Technologies

**SHAWN RILEY, ME98, MSME01**  
Engineering associate supporting Gore filtration products; former process improvement and product engineer with Rohm and Haas Electronic Materials

## No substitute for experience

### Advisory Panelists guidance critical for students

Each year, industry experts lend their time and talent to help senior design students succeed. The Engineering Advisory panelists meet the student teams in late October to review design concepts. They share their expertise and insight about the students' prototypes and engineering plans, encourage the students to fine tune their proposals, and then return at semester's end to evaluate the final presentations.

Senior Design faculty advisor Michael Keefe, associate professor and associate chairman of undergraduate education for mechanical engineering, says the Engineering Panel confirms what faculty stress throughout the course. "Industry experts bring 'credibility' to the evaluation process," he acknowledges. "Students might do an excellent job with individual elements, but the pieces have to come together in the final analysis. Faculty can tell this to students, but hearing it from an 'accomplished engineer' drives the message home."

This external evaluation of the students' work also provides an independent assessment of their efforts, which is important documentation used by the faculty for maintaining the program's accreditation through the Engineering Accreditation Commission of ABET.

Keefe notes, "We teach theory quite well, but there is also an art to the science of engineering. The panelists not only reinforce the technical side, but then help the students consider the less technical aspects, such as project management, communication, teamwork and budget."

Panelist Peter Cloud, ME65, former president/general manager of multiple Astra Zeneca specialty chemical businesses, concurs. "Interacting with the sponsors and advisory panelists gives the students experience dealing with people in industry and teaches them that the people for whom they are doing the project—and the suppliers they need for services and materials—might not always react to their requests as quickly or as thoroughly as they would want. This is a lesson they will learn, and re-learn, throughout their engineering careers."

The 10-member panel—which includes six UD alumni; two former faculty members and senior design advisors; and three ASME life members—represents 400 years of combined academic, engineering and business experience.

# Highlights, News, Awards

## ME students finish strong in international club car competition

Eleven mechanical engineering students maneuvered a UD-created race car weighing 458 pounds through dynamic demonstrations on braking and acceleration, skid pad, autocross and endurance exercises in the Formula Society of Automotive Engineers (FSAE) international club car competition last summer in Lincoln, Neb. They also competed in presentations on budget, design and marketing, and safety and race rule compliance.

Led by faculty advisor Steven Timmins, instructor in the Department of Mechanical Engineering, the UD team was one of only 29 teams to finish the event from among 81 competitors. Stephen Hale, UD FSAE president, summed up the experience saying, "There isn't another club on campus that allows the students to put every bit of their engineering knowledge into practice and get hands-on experience building a functioning vehicle, starting with design and fabrication to testing and competing."

Club members contribute toward annual competition travel expenses by tuning lawnmowers for local residents and community members



*The Formula Society of Automotive Engineers senior design teams. Read more about senior design on pages 21–25.*

each spring. UD's Department of Mechanical Engineering and the College of Engineering Dean's Office also support the program.

## UD student's research may help increase solar cell efficiency

During a two-month student exchange trip to Tsinghua University in Beijing, China in his senior year, Stephen Mulligan (ME2012) co-authored a paper published in the *Journal of Materials Chemistry* explaining the effects of gas flow on newly developed solar cells.

The paper, entitled "Hybrid Effect of Gas Flow and Light Excitation in Carbon/Silicon Schottky Solar Cells," investigated the behavior of carbon/silicon solar cells, how the presence of gas flow results in enhanced cell efficiency and how the cells could then act as improved gas flow sensors.

Using a solar simulator, Mulligan and his team shined artificial sunlight on a series of solar cells to obtain a source of power, or voltage. They then blew gas, such as nitrogen, over the solar cells and noticed that their temperature lowered. This lower

temperature, in turn, increased the solar cell's efficiency by 5–10 percent, which is "quite the jump," he explained.

Mulligan had the opportunity at Tsinghua to assemble the solar cells used in tests, an important aspect to the research's results and success.

"We were specifically working with carbon/silicon cells," says Mulligan. "I would assemble graphene, a flat, single-layer of carbon atoms, onto a silicon wafer. The cells' flat membrane acted as the ideal structure for the tests we were running."

Interest in the use of graphene, first produced in 2004, has exploded in recent years.

"Graphene and nanotubes aren't commonly used today but will increase capability and efficiency years down the road in the industry," says Mulligan. "It was like experimenting with new technology."



*Stephen Mulligan, a UD senior, has co-authored a paper in the *Journal of Materials Chemistry* that investigates the beneficial effects of nitrogen gas flow on solar cells.*

Mulligan's co-authors were Bingqing Wei, ME professor and his UD advisor; Hongwei Zhu, Mulligan's advisor abroad and laboratory supervisor; and Guifeng Fan, a doctoral student at Tsinghua University.

*Adapted from an article by Zac Anderson*



## International Classroom

### Global exchange program builds cultural diversity in engineering

In December 2011, University of Delaware and Peking University (PKU), also known as China's Harvard, signed a Global Educational Exchange Initiative (GLOBEX) aimed at building cultural diversity in engineering.

Last summer, engineering faculty and two engineering undergraduates participated in the inaugural GLOBEX exchange.

Mechanical engineering professors Michael Santare and Bingqing Wei, and Babatunde A. Ogunnaiké, interim dean of the College of Engineering, taught a four-week summer course, while the students took courses offered by UD faculty, PKU's other GLOBEX partners or elective PKU courses related to Chinese language, history and culture.

"This unique program provided me the opportunity to work with people around the world. We all had different cultural backgrounds, customs, mannerisms and languages, but instead of letting them stop us, we turned our differences into advantages," explained Devon Bond. The biomedical engineering major took courses alongside students from Chile, Japan and China, along with fellow Blue Hen Yingshuo Fu, a mechanical engineering student.

Santare described Beijing as a vibrant city in which to live and work—for both students and faculty. "I was particularly impressed with the students, and I think it was a great cultural and intellectual experience for them to live and study together," he said.

Developed as a two-way exchange, UD welcomed three students from PKU's College of Engineering as full-time exchange students this spring under the GLOBEX initiative. Yimin Liu, Jianzhou Lu and Ren Yang are all from PKU where they are studying energy and resource engineering,

theoretical and applied mechanics and engineering structure analysis, respectively.

Lian-Ping Wang, professor of mechanical engineering, who spent a significant part of his 2009–2010 sabbatical working at PKU with Prof. Shiyi Chen, dean of the College of Engineering, lauded the exchange program's benefits.

"Exchanges like GLOBEX are opening doors to mutually beneficial collaboration. For me personally, my sabbatical visit has resulted in four published papers in high impact journals on the simulation and analysis of highly compressible turbulence," Wang said.

*Article by Karen Roberts*

## Grad Students

### Put a cork in it: UD research team studies cork-based sandwich composites

Cork, known for its use in such low-tech applications as wine bottle stoppers and bulletin boards, now shows promise as the core material in composite sandwich structures for use in high-tech automotive, aircraft and energy applications.

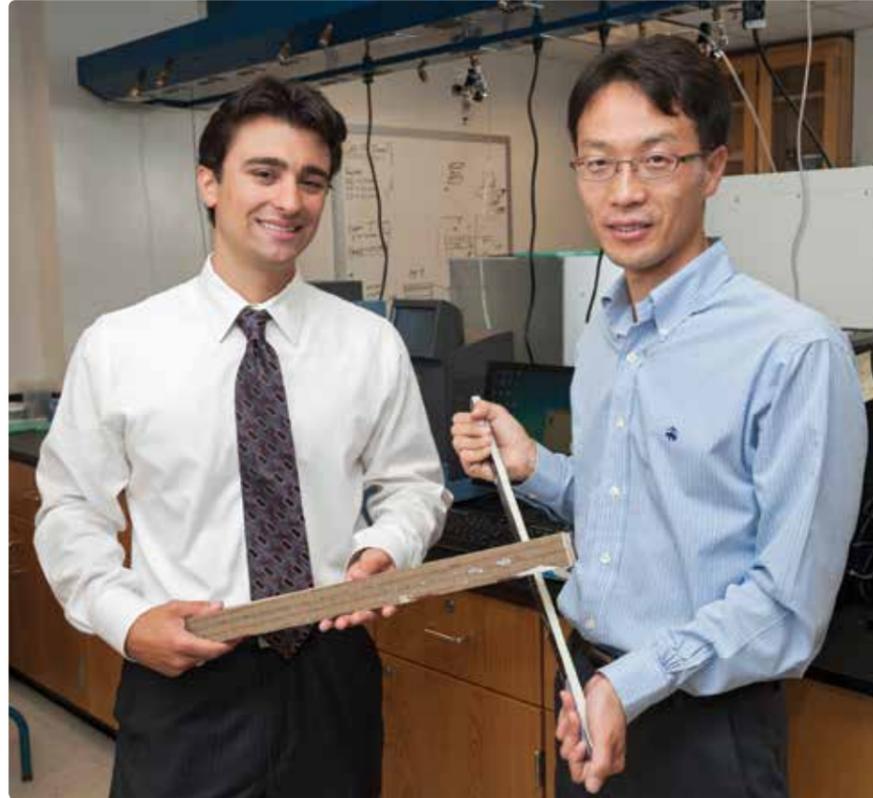
A UD research team investigating this natural material as an environmentally friendly solution for quiet sandwich composites published the work in *Scientific Reports*, an online, open-access research publication.

“Cork is energy absorbing, tough, lightweight and impact-resistant, and it has excellent vibrational and acoustic damping properties,” explains Jonghwan Suhr, assistant professor and an affiliated faculty member in the Center for Composite Materials (CCM). “Its unique cellular arrangement also results in good thermal properties, and it’s impermeable to moisture.”

Suhr was adviser to the lead author on the paper, James Sargianis, who completed his master’s in 2012. The third team member was Hyung-ick Kim, a postdoctoral researcher with CCM.

Sargianis’ graduate research focused on exploring natural material-based sandwich composites with enhanced noise mitigation. Cork turned out to be one of the most promising alternatives to traditional sandwich structures.

Composite sandwich structures—typically made from synthetic foam cores or honeycomb materials bonded to carbon-epoxy face sheets—are commonly used in aerospace applications because they offer high bending stiffness and are lightweight. However, they also radiate noise, an



*James Sargianis and Jonghwan Suhr*

undesirable feature in an airplane. The current solution is to line the interior with four to six inches of glass fabric, but this increases weight and reduces space inside the cabin.

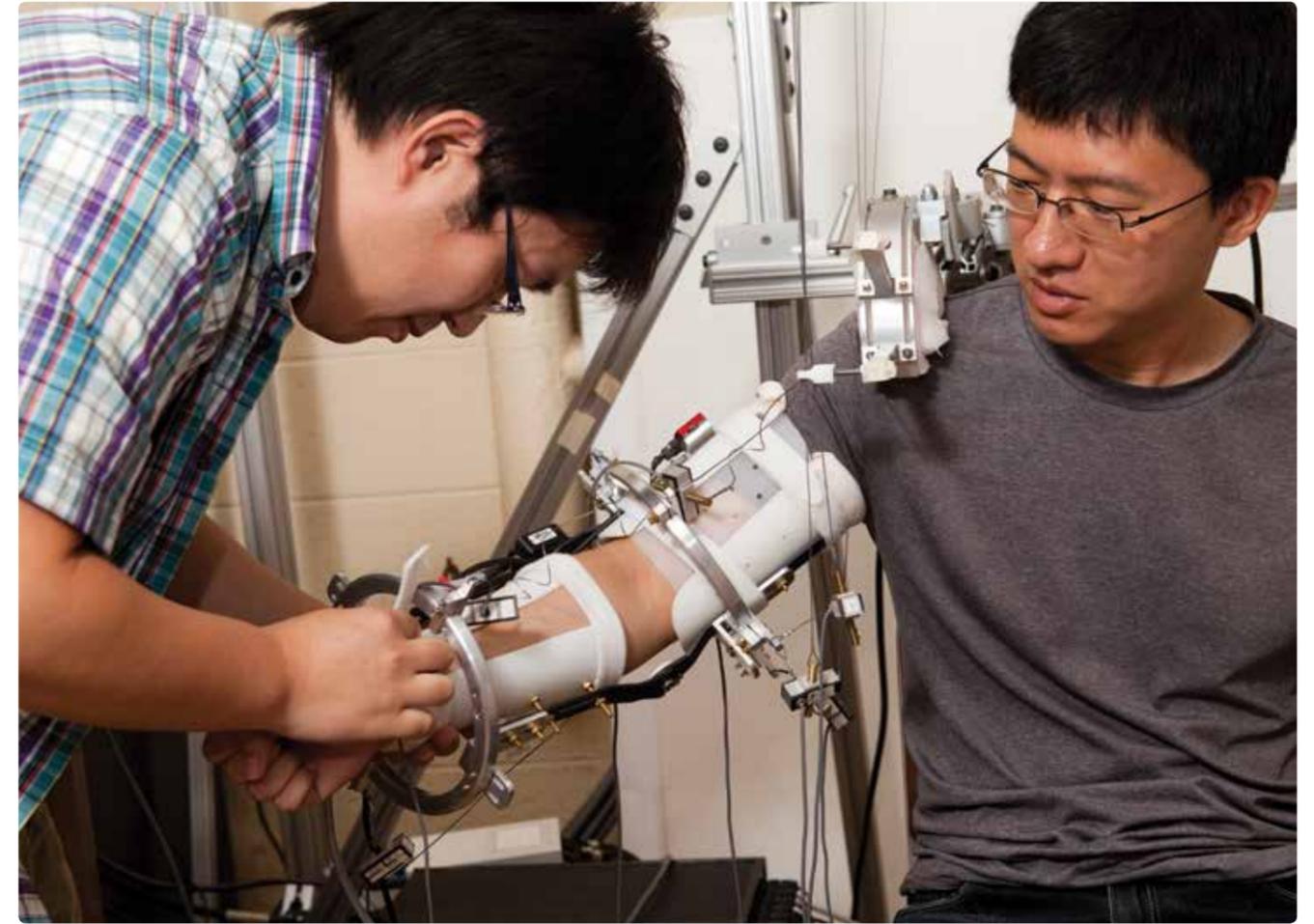
Enter cork as the new core for the sandwich.

The UD team compared sandwich structures made from a natural cork agglomerate core with those using a core made from a high-quality synthetic foam called Rohacell. Carbon-epoxy was used as the face sheet material with both cores.

“We achieved a 250 percent improvement in damping performance using the cork-based materials, with no sacrifice in mechanical properties,” Suhr says. “Further, cork radiates little to no noise and is inexpensive. It’s also sustainable and environmentally friendly because there are no carbon emissions associated with its production.”

Suhr sees the potential for application of cork-based sandwich structures in not only aircraft cabins, but also car engine mounts, launch vehicle fairings and wind turbine blades.

*Article by Diane Kukich*



### IEEE recognizes doctoral student’s robotics work with ‘Best Paper’ award

ME doctoral student Ying Mao earned the “Best Student Paper” award among 800 entries at the 2012 IEEE International Conference on Robotics and Automation. His paper is titled “Transition from Mechanical Arm to Human Arm with CAREX: a Cable Driven ARm EXoskeleton (CAREX) for Neural Rehabilitation.”

Previous arm exoskeleton designs used an anthropomorphic mechanical arm attached in parallel to the human arm to help patients regain neuromuscular functions in the arm following stroke. By replacing mechanical links and joints with cables,

Mao created CAREX, a system lighter than conventional exoskeletons, which makes agile arm movement possible, and does not require joint alignment between the patient and the machine.

“One of the fundamental challenges of cable-driven exoskeletons is to deliver training forces in all directions to the patient while maintaining tension on all of the cables,” Mao said.

If a cable becomes slack, researchers can lose control of the system. To tackle this problem, Mao “optimized the cable attachment point”—a mechanical change to the exoskeleton that is done before being used on a patient. He then developed a planner to calculate positive cable tensions

*Ying Mao (left), a doctoral student studying mechanical engineering at the University of Delaware, earned the “Best Student Paper” award at the 2012 IEEE International Conference on Robotics and Automation.*

while maintaining the proper force on the patient during training.

“Cable-driven exoskeletons offer a paradigm shift in the field of functional rehabilitation and we are currently exploring the use of CAREX with researchers at Rusk Rehabilitation Center of NYU,” said Sunil Agrawal, former UD ME professor

*Adapted from an article by Karen Roberts*

## Q&A with alumnus Paul N. Costello, ME66



Paul N. Costello, ME66 enjoyed a successful 37-year career with the DuPont Company. Now retired, he is president and principal consultant of Evergreen Management Consulting, Inc., in West Chester, Penn., where he helps organizations develop successful business strategies and cope with challenging environmental, competitive and regulatory issues. Financing his education took “tremendous work” and involved help from many sources. Now, Costello explains why he is using his success to help others.

### How did UD prepare you for your engineering career?

My career began in technical service and engineering, but transitioned to marketing and sales, and then on to general management. My UD engineering courses taught me how to conceptualize problems, break them down to their root cause and establish a plan for effective resolution. This was particularly useful when I was a senior business consultant. While I could not be an expert in every industry or business, by working with and listening to the people involved, I could determine the areas of vulnerability and strength, and help devise strategies to be more competitive.

### What are the key skills engineering students need to succeed in the workforce?

Engineers need the ability to understand and conceptualize problems, to devise successful strategies around those problems, and to see areas of opportunity. We must also think systemically—how operating on one part impacts the entire system. This requires discipline, organizational skills, analytical skills

and judgment. Communication, both written and verbal, is also important. You can do the correct analysis and come up with an outstanding plan, but if you can't communicate it, you can't sell it.

### You recently created an endowed undergraduate scholarship in mechanical engineering. What inspired your gift?

My family did not have the financial means to support my college education, and while I worked during high school to save money, it was by no means enough. I was fortunate to receive a Union Carbide scholarship, an NDEA loan, and to find on-campus work as a dormitory floor advisor, and then as an assistant dormitory director. I held part-time jobs at breaks and over the summers, too. All of this enabled me to complete my engineering degree in four years and to achieve a satisfying career and life.

When I look at the cost of college today, I find it staggering. I believe this country needs the discipline, problem solving capability and innovation that an engineering background brings. We need more engineers and technically trained

people. I got a boost when I was starting out, now I am in position to help others achieve their dreams.

### How would you encourage fellow alumni considering reconnecting with UD?

While I contributed to UD over the years, I never really got involved until retirement. The ability to witness how the university has grown; the opportunity to see current students and learn what motivates them; and the chance to renew old acquaintances is very rewarding. UD was an early part of my life and made a strong contribution to my success. Reconnecting with it towards the end brings me full circle.

### What career advice do you have for students or fellow alumni?

Always strive for continuous improvement; never be satisfied with the status quo. Treat everyone you meet with respect. Relationships are very important. It is rare that you achieve success without the help of others; make sure to recognize your help. And finally, give back to the community in which you work and live in whatever way you can.

## Careers celebrated and anticipated



### April 26 Career Celebration & Senior Appreciation gathering puts new twist on two popular UD events

In a new twist on two popular UD events, the Department of Mechanical Engineering will host a joint Career Celebration and Senior Appreciation event Friday, April 26 at Clayton Hall. The program begins at 3 p.m.; cocktails and networking start at 5:30 p.m. and dinner will be served at 7 p.m.

The combined festivities wrap the Senior Appreciation Dinner, previously held in the winter months, and the Career Celebration, centered on the prestigious Distinguished Career Awards that was previously held during Alumni Weekend in June, into one exciting afternoon and

evening. The new format allows senior ME students and their parents, faculty, alumni and senior design sponsors to network in a casual, celebratory manner; recognize career success of our new class of Distinguished Career Alumni (see page 32); and celebrate the vibrant future of our outstanding senior students as we recognize our Senior Design teams and acknowledge the industry sponsors who provide them with invaluable real-world engineering experience (see page 21).

**Alumni—this is a tremendous opportunity to reconnect with the department, network with other alums and industry leaders, and to discover partnering opportunities, career and educational support services available through UD.**

### Program highlights:

- A look at key mechanical engineering research initiatives with department chair Suresh G. Advani
- Senior Design highlights and presentation of the ASME Award for the Outstanding Project 2012
- Presentation of student honors and awards
- Distinguished Career Award presentations and panel discussion
- Networking cocktail party and full dinner



### Keynote address to be presented by 2005 Distinguished Career Award honoree John S. Thackrah, ME79

Executive director of the U.S. Navy's Military Sealift Command; former principal deputy of the Navy's Strategic System's Program, acting assistant secretary of Research, Development and Acquisition and deputy assistant secretary of management and Budget; and senior executive at United Technologies Corporation.

# Distinguished Career Awards

Four distinguished alumni will be honored at the Mechanical Engineering Career Celebration & Senior Appreciation on April 26, 2013. Alumni are selected for recognition based on several criteria, including achievement, impact, uniqueness and interest.

## Ellen Fletcher Benedict (ME75)

Ellen Fletcher Benedict is a self-described strategic architect for health care programs that take incubator projects from ideation to reality. Currently the director of Strategy and Business Programs for Global Oncology Care, Philips Healthcare in Andover, Mass., she uses her expertise in business analytic modeling, market research, segmentation and analysis, strategy and execution, product management, medical science, Six Sigma (she's a black belt) and biomedical engineering to translate the needs of medical care providers into products and solutions that improve patient care.



Following her bachelor's degree in mechanical engineering from UD, Benedict earned a master of science in biomedical engineering from Rensselaer Polytechnic Institute, which included a two-year clinical internship at Hartford Hospital. She launched her career as an engineer, but it was during her time with Hewlett-Packard/Agilent Technologies that she transitioned to the marketing side of the business.

She says her engineering background has proven valuable throughout her career, even as she transitioned to marketing/business strategy responsibilities. Skills that served her well include analysis and problem solving, the ability to understand and evaluate complex new technologies and the ability to work effectively with engineering professionals on cross-functional teams.

This member of the chairman's Advisory Council for UD's mechanical engineering credits Jack Vinson, UD H. Fletcher Brown Professor Emeritus, with being particularly supportive in offering encouragement and solutions to help her persevere in completing her undergraduate degree.

She recalls the most challenging undertaking of her career as establishing the marketing function at a medical device start-up that was developing an optical detection method for cancer diagnosis based on UV fluorescence, white light backscatter and image analysis techniques. Personally, she cites partnering with her electrical engineering husband in raising their now 16-year-old son to be a caring, tolerant person who is an enthusiastic learner as her greatest achievement towards making a difference in the world.

## Brian R. Scott (PhD84)

Major USAR (ret.) Brian R. Scott—today the U.S. Army's most senior researcher dealing with composite armor materials—spent much of the late 1970s and early 80s developing higher performance warheads, studying composite materials and working as part of the design team for the M1 battle tank armor. He provides a rare example of a non-traditional military career, still maintaining his commission in the Ordnance Corps.

He redesigned high-temperature carbon composite rocket nozzle sections with Morton Thiokol, then accepted a



position with the DuPont Company as technology manager of armor systems, where he was responsible for textile, ceramic, organic fiber reinforced laminates, explosives and explosive systems. With the end of the Cold War, DuPont shut down its military explosives business and Scott was transferred to the company's Kevlar business in Richmond to focus on body armor. There he developed helmets, vests and spall liners for vehicles. He

was transferred back to corporate engineering in 2001 and retired from DuPont in 2003.

Scott returned to Army civilian status at the Army Research Laboratory at Aberdeen Proving Ground, where he earned his Ph.D. and now focuses on designing vehicle armors. Throughout his 38 years in this field of non-classical research and development, he has witnessed steel and aluminum give way to fiber-reinforced composite materials for vehicle armor defense systems against warhead threats.

This career ballisticsian with an undergraduate background in physics, mechanics and fluid flow, pursued materials and more advanced methods of solid and fluid mechanics in his doctorate work at UD. He reflects on his good fortune to have been advised by Jack Vinson, who, he says, not only had familiarity with textile-based penetration mechanics, but was also the founding professor of the Center for Composite Materials. Scott acknowledges that what he learned from Vinson and others at UD allows him to advance state-of-the-art in armor technology and improve the survivability of ground troops in both current combat theaters.

## Alfred J. Unione (ME67)

Al Unione's most recent assignment was at the National Energy Technology Laboratory, where he was chief technology officer for Parsons and URS Corporation. For much of his career, this mechanical and aerospace engineering alum worked at Department of Energy National Laboratories in Los Alamos, Idaho and Nevada.

He spent almost four decades in risk management of nuclear plants, in energy and water technology development and in developing the infrastructure to safely and sustainably manage "cold war" nuclear wastes. Today he consults in the nuclear power industry and for the Department of Energy.



Most of his career, which included roles with the federal government, private companies and in academia, was here in the US, but he led energy and risk management projects overseas and even participated in a televised debate on the safety of nuclear power in the Swedish Parliament. He confesses that he has always been attracted to jobs

that are "where the action is," where the problems are large and you can make your contribution.

Career highlights include an early role in developing risk assessment methodology for the design of safer nuclear and high-hazard operations. Currently, he is part of a committee developing codes and standards for hydrogen systems, and serves on a team adapting NASA Technology Readiness metrics to Department of Energy research activities. He was also part of a team recently awarded a patent for a technology enabling methane to be economically stored and transported as an inherently safe and compressed hydrate.

Al and his wife Becky, also a UD graduate, are the proud parents of four daughters and are ready to "entertain" with endless pictures of grandchildren. He fondly remembers his days at UD – walking the campus in early spring, eating in the dining halls and working lots of hours with others on a challenging curriculum that became the foundation for his career. In particular, it taught him how to work effectively and to never even think of giving up.

## Jeffrey C. Weil (ME67)

An international expert on atmospheric dispersion, Jeff Weil currently holds joint appointments as a scientist at the University of Colorado and as a visiting scientist with the National Center for Atmospheric Research. Following UD, he earned his master's and doctoral degrees from MIT before spending 15 years with Martin Marietta Laboratories in Baltimore.

Weil made significant contributions to numerical simulation of atmospheric dispersion, buoyant plume modeling and laboratory dispersion experiments and was among the first to address the role of large-scale boundary layer structure on the vertical asymmetry of dispersion. He also developed dispersion models for real-world problems involving stacks, buoyant emissions and turbulence—issues commonly encountered in air pollution, environmental safety and toxics modeling.



He actively supported the dispersion community through leadership roles, lecturing at short courses and as

associate editor of several journals, including Boundary-Layer Meteorology. He organized and/or was an invited speaker for high-profile workshops sponsored by the American Meteorological Society and the Environmental Protection Agency, among others. He also chaired the AMS/EPA committee that developed the EPA's 2005 air quality model, AERMOD, routinely used in the U.S. and abroad for industrial source applications.

Weil built his career on the traditional mechanical engineering training gained at UD, and by integrating theory, numerical simulations and experimental observations, has extended it to address the interdisciplinary and complex field of environmental fluid mechanics and pollution.

He enjoys skiing, backpacking the Rockies, Alaska and Patagonia, and is an avid road cyclist and participant in the annual fundraiser for CU's scholarship program. He usually commutes to work by bus, foot or bike.

He recalls pulling his first "all-nighter" to finish designing an environmental control/ventilation system for a manned space capsule that came in "only inches from first place," according to senior design advisor Dr. Costello. It was a rewarding experience that made Weil think about technical management—until he got "hooked" on research.

## Designs on the Future



The Design Studio project proposed for Spencer Lab (see article on next page) has the potential to raise the experiential bar for UD's mechanical engineering undergraduate students in new and spectacular ways. In a very real sense, the project mimics the concept behind the ISE Lab\*, our nearly completed teaching and research facility a few buildings south of Spencer Lab on Academy Street. The ISE Lab will transform science and engineering education at UD in ways that will draw greater numbers of students to Delaware to study science, technology, engineering and mathematics. Mechanical engineering's Design Studio has the same potential—to transform undergraduate education by integrating collaborative and relevant learning experiences. This is how today's students learn, and how we hope to train tomorrow's mechanical engineers.

The style of traditional learning that most of us remember—sitting in the classroom, taking notes and memorizing concepts—is being replaced by interactive opportunities allowing students to tackle projects directly relevant to today's environmental, energy and materials challenges. The goal is for students to develop workable solutions that translate into a better world. The education model becomes one that is practical, applicable and current.

The Design Studio, will perhaps be the most important enhancement to impact undergraduate mechanical engineering education in decades. Just a few universities have taken the all-important step to transform how mechanical engineering is taught in their institutions. Stanford University's Design School and Penn State's Learning Factory are among the first, and the concept is already proving to be a competitive offering to incoming freshmen.

This is an opportunity for charitably inclined alumni to directly support the education of tomorrow's mechanical engineers, in ways much like a scholarship gift. Fortunately, the entire Design Studio project can be accommodated within the existing Spencer Laboratory. We have a number of affordable "naming opportunities" tied to the actual spaces within the studio. If you are interested in helping the mechanical engineering department bring this project to fruition, please contact the Engineering Development Office at (302) 831-6892. Your gift will help us create an environment designed for the way students learn best today, and prepare them to be the engineering leaders of tomorrow.

**Armand Battisti**  
Director of Development

\*Interdisciplinary Science & Engineering Laboratory ([www.udel.edu/iselab](http://www.udel.edu/iselab))



## Creating the ultimate engineering playground

[Design Studio promotes collaborative hands-on learning environment](#)

The mechanical engineering department's new Design Studio conceptual plan for renovating Spencer Lab positions the University of Delaware among the nation's earliest to offer a transformative undergraduate experiential learning approach that is capturing the attention of both potential students and industry experts looking to hire better engineers.

The plan involves renovating 5,900 square feet of laboratory space on the first floor of Spencer Lab to serve as dedicated design,

prototyping and teaching laboratory space for undergraduate mechanical engineers. The project will also include purchasing a high resolution 3-D printer and scanner system, upgrading computer-aided manufacturing equipment in the student shop, and acquiring multiple sensor and measurement systems for laboratory instruction and student exploration.

"The Design Studio takes UD Mechanical Engineering to another level in terms of undergraduate education. It builds on our existing strengths in design education by giving our students a space to get hands-on and be creative," shares assistant professor Jenni M. Buckley, who adds, "Engineers nowadays need to be flexible and work in teams to move quickly from concept to working prototype. The Design Studio will give us the space—literally—to develop this type of engineering talent."

Proposed renovations include open-access student design and fabrication space; multi-use laboratory workstations; and informal teaching and demonstration areas with fully stocked materials and tool libraries. The concept integrates project management, prototyping and experimentation stations and provides space and equipment resources, all in a collaborative team-building environment. Key to its success is intensive collaboration among students, faculty, alumni and industry.

"The Design Studio will be the ultimate engineering playground," Buckley predicts. "Ten or 15 years from now, our alumni will think back on their UD ME experience and say, 'that program made me the creative, entrepreneurial person that I am today.'"

# Thank you alumni donors!

We wish to thank the many friends and alumni who have made generous contributions over the past year. Your gifts are used for many worthwhile purposes, including support of our research and educational programs. To make a donation, please visit UD Connection ([www.udconnection.com](http://www.udconnection.com)) and click Donate Today. If you wish to designate your gift to ME, select other from the list provided, then specify Mechanical Engineering.

July 1, 2011–June 30, 2012

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