FALL 2015 | Vol. 15, No. 2

E@M

THE MAGAZINE OF THE A. JAMES CLARK SCHOOL *of* ENGINEERING

MEET THE MAKERS

Clark School researchers at the front lines of the additive manufacturing revolution

What's on the cover?
A motor-driven Crank-and-Slider mechanism made from 3-D printed pieces that snap together.

FEATURE

DEPARTMENTS

PHOTO CREDIT: MIKE MORGAN

> ***"The Clark School has placed a priority on providing its students with hands-on 3-D printing experience."***

Dear Friends of the Clark School,

At the Clark School of Engineering, a chorus of 3-D printers provides a new—and somewhat tuneless—soundtrack for creativity. In our newly established MakerBot Innovation Center, students and faculty from the Clark School and all over campus are using the center's 52 3-D printers as instruments to bring their ideas to life.

The opening of this center in April marked the beginning of a new era for the Clark School and the entire University of Maryland community, launching us into the next industrial revolution: 3-D printing, advanced, and additive manufacturing.

In his 2013 State of the Union address, President Barack Obama cited 3-D printing as a technology "that has the potential to revolutionize the way we make almost everything." In Youngstown, Ohio, America Makes, the flagship institute for the National Network for Manufacturing Innovation (NNMI), is bringing together academia, industry, government and non-government agencies, and workforce and economic development resources to help the U.S. manufacturing industry advance its competitiveness in the global market.

Engineers worldwide—Clark School students and faculty included—have the opportunity to make waves in this burgeoning field, with the ultimate goal of tackling the grand challenges of the 21st century.

To ensure our graduates are prepared to join this revolution, the Clark School has placed a priority on providing its students with hands-on 3-D printing experience, and as of this year, freshmen are getting that experience within the first few weeks of their required first-year course, an Introduction to Engineering Design.

In the following pages, you will meet several faculty who have joined the maker movement. From 3-D printed sprinkler nozzle prototypes to software aimed at finding the nexus between design and manufacturing, our researchers' creations exemplify the imagination unleashed in the virtually boundless realm of the next industrial revolution.

Darryll J. Pines

Darryll Pines
DEAN AND FARVARDIN PROFESSOR OF ENGINEERING

Engineering @ Maryland is published twice a year for alumni and friends of the A. James Clark School of Engineering and the Glenn L. Martin Institute of Technology at the University of Maryland.

Letters to the editor and alumni notes are welcome. Please send them to ***Engineering @ Maryland*** Editor, 3228 Kim Engineering Building, 8228 Paint Branch Drive, College Park, MD 20742-2831. Information can be sent by fax to 301.314.6868 or by e-mail to ecarbo@umd.edu.

Please note that ***Engineering @ Maryland*** refers to the A. James Clark School of Engineering by that name in all cases, including stories that describe alumni who graduated before the name was established, in 1994, to honor Mr. Clark's outstanding philanthropy.

E@M

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MEET THE MAKERS

MARK FUGE WITH STUDENTS.

PHOTO CREDIT: MIKE MORGAN

When Assistant Professor Mark Fuge scans a crowd of strangers, he sees the next generation of engineers. On a mission to make that dream a reality, he researches solutions to one fundamental question: "How do we bring design and engineering to as many people as possible, from my 3-year-old nephew to my 90-year-old grandma?"

Welcome to the maker movement, a revolution to empower more people to design, build, and innovate. It is also an opportunity to bring the power of engineering to learners of all ages, and transform the way engineers create, iterate, and teach. "I think of the maker movement as the gateway drug for engineering," said Fuge, who joined the mechanical engineering department at the University of Maryland A. James Clark School of Engineering in 2014. "You're not going to build a jet engine with a 3-D printer you can get for a hundred dollars, but it could be a portal to get interested in STEM topics."

Fuge contends that many people don't have the time or background to learn the requisite engineering tools and theory to freely innovate. His goal is to break down those barriers. He compares 3-D printing to the evolution of 2-D printing, which transitioned from the manually maneuvered Gutenberg press to the dawn of word processing software that turned consumers into makers.

"When you think about the value of a home printer, it isn't necessarily in the ability to download great works of Shakespeare to print—it's in home publishing," Fuge said. "Microsoft Word gave people the agency to create something of value without having to worry about typographic complexities. We're trying to do the same sort of thing for 3-D printing."

His group's research on 3-D-printed mechanisms—from walkable robots to prosthetic hands—focuses on customization capabilities across many platforms. Fuge's lab has created a printable mechanical part that is designed to evaluate the capabilities of an individual's printing equipment. Anyone with a 3-D printer can download and print this part, which Fuge describes as a nesting doll of sorts, and then follow instructions to place the printed object into a simple household solvent. At this point, certain parts of the object will dissolve, depending on the mechanical capabilities of the printer. The user simply enters what they observe—which pieces remain fused, which ones fell off—into Fuge's system, the "MechProcessor," which is like a word processor for mechanics.

Because of key mechanical information embedded in the part, the system can automatically create printing specifications based on that particular printer's capabilities and limitations. "Through our algorithms, we can optimize a design so that it will print correctly on your specific printer," Fuge said. "We're connecting the thread between design and manufacturing capabilities."

All around the University of Maryland campus, faculty and students are imagining novel solutions to real-life challenges, from vascular grafts and prosthetics to wearable electronics and car parts. Better yet, they're turning those ideas into innovations, and they're doing so quickly and efficiently thanks to the powers of automation, 3-D printing, and additive manufacturing—the process of making objects from layers of 3-D modeling.

> "I think of the maker movement as the gateway drug for engineering."

GETTING A LEG UP

Just across the street from Fuge's lab, Sarah Bergbreiter is running robot trials at the University of Maryland Microrobotics Laboratory. Four cameras point at a runway, capturing the movements of the ant-like robots. These miniature models range from a few millimeters to a couple of centimeters. Rather than practicing their slow sashay down the catwalk, they run or jump up to several body lengths per second.

In these simple machines, Bergbreiter sees limitless possibilities. The associate professor of mechanical engineering imagines dispatches of microrobots navigating rubble in the aftermath of a disaster, searching out survivors and toxic chemicals. She predicts swarms of robotic bugs building complex structures, akin to the towering mounds erected by termites in places such as Africa and Australia. She envisions the tiniest of robots attached to a pill deployed for surgery inside a patient's body. "There are a lot of fantastic and seemingly far-out-there things you can do once you have functional, well-integrated structures at this scale," Bergbreiter said.

Fast and nimble, jumping over hurdles to lead the pack—Bergbreiter's ground-breaking robots could double as a metaphor for the maker movement's growing ascent across the country.

In June of 2014, President Obama hosted the first-ever White House Maker Faire, part of a National Week of Making that issued a call to action that "every company, every college, every community, every citizen joins us as we lift up makers and builders and doers across the country." In response, the Association of Public and Land-grant Universities—of which the University of Maryland is a member—pledged public support to the initiative. The University of Maryland also joined more than 150 other educational institutions in a formal commitment to promote and encourage making on campus.

The White House also issued a report that asserted that the "ability to rapidly and affordably test, tinker, monitor, and customize…opens new doors to entrepreneurship and innovation in manufacturing." For example, additive manufacturing has been found to lower the cost of designing and prototyping automobile components by up to 99 percent.

In Bergbreiter's lab, 3-D printing encourages rapid prototyping. The latest addition to the lab, the Nanoscribe, expands printing to the submillimeter scale. "The college has made a big investment in 3-D printing, and we are loving it," Bergbreiter said.

With the help of such micro and nanoscale 3-D printing technology, Ryan Sochol is focused on the marriage between biology and engineering, creating biomimetic "organ-on-a-chip" living systems in his Bioinspired Advanced Manufacturing Lab.

Traditionally, these systems are fabricated in a controlled clean lab, and after several hours and hundreds of dollars, the result is a flat, 2-D representation of an organ system. The problem lies in the fact that the architecture of an organ system isn't flat.

"There is no better solution than 3-D printing for solving today's most pressing mechanically and physically-complex biological challenges," said Sochol, who has developed a 3-D printed, microscale kidney-on-a-chip system to determine if architecture affects cell behavior. "In the time it would take me to suit up in a hairnet and booties for the clean lab, I could have already begun printing a tubule structure at the scale of what you'd find in the human kidney."

With the time and cost-saving benefits of 3-D printing technology, new parts and design elements are only a mouse-click away.

"We can print a bunch of new leg designs at once, try them out quickly, go back and play with the model some more, and iterate through the cycle again in the matter of a couple of days. In the past that process would have taken months," said Bergbreiter.

LAST SPRING, THE A. JAMES CLARK SCHOOL OF ENGINEERING UNVEILED THE UMD MAKERBOT INNOVATION CENTER


PHOTO CREDIT: MIKE MORGAN

The first large-scale 3-D printing center of its kind in the region and one of only a few such university-based centers in the in the world, the MakerBot Innovation Center serves as a catalyst for exploring new ideas quickly and efficiently because anyone on campus can upload and send their projects remotely to the center's 50-plus 3-D printers. According to MakerBot, it is the most active of its centers, with over 20,000 hours of print time and more than 190,000 grams of material under its belt.

The MakerBot Innovation Center is the newest of a growing crop of spaces where students can try new equipment and experiment with a variety of materials—from 3-D printers to vinyl cutters and soldering kits—including the John and Stella Graves MakerSpace in McKeldin Library. Engineering faculty and students have access to six locations and 21 different kinds of digital fabrication tools, all housed under Terrapin Works, a collection of digital manufacturing resources provided as a service to the Clark School and the surrounding community.

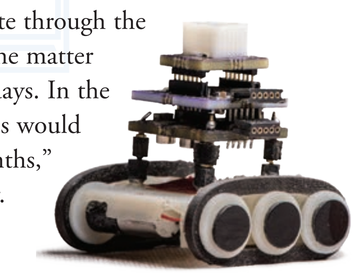
The projects created in these spaces are more than pipe dreams: More than 60 student-founded startup companies have launched from the Startup Shell, a student-run co-working space and incubator headquartered next door to the MakerBot Innovation Center.

SARAH BERGBREITER HOLDING A MICROROBOT.

PHOTO CREDIT: MIKE MORGAN


PHOTO CREDIT: ELISE CARBONARO

RYAN SOCHOL WITH A 3-D PRINTED TUBULE.



> “In essence, we can paint a nervous system on any robot.”

Like many scientists, Bergbreiter follows cues from nature to build her creations. “Existence proof,” as she calls it, motivates her to develop sensors and controls that will equip her microrobots to react to their environment, just as any autonomous creature would.

Such natural sensing capabilities form the basis of the pioneering work led by Department of Mechanical Engineering Professors Elisabeth Smela, Hugh Bruck, and Miao Yu. Funded by a National Science Foundation National Robotics Initiative award, the group is creating a smart skin that can revolutionize the way we interact with robots.

“Instead of programming robots, we would like them to sense our touch while we guide it through a task in order to train it, the same way you might teach someone to play a piano or to swing a golf club,” Bruck said.

“Envisioning robots of the future, we imagine them working alongside humans,” Smela explained. “If we want robots to interact with people, especially in settings like hospitals, they’re going to need to be soft, or padded—not rigid with the possibility to injure us—and they will need to be able to sense their surroundings by touch. Sensing skins enable robots to have tactile information about their environment, and enable them to tell the difference between a sharp needle and a hot iron.”

The sensors used on the stretchable skin under development by these three colleagues and their students can be sprayed on like paint—it is a composite of exfoliated graphite carbon nanoparticles in latex that is lightweight, compliant, and electrically conductive. Because of their unique approach, the material can be applied to large areas as a coating and can be used to retrofit existing robots. With the addition of this new skin, old robots would have the power to more safely coexist and communicate with humans. “In essence, we can paint a nervous system on any robot,” Bruck said.

In a similar vein, the team recently developed a sensing latex glove that can perform tasks such as reading Braille, enabling robots to see by touch.

While Bergbreiter relies on 3-D printing for rapid prototyping, Smela and Bruck look to expand additive manufacturing capabilities through their work. According to Smela, because the skin is applied as a material layer, it could be incorporated into 3-D printing processes to enhance the functionality of a variety of products.

“We’re making technologies that are robust for use in the real world, where things are going to crash and bump and fall into things,” Smela said.

PHOTO CREDIT: MIKE MORGAN

HUGH BRUCK TRIES ON THE SENSING GLOVE WITH THE HELP OF MIAO YU.

PHOTO CREDIT: MIKE MORGAN

ELISABETH SMELA HOLDING EXFOLIATED GRAPHITE CARBON NANOPARTICLES.

SECOND NATURE

PHOTO CREDIT: MIKE MORGAN

ANDRE MARSHALL DEMONSTRATES AN ENHANCED SPRINKLER SYSTEM PROTOTYPE (UPPER RIGHT).

LIFE ENGINEERED

3-D printed robots have not come to a household near you, but advancements in additive manufacturing by Clark School faculty could soon be part of the safety equipment right above your head.

As the director of the University of Maryland's Fire Testing and Evaluation Center, Associate Professor Andre Marshall specializes in technologically enhanced sprinkler systems that minimize fire damage and protect people.

When safety is the goal, time is always of the essence. "Speed is important—but it's not just the speed of making something, but also the speed of taking something from concept to physical product," Marshall said.

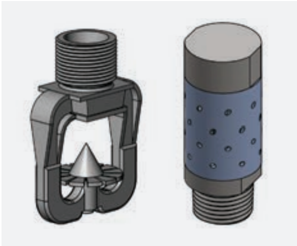
Conventional testing systems for sprinklers typically require filling an empty room with buckets to measure water dispersion. Sound old-fashioned? It is. Conversely, Marshall's patented, laser-based diagnostics methodology joins forces with simulation technology to virtually predict water dispersion.

> "The public has a right to the most advanced technology applied to their safety."

Marshall also relies on 3-D printers to quickly make prototypes, such as novel sprinkler heads with rotating parts. Standard sprinklers feature notches that disperse a universal jet of water, while the latest sprinklers developed by Marshall's team—and commercialized by the company he owns with two fire protection engineering alumni, Custom Spray Solutions—incorporate targeted holes surrounding a rotating shaft of water. The result is more efficient water delivery.

"The public has a right to the most advanced technology applied to their safety," Marshall said. "Without 3-D printing, the process would be slow, expensive, and limited by the manufacturing process in thinking of new ways to more precisely design targeted water pathways."

After all, according to Marshall, the issue of fire suppression will never extinguish itself. "Fire was a problem 2,000 years ago, and 2,000 years from now it's still going to present a challenge," Marshall said. "It's exciting to transform discoveries into technology that has a real impact on society."



LEFT, STANDARD SPRINKLER HEAD
RIGHT, ROTATING SHAFT SPRINKLER HEAD

MAKING FOR SPACE

PHOTO CREDIT: NASA - BILL STAFFORD

SPACE SYSTEMS LAB GRADUATE STUDENTS TESTING A SPACE MANIPULATOR ON BOARD NASA'S ZERO-G C-9B AIRCRAFT.

An early adopter of 3-D printing, Professor Dave Akin is known as one of the Clark School's original makers. It all started in the mid-1990s, when Akin purchased an early 3-D printer to advance the work of his Space Systems Laboratory (SSL). While the device was the size of a large cabinet, the build volume was smaller than many consumer units today.

The plastics most commonly used in 3-D printing lend themselves well to designing and testing products for space.

"Plastic is fairly neutrally buoyant," said Akin, meaning that the objects he prints tend to stay suspended in the water, rather than floating or sinking in the SSL's Neutral Buoyancy Research Facility, one of two operating neutral buoyancy tanks in the United States and the only one located on a college campus. Neutral buoyancy is considered a gold standard for simulating weightlessness.

"We have a complete prototype of a space manipulator that's made entirely of 3-D printed parts, " said Akin. These robotic manipulators are used in space to launch satellites, perform maintenance, and move cargo. "In design engineering, the ability to build an early prototype is invaluable."

Two decades after removing his first print from a build plate, Akin's next goal is to meet the environmental qualifications to send his creations to space.

LEADERS IN THE MAKING

At the helm of the maker revolution is the next generation of Clark School graduates. Indeed, even as the process becomes democratized, the need for experts in additive manufacturing has never been more critical. Students at the Clark School are jumping right into the mix.

In the newly structured curriculum for an Introduction to Engineering Design (ENES 100), a first-year course within the Clark School's Keystone Program, all 600 or so incoming engineering students form multidisciplinary teams to design, build, and test an autonomous over-sand vehicle. Each group's end result must meet a set of challenging product specifications, from navigating sandy terrain to checking the salinity and depth of a water pool. As of last year, that process has added the use and manipulation of 3-D printers, teaching students how to link computer-aided drafting (CAD) with additive manufacturing from the launch of their university experience.

"We're enabling first-year engineering students with a really powerful tool from the outset of their education, so that they can realize their own products early on," said Keystone Instructor Kevin Calabro. For starters, students learn how to draw a wheel using CAD, then another team member must take that design and print it. Over the course of the first few weeks of class, every student will have created something on a 3-D printer.

"Students have done absolutely amazing things with the 3-D printers," Calabro said. "The printers allow students to easily construct innovative products that never existed before."

Of course, ENES 100 isn't the only course that encourages making from day one. Another new course, Introduction to Electrical and Computer Engineering (ECE), takes a similar tack. Professor Romel Gomez, who also serves as the Associate Chair for Undergraduate Education, leads this interactive class in collaboration with several colleagues through a series of key elements of the curriculum. The course takes place in the department's brand new Texas Instruments Discovery Lab, part of a company-level commitment by Texas Instruments Incorporated (TI) to ensure young engineering students are engineering and industry-ready by inspiring them at the inception of their academic careers. Faculty members developed each of the seven hands-on modules that demonstrate applications of ECE in communications, energy harvesting, image processing, brainwaves, Android devices and microprocessors, software design, and controls.

When it's time to teach the basics of control theory, that's when things really get cooking—literally. Like highly trained chefs in a five-star kitchen, students in the course must figure out how to cook eggs in a highly specific way typically reserved for gourmands—slow-cooked to 65 degrees Celsius. To do so, class participants make a sophisticated egg cooker based on the concept of feedback control.

As Gomez—who collaborated with Professor William Levine to design the feedback control module—explains it, students place an egg in a beaker on a heating element that is controlled by a transistor, and measure the temperature of the beaker using a sensor. That measurement is then fed into a micro-controller, which is regulated by software written in MATLAB. The software processes that information and releases a signal to control the amount of power supplied to the transistor, in effect turning the heater up or down as needed.

KEVIN CALABRO DISCUSSES PROJECTS FOR INTRODUCTION TO ENGINEERING DESIGN WITH AN ENES 100 TEACHING ASSISTANT.

PHOTO CREDIT: MIKE MORGAN

PHOTO CREDIT: MIKE MORGAN

PROFESSOR WILLIAM LEVINE (FAR LEFT) AND PROFESSOR ROMEL GOMEZ (CENTER) DEMONSTRATE THE EGG COOKER USED TO TEACH THE CONCEPT OF FEEDBACK CONTROL.

"Being able to establish a feedback to control something is ubiquitous in engineering," Gomez said. "The same concept applies to cruise control and autopilot. There are probably at least a thousand control systems in an iPhone, from the screen brightness to the autofocus of the camera, and in the circuits that make them work."

Today these students are cooking eggs, but a few tomorrows from now they could be implementing the same fundamental theory to control the systems that fly fighter jets.

SAY YOU WANT A REVOLUTION

Indeed, if Clark School innovations are any indication, makers are revolutionizing daily life. For professors Smela, Bruck, and Yu, their creation of an artificial, sensing skin holds the power to bring together humans and robots. "Our work will enable robots to be more like humans, to sense and feel like we do," Bruck said.

Growing up, Professor Bergbreiter read science fiction novels and built with Legos. Now she's taking real steps toward a future aided by fully functional robots the size of ants—equipped with sophisticated control systems that will enable them to accomplish tasks that humans never could on their own.

As for Fuge, design customization is about more than successfully printing a prosthetic hand at home. "The least sustainable product is the one you make that nobody wants because it doesn't fit their needs, no matter how cool or efficient it may be," he said. "With additive manufacturing, we're literally able to print something to the individual. We've gone from small-scale craft to big industrial copying of parts and, now, a return to customization for certain products. That's the next big industrial revolution."

Sami Khan (right) and Richard Vogel.

PHOTO CREDIT: ALAN SANTOS

Sami Khan: Building His Own American Dream

Sami Khan has a thing for building. After his first year as a mechanical engineering major at the University of Maryland, he explored his love for design in architecture courses before declaring his major in civil engineering. But beyond the physical, building takes on a different meaning for Khan. Since he came to the United States in 2012, Khan has been laying the foundation for his future.

With just one suitcase full of belongings and only a few dollars in his pockets, Khan left his home in Karachi, Pakistan, with one mission: to build a better life for himself and his family.

"Coming to Maryland was my first step in a dream I'd had for many years," said Khan. The conduit for this dream, Khan decided, was education.

He began his educational career in Maryland at Montgomery College, living first with a friend and then with a family whose children he tutored in exchange for his room. After transferring to the University of Maryland in 2013—an important next step in realizing his dream—he was faced with the reality of meager finances.

"Working more than 20 hours per week and more on the weekends, surviving on nothing more than one packet of ramen noodles a day—it wasn't a cake walk in the least," said Khan. "After my first year at the University of Maryland, I was several thousand dollars in debt and 60 pounds lighter than when I first got here."

Shortly before his second year, Khan received an email that would change his life for the better. He had been awarded the Richard and Stefanie Vogel Scholarship. Mr. Vogel, a civil engineering and MBA alumnus who is a senior vice president at The Whiting-Turner Contracting Company, established the scholarship in 2003 to support promising students in the Department of Civil and Environmental Engineering.

"I remember calling my mother back in Pakistan to tell her the news and her voice cracking as she told me to keep studying hard and that I would have a good life ahead," Khan said.

Khan credits the Vogels' generosity to his recent success at the Clark School.

"Their scholarship gift enabled me to focus more on my studies, to pick up my grades, to take more classes, to join more extracurricular activities, and to experience university life to the fullest," said Khan, who received two awards from the UMD Office of Multi-Ethnic Student Education this year for his dedication to tutoring and was invited to join Chi Epsilon, the Civil Engineering Honor Society—honors he never could have imagined just months before. This past summer, he interned at Structural, a specialty contracting services company in Elkridge, Md. He said he also gained back the weight he'd lost when all he could afford was one meal per day.

With the help of the Vogels, Khan got a glimpse of his future as a civil engineer living and working in the United States. Following graduation, he plans to build a career in structural design engineering and within a heartbeat of accepting his first job offer, he'll begin the process of bringing his parents to live with him.

Khan said it's impossible to feel anything but gratitude for the impact of the scholarship he received, not only on himself but also on the entire world.

"I'm just one of countless students in need of financial support to help me reach my academic goals," said Khan. "Scholarships afford bright students who might not have the means to pursue their dreams the opportunity to grow into the leaders of our future, making our world a better place for everyone."

REMEMBERING THE PAST, ENSURING THE FUTURE: Black Engineers Society Founders Give Back

PHOTO COURTESY OF GREG JOYNER

The founders and original members of BES at the CMSE banquet in 1981.

When Greg Butler (B.S. '77) and Greg Joyner (B.S. '78) look back on their undergraduate years at the University of Maryland, both recall the same memory: they were always the only minority in their engineering classes. In interactions with their classmates and faculty, they often felt unwelcome in spite of their academic abilities.

Joyner relied on time between classes to seek support from Butler and other minority students. "After each conversation, one of us would always say, 'Man, we have to do something to come together,'" said Joyner.

A community for engineering students of color was yet to be built, so Butler and Joyner—in collaboration with fellow students Curtis Chapman and Gary White—did what engineers are known for: they found a solution. The four young engineers came together to pioneer the formation of the Black Engineers Society (BES).

With the help of the Center for Minorities in Science and Engineering's former Director James Newton, Professor Emeritus and former Dean George Dieter, and former Associate Dean Marilyn Berman Pollans, the group officially got off the ground in 1976 and today, current BES members uphold the primary mission set forth 40 years ago: to recruit, retain, and release qualified minorities into the fields of science and engineering, or the "3Rs." BES supports these goals through numerous programs, services, and activities aimed at fostering the academic and professional growth of minority science and engineering students.

In honor of the society's upcoming 40th anniversary, Butler and Joyner have joined forces once again to establish the BES Legacy Enhancement Fund, which will support BES students in the Clark School of Engineering.

"Young men and women have the opportunity to further the advancement of our society through engineering principles taught at the University of Maryland," said Butler, who served as the first president of BES and laid the cornerstone on which minority students continue to share ideas, and support and learn from each other. "It is my hope that through BES, engineering students will have the confidence of creating, dreaming, using their imaginations, and building what has yet to be done."

WHITING-TURNER CONTRIBUTES $1.5 MILLION TO RENOVATION INITIATIVE

The Whiting-Turner Contracting Company committed $1.5 million in support of the Department of Civil and Environmental Engineering Infrastructure Laboratories renovation initiative.

The initiative, which will involve a redesign of its physical and virtual facilities, supports the department's efforts to equip civil and environmental engineering students with the resources needed to develop comprehensive understanding of the engineering science behind the systems and structures on which society relies. Students will develop better hands-on understanding of the behaviors of steel, timber, concrete, asphalt, soil composites, and other materials employed in infrastructure design. Additionally, students will master Quality Assurance testing techniques for infrastructure construction and learn cutting-edge nondestructive evaluation approaches for monitoring the structural health of bridges, buildings, and other critical infrastructure assets.

Whiting-Turner's donation will span five years and will help bring to life the department's vision for new, state-of-the-art facilities and laboratory equipment.

"We are proud to partner with the University of Maryland and the Clark School in support of the Infrastructure Engineering Laboratories renovation initiative,"

said Timothy J. Regan, President and CEO of Whiting-Turner, the Chair of the Clark School's Board of Visitors, and a civil engineering alumnus (B.S. '77). "We believe our support will help further the Department of Civil and Environmental Engineering's mission to prepare graduates to be proficient in both analysis and synthesis aspects of civil engineering design and practice."

PREPARING TOMORROW'S ENGINEERS:
A Partnership with Baltimore Polytechnic Institute

Forty miles north of College Park, Md., students at Baltimore Polytechnic Institute—known as Poly—are trying their hand at college-level engineering curriculum, modeled after classes at the University of Maryland. Nestled on a 53-acre campus in Baltimore, its tradition of providing premier STEM education to the city's youth dates back to 1883, but Poly's close relationship with the Clark School of Engineering took root in 2012.

At the time, William Wolfe (B.S. '84) was one year into his role at the helm of Poly's engineering department and he was on a mission to improve the curriculum,

PHOTO COURTESY OF WILLIAM WOLFE

moving from what he called "death by PowerPoint presentation" to a more hands-on, project-based model to get students excited about engineering. With his alma mater in mind, he knew where to go for help.

Over the course of several meetings with the Clark School's leadership, Wolfe and the Poly team transformed the engineering curriculum to emulate the Clark School's, with the ultimate goal of helping students understand what it would take to be admitted to the Clark

PHOTO COURTESY OF WILLIAM WOLFE

School. To give them a taste of what it's like to be a Clark School student, Wolfe loads a bus full of 30 students twice a year to visit Mechanical Engineering's Design Day.

"When the bus pulls up to campus, they think they've gone to heaven," said Wolfe, who polls the students' interest in the Clark School on each leg of the trip. "On the way back to Baltimore I ask, 'How many of you think you want to go here?' and almost everyone raises a hand."

This year, for the first time, students have the opportunity to take ENES100: An Introduction to Engineering Design—a required course for all first-year engineering students—on their campus in Baltimore.

Just five years ago, the students from Poly barely considered applying to the Clark School, but as of fall 2015, more than five students joined its freshman class.

Upon graduating from Poly, Kerry Wisnosky (B.S. '86) had the grades and the desire to earn a spot as an aerospace engineering student at the University of Maryland, but paying for college was a struggle.

"My family didn't have the means to finance my education," said Wisnosky, who benefited from merit scholarships, Federal Pell Grants, the Co-op Program, and the Federal Work-Study Program as a student in the 1980s. "Scholarships allowed me to focus on being a full-time student, rather than take time off to work."

A firm believer in the adage, "where there's a will, there's a way," Wisnosky channeled his appreciation for the merit of hard work into a philanthropic gift: the Kerry and Robin Wisnosky Endowed Scholarship. Established to benefit promising students from Baltimore Polytechnic Institute, Eleanor Roosevelt High School, and the Bullis School, the scholarships are granted based on merit and need.

In August, Poly alumni Jinchan Wang and Ralinkae Kane-Jackson started their college careers at the University of Maryland, with the support of the four-year inaugural Kerry and Robin Wisnosky Endowed Scholarship.

PHOTO CREDIT: JENNIFER ROOKS

"Over the years, I've met some really bright people doing really great work who just didn't have the opportunity to achieve their goals because of the financial burden," said Wisnosky. "My hope is that students who receive this scholarship will have one less thing to worry about upon graduation so they can focus on navigating a successful career path."

Blood Clotting Pad Cleared for Sale by FDA

PHOTO CREDIT: FAYE LEVINE

The U.S. Food and Drug Administration (FDA) has cleared for sale a fast-acting, blood-clotting bandage invented at the University of Maryland (UMD). The product, called the Hemogrip™ Patch, is made by Remedium Technologies, the startup company launched by its inventor, bioengineering (BioE) alumnus Matthew Dowling (Ph.D. '10).

Hemogrip's patented, life-saving technology is based on modified chitosan, a biopolymer derived from chitin, which is found in the exoskeletons of shrimp, crabs, and other crustaceans. Chitosan is a unique natural material because it is biocompatible, anti-microbial, and highly durable under a wide range of environmental conditions.

When applied to wounds, Hemogrip almost immediately creates a three-dimensional nanoscale mesh that coagulates blood and stops hemorrhaging. Despite its effective bonds with tissue, it is gentle enough to be removed from the patient without causing further injury. The pad is designed for use by surgeons, soldiers, first responders, or even unskilled helpers in locations ranging from the operating room to the battlefield.

PHOTO CREDIT: ERIC SCHURR

Dowling, a 2005 recipient of BioE's competitive Fischell Fellowship, said that what makes his product stand out from similar ones is its improved physical properties, which allow it to hold together under higher blood pressure flows.

The FDA's clearance for sale of the Hemogrip Patch represents a regulatory milestone that paves the way for Remedium to seek FDA approval for and commercialize a suite of unique products based on the same technology, including a sprayable foam that expands into large and deep body cavity wounds, where direct pressure cannot be applied.

Hemogrip was developed in the Department of Chemical and Biomolecular Engineering's Complex Fluids and Nanomaterials Group, directed by Dowling's advisor, Professor Srinivasa Raghavan. Dowling is a veteran of and current participant in programs managed by the Clark School's Maryland Technology Enterprise Institute (Mtech), including the $50K Business Plan Competition, the Venture Accelerator program, the Maryland Industrial Partnerships (MIPS) Program, and the Technology Advancement Program. Hemogrip was patented with the help of UMD's Office of Technology Commercialization.

Dowling said Remedium's next steps are to focus on manufacturing, acquire FDA clearance to market additional products, and create distribution partnerships.

›› **LEARN MORE: http://remediumtechnologies.com**

Ikeda Receives Office of Naval Research Young Investigator Program Award

PHOTO CREDIT: UNIVERSITY OF NEW ORLEANS

Mechanical engineering alumna Christine Ikeda (Ph.D. '12, M.S. '11, B.S. '06) received a 2015 Young Investigator Program Award from the Office of Naval Research (ONR). The award, which is presented to those who are early in their academic careers and show exceptional promise for doing creative research, provides her with a three-year $510,000 research grant. Ikeda is one of only 36 researchers from across the country to receive this honor.

Ikeda is currently an assistant professor of naval architecture and marine engineering at the University of New Orleans. The ONR grant will fund her research on how the hulls of high-speed watercraft interact with waves.

During her time at Maryland, Ikeda was part of the Clark School's Future Faculty Program and completed her Ph.D. work on "The Implosion of Cylindrical Shell Structures in a High-Pressure Water Environment" under the mentorship of Professor James Duncan. After graduating from Maryland, she became an assistant research professor at the United States Naval Academy and worked with Professor Carolyn Judge on water impact of hydrodynamically-supported rigid bodies from 2012 to 2014.

>> LEARN MORE: http://go.umd.edu/ikedaonr

KUB INDUCTED INTO INNOVATION HALL OF FAME

Electrical engineering alumnus Dr. Fritz Kub (Ph.D. '85) was inducted into the Clark School's Innovation Hall of Fame for his technology innovations related to gallium nitride (GaN) light-emitting diodes (LED) and microwave transistors.

Kub currently serves as Head of the Power Electronics Branch at the Naval Research Laboratory. His thesis advisor at UMD was Professor Hung C. "Jimmy" Lin (1919-2009), a prolific inventor and university benefactor whose innovative spirit was shared by his former advisee.

Kub's innovations in novel wafer bonded substrate technology for GaN LED and microwave transistors include a method to implement large diameter GaN engineered substrates, a process to implement an ultrathin silicon body layer for fully-depleted, strained silicon-on-insulator (SOI) circuits, and a technique to integrate an insulating substrate with silicon microwave integrated circuits.

>> LEARN MORE: http://go.umd.edu/IHOFKub

2015-2016 Engineering Alumni Network Events

SEPTEMBER 15: Women in Engineering Alumnae and Friends event in Baltimore, Md. Learn more at http://go.umd.edu/wieevent

OCTOBER 15: Clark and Smith Schools Alumni Reception featuring UMD Startups in Tysons Corner, Va. Learn more at http://go.umd.edu/umdbiztech15

NOVEMBER 7: Homecoming in College Park, Md. Learn more at http://homecoming.umd.edu

NOVEMBER 19: Engineering Alumni Networking event in Baltimore, Md. RSVP forthcoming

FEBRUARY 26: 5th Annual Alumni Cup Competition in College Park, Md. Learn more at http://go.umd.edu/alumnicup

Golden Terps Honored at May Commencement Ceremony

PHOTO CREDIT: ALAN SANTOS

Golden Terps celebrating their 50th, 55th, 60th, 65th, 70th, and 75th reunions were honored at the May 22, 2015 Commencement Ceremony. Twenty-eight alumni returned to campus to share stories from their time as students at the Clark School and lead the graduation processional at the Xfinity Center. The Golden Terps serve as an inspiration to past and future engineering alumni for their success and loyalty to the University of Maryland.

Engineering Alumni Receive Inaugural Volunteer Leadership Awards

Mechanical engineering alumna Liz Goldwasser (B.S. '03) and civil and environmental engineering alumnus Jonathan Schneider (B.S. '15) were recognized by the UMD Alumni Association in May for their above and beyond service to the UMD community.

Goldwasser received the Alumni Volunteer Award in recognition of her outstanding service and leadership. Most recently, she helped organize the first-ever Engineering Terp Service Month projects, including their marquee event with the Baltimore Community ToolBank. She has also made significant changes to the operations of the Engineering Alumni Network by revising bylaws, updating their strategic plan, and spearheading the creation of the Alumni Network Leadership Scholarship endowment.

Schneider received the inaugural Carapace Award, which was established to honor a graduating student who has done great work for the campus community. During his undergraduate career, he served as president of the University of Maryland American Society of Civil Engineers (ASCE) Chapter, a peer mentor, and president of his Living & Learning community. Schneider also helped the Engineering Alumni Network raise more than $6,500 for student outreach programming, and helped establish ASCE Maryland's inaugural Suit Up & Be Civil networking event.

GRIFFIN HONORED FOR TERP SPIRIT

PHOTO CREDIT: MIKE MORGAN

Michael D. Griffin (Ph.D. '77, aerospace engineering) was inducted into the University of Maryland's Hall of Fame in recognition of his exemplification of Terp spirit: creativity, generosity, innovation, courage, and perseverance. Griffin was space department head at Johns Hopkins University's Applied Physics Laboratory and was a NASA administrator from 2005 to 2009. Griffin is a member of the National Academy of Engineering and has received numerous awards, including the Department of Defense Distinguished Public Service Medal and the 2007 President's Distinguished Alumnus Award. He now runs Schafer Corp., an aerospace/national security firm in Huntsville, Ala.

UMD No.1 in ARPA-E Awards

The University of Maryland (UMD) is currently No. 1 among all U.S. universities in number of active awards from the U.S. Department of Energy's (DOE) Advanced Research Projects Agency–Energy (ARPA-E). Since the inception of ARPA-E in 2009, UMD has participated in 15 projects, leading 10 of those projects. At the time of this publication, the university is participating in 13 projects funded by ARPA-E, nine of which are led by UMD, placing the university at the top of the list of awardees both as lead organization and total active awards. To date, ARPA-E has awarded UMD participating teams over $39 million for its energy research efforts.

In 2015 alone, researchers from the University of Maryland Energy Research Center (UMERC) led six new ARPA-E awards and had two others extended, for over $15 million. A few of these projects are detailed below.

>> TO LEARN MORE ABOUT ENERGY RESEARCH AT UMD, VISIT http://energy.umd.edu

NOVEL MICROEMULSION ABSORPTION SYSTEMS FOR SUPPLEMENTAL POWER PLANT COOLING

This project aims at developing an absorption cooling system for power plants utilizing a novel microemulsion liquid absorbent.

Led by Department of Mechanical Engineering Associate Professor Bao Yang, the project's UMD co-principal investigators include Professor Michael Ohadi and Minta Martin Professor Reinhard Radermacher, who is also the director of Maryland's Center for Environmental Energy Engineering (CEEE). The team will also work with partners at Stony Brook University, the Electric Power Research Institute, WorleyParsons Group, and Rocky Research.

NOVEL POLYMER COMPOSITE HEAT EXCHANGER FOR DRY COOLING OF POWER PLANTS

The goal of this project is to improve power plant cooling technologies through the development and application of new composite heat exchangers that use a low-cost, high conductivity medium encapsulated in a polymeric material that is highly durable, low cost and has a high resistance to corrosion.

Department of Mechanical Engineering Professor Michael Ohadi is leading the team and his partners include Mechanical Engineering Professor Hugh Bruck, Associate Research Scientist Dr. Serguei Dessiatoun, and Assistant Research Scientist Dr. Amir Shooshtari, who will serve as co-PIs, along with Professor Joshua Pearce at Michigan Technological University, and Dr. Arun Muley at Boeing Research and Technology, Huntington Beach, Calif. Dr. Justin Zachary at ExperTech Engineering Corp. will serve as consultant on the power plant feasibility studies and will be the link between the project and the power plant community.

>> LEARN MORE: http://go.umd.edu/powerplanttech

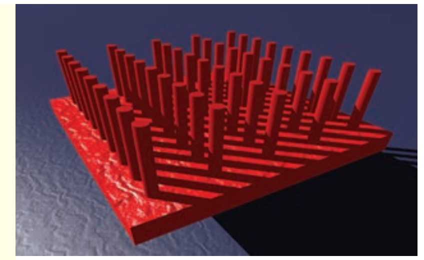
INTEGRATED, PERSONALIZED, REAL-TIME TRAVELER INFORMATION AND INCENTIVE TECHNOLOGY FOR OPTIMIZING ENERGY EFFICIENCY IN MULTIMODAL TRANSPORTATION SYSTEMS

The National Transportation Center at Maryland (NTC@Maryland) is developing a technology to deliver personalized, real-time travel information to users and incentivize energy-efficient travel.

Led by NTC@Maryland Director and Associate Professor of Civil and Environmental Engineering Lei Zhang, the funding will be used to develop what is known as an Integrated, Personalized, Real-time Traveler Information and Incentive (iPretii) technology. iPretii will use traveler behavior data to stimulate the effects of traveler choices on energy use in the Washington-Baltimore area. UMD researchers will conduct behavioral studies to predict travelers' responses and identify incentives to encourage drivers to alter routes, departure times, and driving styles, or take mass transit or ride-sharing services.

>> LEARN MORE: http://go.umd.edu/NTCARPAE

NEW NANOSCALE SOLAR CELLS COULD REVOLUTIONIZE SOLAR INDUSTRY



Assistant Professor Jeremy Munday (ECE/IREAP) and electrical and computer engineering graduate students Yunlu Xu and Tao Gong have designed a new type of nanoscale solar cell that they predict could outperform traditional devices by as much as 40 percent. This new technology could revolutionize the solar industry by allowing for significantly more power generation from a single device by simply making it much smaller.

The team's research on the Shockley-Queisser limit for nanostructured solar cells was published in Scientific Reports in early September.

The Shockley-Queisser limit describes the maximum solar energy conversion efficiency achievable for a particular material and is the standard of comparison for new photovoltaic technologies. For a standard solar cell, this efficiency limit is approximately 33 percent. However, recently people have wondered if nanoscale solar cells are also bounded by this limit.

Now Xu, Gong, and Munday have shown that a single-junction nanostructured solar cell has a theoretical maximum efficiency of approximately 42 percent under typical solar illumination, exceeding the efficiency of a traditional planar device, but not the Shockley-Queisser limit for a planar device with optical concentration. The researchers found that nanostructured solar cells offer an important avenue to achieving high efficiency photovoltaic devices through a "built-in optical concentration." Even when they consider the effects of light scattering in the atmosphere, nanostructured solar cells can achieve 35.5 percent efficiency with a modest built-in optical concentration of only approximately 1,000.

As Munday and his team continue to design and fabricate nanoscale solar cells they find the biggest challenge is nano-fabrication. "You start with a solar cell that works well, and then you perform some extreme treatments to structure it on the nanoscale, all without causing any harm," Munday said. "Luckily, we've found a few materials and processes that look promising and have a team of dedicated students determined to make a big impact in solar energy."

>> LEARN MORE: http://go.umd.edu/jmnnanosolar

Revealing How Wildfires Spread

The phrase "spreads like wildfire" is well known, but it wasn't well-understood how wildfires actually spread. Now researchers at the University of Maryland, U.S. Forest Service, and University of Kentucky have a never-before-seen snapshot of flame movement that will affect the way wildfires are managed and mitigated.

Specifically, it was unclear how radiation and convection—two heat transfer processes that occur in wildfires—contribute to the spread of such fires. Now, evidence presented in a new paper in the Proceedings of the National Academy of Sciences (PNAS) reveals that the spread of wildfire is caused primarily by convection, the transfer of heat through the movement of liquids or gases. Convection determines flame behavior in a fire, and convective air currents also can heat or cool nearby vegetation.

"This discovery provides the missing piece of the puzzle we needed to describe wildfire dynamics," says Michael Gollner, an assistant professor in the University of Maryland's Department of Fire Protection Engineering who contributed to the study. "Current computer modeling systems are not very

PHOTO CREDIT: JASON FORTHOFER, USDA FS

2011 Diamond Complex in southeastern Montana.

good at predicting the spread of fire. We present a physical basis from which to create a new model that won't break down under the most extreme conditions. This will have a huge impact on firefighting strategy, effectiveness, and safety."

Outdoor experiments and prescribed fires extended their results, demonstrating the model could replicate the behavior of large-scale wildfires. The experiments led to the discovery of previously unrecognized flame behaviors and how those behaviors cause wildfires to spread. The team discovered that flame vorticity (circulations) and instabilities due to the buoyancy of flame gasses cause wildfires to spread by forcing flames downward into the fuel bed and bursting forward ahead of the fire into fresh fuel, such as grass and brush.

>> READ THE FULL STUDY: http://go.umd.edu/wildfirespreadPNAS

UMD PARTNERS WITH ARMY, NIST TO LAUNCH EXTREME BATTERY RESEARCH CENTER

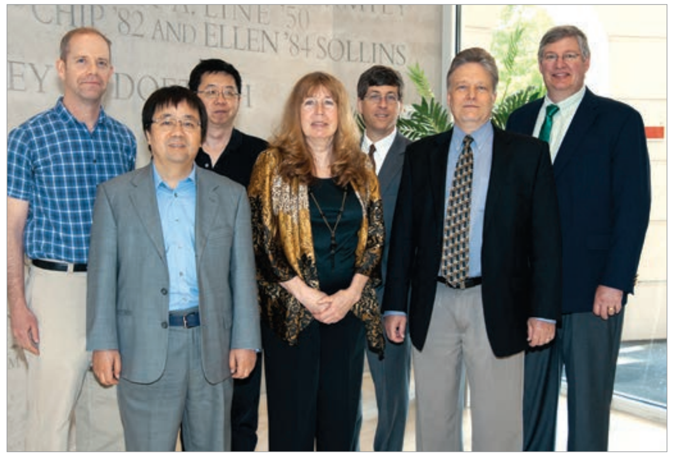


PHOTO CREDIT: DOUG LAFON, ARL

Department of Chemical and Biomolecular Engineering Associate Professor Chunsheng Wang is one of the cofounders behind the new Center for Research in Extreme Batteries (CREB), a partnership among scientists at the University of Maryland, the U.S. Army Research Laboratory (ARL), and the National Institute for Standards and Technology (NIST). Established as a regional hub for advancing battery chemistries, the center's mission is to solve practical battery problems faced by U.S. ground forces. The research is centered on batteries for extreme performance, environments and properties, such as defense, space and biomedical applications.

Wang, an electrode expert, has collaborated for several years with ARL research scientist Kang Xu, an electrolyte expert, to win funding from the U.S. Department of Energy, build advances in rechargeable batteries, jointly file patent disclosures, and publish their results in a number of high-impact journals.

They knew if they could produce a rechargeable battery with higher energy output, it would not only be beneficial to soldiers, but would also be useful for keeping commercial devices charged for much longer periods of time.

The university's close proximity to ARL—less than five miles—has enabled the scientists to forge a unique and effective relationship over the past few years, leading to what Wang describes as "several key advancements in battery research."

>> **LEARN MORE ABOUT CREB: http://go.umd.edu/creb**

Engineering Faculty Receive 2015 DURIP Awards

Four Clark School faculty have received over $1.4 million in combined funding through the Office of Naval Research's (ONR) Defense University Research Instrumentation Program (DURIP). DURIP supports university research infrastructure essential to high-quality relevant research, providing funding for instrumentation that is necessary to carry out cutting-edge research.

Department of Aerospace Engineering Assistant Professor **STUART LAURENCE'S** project, "Preheated piston-driven Ludwieg tube for the realistic simulation of hypersonic flows," focuses on many aspects of high-speed flows, including hypersonic aerodynamics and aerothermodynamics, boundary-layer transition, supersonic combustion and propulsion, high-temperature gas dynamics, naturally occurring hypersonics (meteoritics) and diagnostic development.

Samuel P. Langley Distinguished Professor **JAMES HUBBARD** of the Department of Aerospace Engineering focuses on the areas of morphing airframe architecture, airfoils, and missile control surfaces. He received funding for his project, "Quantification and analysis of small unmanned autonomous vehicles."

Materials Science and Engineering Professor **ICHIRO TAKEUCHI** received funding for his project, "Topological decompositions and spectral sampling algorithms," which is aimed at developing new high-throughput characterization equipment used to identify materials with unique and valuable properties.

Aerospace Engineering Associate Professor **KENNETH YU** received the award for "Ultra high-speed optical diagnostics," and his work on active combustion control and supersonic mixing has made significant impact on developing enabling technologies for propulsion and power systems.

Laurence, Hubbard, Takeuchi, and Yu were four of 225 researchers receiving 2015 DURIP awards, selected from 695 proposals.

>> **LEARN MORE: http://go.umd.edu/UMERCbatteries and http://go.umd.edu/takeuchidurip**

TWO MARYLAND SOFC PROJECTS SELECTED BY THE DEPARTMENT OF ENERGY

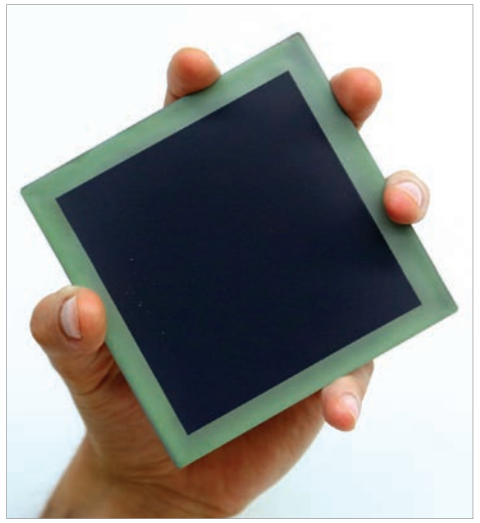


PHOTO CREDIT: ERIC SCHURR

Two solid-oxide fuel cell (SOFC) technology projects from the University of Maryland have been selected by the Department of Energy's (DOE) National Energy Technology Laboratory (NETL) for more than $3 million of funding.

Fuel cells are a modular, efficient, and virtually pollution-free power generation technology.

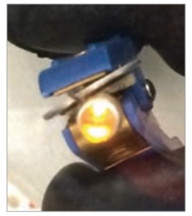
The projects are under two topic areas: Innovative Concepts, geared toward undercutting current SOFC technology costs; and SOFC Core Technology, aimed at laboratory- and bench-scale projects that improve SOFC design. The University of Maryland is leading a SOFC Core Technology project, and is a partner on Redox Power Systems' Innovative Concepts project. These projects will serve a critical role in moving SOFC technology closer to commercial deployment, with some of the small-scale demonstration projects illustrating the potential of SOFC technology to transfer to industry applications within the next five to 10 years.

>> **LEARN MORE: http://go.umd.edu/sofcdoe**

Building a Better Battery for Space Exploration

A team of researchers from the University of Maryland Energy Research Center (UMERC) has been awarded up to $1 million in NASA funding for its Garnet Electrolyte Based Safe, Lithium-Sulfur Energy Storage project, a game-changing battery technology that could potentially power future space missions.

The solid-state battery, developed by A. James Clark School of Engineering faculty members Eric Wachsman (MSE), Liangbing Hu (MSE), and Chunsheng Wang (ChBE), is a triple threat, solving the typical problems that trouble existing lithium-ion batteries: safety, cost, and performance.



Lithium-ion batteries, which typically contain a pressurized, liquid electrolyte, can ignite when under certain conditions. The research team's use of a solid-state ceramic electrolyte eliminates that risk, making its battery intrinsically safer than the preceding liquid-based lithium-ion batteries.

By employing thin-film ceramic techniques, Wachsman, Hu, and Wang significantly reduced the cost of fabricating the battery. The battery's sulfur cathode offers increased battery capacity at the highest density and lowest weight possible, outperforming the longevity of lithium-ion batteries currently on the market and meeting NASA's goal of reducing mass required to store electrical power in space.

Now in Phase II of NASA's Game Changing Development (GCD) program, Wachsman, Hu, and Wang will focus on the engineering hardware of the battery. The team's Phase I award last year supported eight months of component testing and analysis. In 2016, the team will submit a proposal for up to $3 million in Phase III funding for prototype hardware development with the ultimate goal of sending its battery to space.

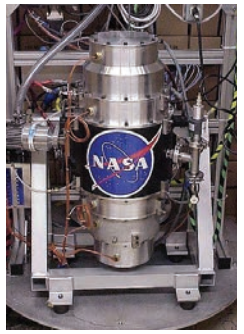


PHOTO CREDIT: NASA

The technology was born from the team's existing battery project, focused on energy storage using solid-state electrolytes and funded by the U.S. Department of Energy Advanced Research Projects Agency-Energy (ARPA-E).

>> **LEARN MORE ABOUT UMERC'S BATTERY RESEARCH: http://go.umd.edu/UMERCbatteries**

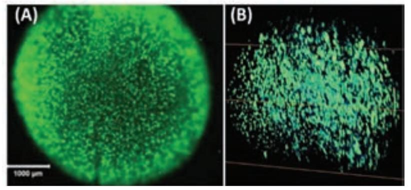
NOVEL IMAGING TECHNIQUE PAVES WAY FOR BONE TISSUE ENGINEERING ADVANCEMENTS

Fischell Department of Bioengineering (BioE) Associate Professor Yu Chen has been awarded a four-year, $1.29 million National Institutes of Health (NIH) Research Project Grant (R01) for developing a new system capable of non-invasive, three-dimensional imaging of engineered tissue.

Along with John Fisher, Fischell Family Distinguished Professor in Bioengineering and Associate Chair, and John Caccamese, Jr., Associate Professor of Oral-Maxillofacial Surgery at the University of Maryland Medical System and University of Maryland Baltimore College of Dental Surgery, Chen is working on a new system capable of quantitatively imaging 3-D cell behavior.

Bone tissue engineering scaffolds are used in a wide variety of clinical settings to promote bone repair and regeneration, and act as vehicles for the delivery of progenitor cell populations or support structures for surrounding tissue ingrowth. To improve tissue regeneration and integration, engineers must design scaffolds that mimic surrounding tissue morphology, structure, and function, and improve mechanical stability between the implanted engineered tissue and the surrounding native bone.

"Three-dimensional cell-based tissue grafts have been increasingly useful in tissue engineering and regenerative medicine," Chen said. "A critical building block in tissue engineering is the scaffold, which can act as the supporting medium to deliver cell populations and induce ingrowth of vessels and surrounding tissues. Therefore, it is necessary to develop tools to characterize the architecture of the scaffold."



Direct comparison between full field fluorescence microscopy (A) and the research team's proposed fluoroscene laminar optical tomography system (B).

Currently, however, there are no non-destructive methods of analyzing engineered tissue structures and stem cell functions beyond the reach of traditional microscopy, meaning researchers have had limited ability to characterize cells located deep inside scaffolds. Most techniques to analyze engineering tissue structures are invasive, discrete methods of analysis, while some are expensive and involve a long data acquisition process.

To combat these challenges, Chen and his fellow researchers are developing a new platform that utilizes optical coherence tomography (OCT) and fluorescence laminar optical tomography (FLOT) for characterization of cell-scaffold interaction. The combined OCT/FLOT system offers promise that researchers will be able to evaluate both structural and cellular information simultaneously to study cell-scaffold interaction and collect feedback on the design of scaffolds in order to achieve optimal cellular function.

The team's efforts demonstrate how multi-disciplinary collaboration can produce revolutionary advancements in engineering. As an Mpowering the State research initiative, Chen and Fisher of the University of Maryland in College Park, Md., are able to work across campuses with University of Maryland Medical System/Baltimore College of Dental Surgery's Caccamese, who contributes clinical expertise to the project.

>> LEARN MORE: http://go.umd.edu/imagingbonetissue

Cybersecurity Researchers Receive NSF Grant for Verifiable Computation

Charalampos "Babis" Papamanthou, an assistant professor in the Department of Electrical and Computer Engineering with appointments in the University of Maryland Institute for Advanced Computer Studies (UMIACS) and the Maryland Cybersecurity Center (MC2), received a $1.2 million National Science Foundation (NSF) grant to support the development of new methods for verifiable computation.

Verifiable computing refers to offloading the computation of some function—perhaps to the cloud—while still maintaining verifiable results.

In collaboration with MC2 Director Jonathan Katz (computer science and UMIACS), Elaine Shi (computer science, MC2, and UMIACS), and Amol Deshpande (computer science and UMIACS), Papamanthou is building a novel architecture—called "Apollo"—that will be able to take large amounts of data and quickly perform verifiable computations without having to trust the cloud-computing infrastructure.

>> WATCH A VIDEO ABOUT PAPAMANTHOU'S CLOUD COMPUTING WORK: http://go.umd.edu/papamanthouvideo

ON THE JOB WITH EMILY FRAIK

Emily Fraik is a senior chemical engineering major and an outside hitter on the Terps volleyball team. Before heading back to campus for practice, she interned at ExxonMobil in Houston, Texas.

PHOTO CREDIT: ALAN SANTOS

E@M ***What were your responsibilities as an ExxonMobil intern?***

Fraik As part of the ExxonMobil Research and Engineering Company, I worked in process design on a revamp project at the Baytown refinery, the biggest integrated refining and petrochemical complex in the country. I got to work in the optimization stage of the project designing a heat exchanger configuration, optimizing the reflux rate of the tower, and incorporating a new line into the process. The first time I visited the refinery was a little overwhelming—it's huge! After doing all of my design work, it was really cool to be able to walk out all of the piping to see the scope that I was working with and determine how much the material would cost.

E@M ***How did your academic experience influence your internship?***

Fraik The internship was definitely a complement to everything that I've learned so far at the Clark School, and I felt very prepared because of my recent classes in heat and mass transfer, separations, and fluid dynamics. I used everything I learned in those classes at ExxonMobil. It was very fulfilling to be able to take the theory and relations that I learned in the classroom and apply them to a real-life project.

E@M ***What was the most challenging part of your internship at ExxonMobil?***

Fraik Time. You have to keep to a tight schedule to meet all of your deliverables, and my internship schedule was condensed so that I could get back in time for volleyball. Every day, something interesting would pop up that I just wanted to spend a week to probe, but I had to prioritize my work so that the necessities would be done before I explored additional interests. More than anything, the challenge of time just got me excited for the opportunity to learn more in the upcoming school year.

E@M ***What is the most important takeaway from your internship experience?***

Fraik In terms of technical skills, my work helped me think about all of the different variables that play into a design project. One of the best things about engineers in general is that we ask a lot of questions. The more people you have asking questions and bouncing ideas off one another, the more you learn and the better a project can be. I never ended my workday without learning something new.

E@M ***What advice would you give to your fellow students?***

Fraik Even if you have your heart set on an internship at one particular place, you should apply to as many opportunities as you have time for. I wasn't too sure that ExxonMobil would be a great fit for me, but now that I've worked there, I couldn't be happier with my decision!

E@M ***What's next for you?***

Fraik Right now, I'm considering graduate school or going straight to work. My internship at ExxonMobil confirmed for me that I definitely want to work in the energy sector, but whether I stay in the oil and gas industry or move elsewhere in the field will be my next decision.

UMD Concrete Canoe, Steel Bridge Teams Take First Place in ASCE Mid-Atlantic Competitions

The Department of Civil and Environmental Engineering's (CEE) Concrete Canoe and Steel Bridge teams took the 2015 American Society of Civil Engineers (ASCE) Mid-Atlantic Regional Competitions by storm, placing first overall in both team competitions and second in the technical paper competition.

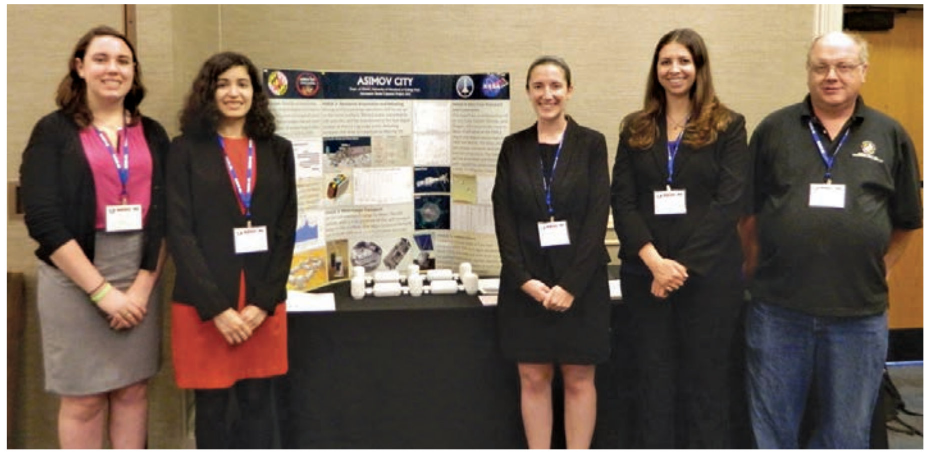
Held at the Pennsylvania State University's Stone Valley Recreation Area, this year's competition showcased the University of Maryland ASCE's competitive spirit and incredible attention to detail as both teams received great praise for their technical presentations and displays.

In commemoration of the 140th Preakness Stakes, the Concrete Canoe team's showcase was unlike any other—from the artwork on the canoe itself to the iconic University of Maryland "M" floral display. Under the leadership of project managers Phil Izzo (B.S. '15) and Craig Lampmann (B.S. '15), and faculty advisor Assistant Professor Brian Phillips, the team celebrated a strong performance in the races, but even higher marks in the technical and presentation categories.

The Steel Bridge team, which was managed by Ross Jespersen (B.S. '15), Emily Krizz (B.S. '14) and Adam Healey (B.S. '16), also went to great lengths to make sure no workmanship details went unnoticed. The team earned first place in both the construction economy and structural efficiency categories, which measure how quickly the team can build their bridge and how well the bridge can handle loads, respectively. 2015 marked only the fifth year in which the University of Maryland had an official Steel Bridge team.

The 2015 Steel Bridge team proudly participated in this year's national competitions, held at the University of Missouri-Kansas City, May 22-23. The Concrete Canoe team also made a strong showing in the team's first nationals appearance in 12 years, held this year at Clemson University. UMD's team performed especially well in the "Design Paper," "Final Product," and "Men's Slalom/Endurance Race" categories, finishing 12th, 13th, and 10th, respectively.

>> VIEW PHOTOS FROM THIS YEAR'S MID-ATLANTIC REGIONAL COMPETITION: http://go.umd.edu/umdasce15



From left to right, the four students who represented the team at the design competition: Samantha Walters, Isabel Martinez, April Claus and Jaclyn Rupert along with Professor Dave Akin.

UMD STUDENTS SWEEP 2015 RASC-AL COMPETITIONS

In the 2015 Revolutionary Aerospace Systems Concepts-Academic Linkage (RASC-AL) competition season, Clark School aerospace engineering students took home first place at both the Robo-Ops competition and the Space Engineering Design contest.

In Professor Dave Akin's Planetary Rover Development course, a team of students designed and developed Frigg, a rover tasked with collecting a variety of "samples"—color-coded rocks—while navigating a course that simulates rocky fields, lunar craters, sand dunes and a Mars hill at the competition in Texas. Teams could also earn bonus points for returning with the rocks to the starting point on top of Mars Hill, for collecting at least one rock from each of the four terrains and for acquiring an "alien life-form."

Sounds simple enough, except that Frigg was being controlled remotely from a home campus "Mission Control Center" using a commercial broadband wireless uplink, and students navigated the course using only the data they received through a streaming video feed from on-board cameras. In Texas, a three-person pit crew team monitored the rover and provided on-site support.

The team took home first place and a new course record, as well as recognition for Frigg's climbing ability and light-weight composition.

At this year's RASC-AL design competition, students were challenged to design a mission with supporting technologies that would enable astronauts to be less reliant on resources transported from Earth.

The UMD team, also led by Akin and comprised of students in his Aerospace Engineering Space Systems Design course, not only won first place overall with their Mars exploration themed project Asimov City, Mars: Developing a Permanent Earth-Independent Settlement on Mars, but the team also placed first in the undergraduate category.

The team's project outlined a Mars settlement that incorporated the moon as a fueling stop for Mars-bound spacecraft, and they developed a strategy for creating fuel from lunar surface materials.

The team presented its design project to industry experts at the American Institute of Aeronautics and Astronautics Space 2015 conference in Pasadena, Calif.

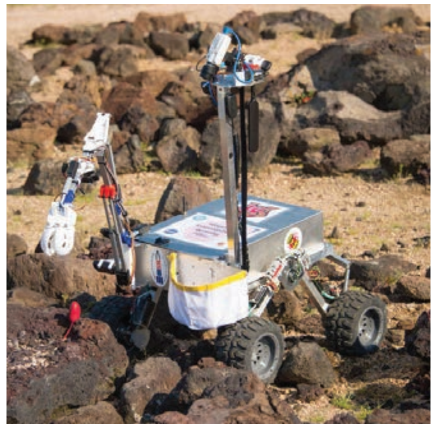


PHOTO CREDIT: BILL STAFFORD/NASA

UMD's Robo-Ops rover, Frigg.

Both competitions are sponsored by NASA and managed by the National Institute of Aerospace.

>> LEARN MORE: http://go.umd.edu/rascal2015 and http://go.umd.edu/robo2015

MATYSIAK NAMED NSF CAREER AWARD RECIPIENT

PHOTO CREDIT: HERNAN STAMATI

Fischell Department of Bioengineering (BioE) Assistant Professor Silvina Matysiak was selected for a five-year, $650,000 National Science Foundation (NSF) Faculty Early Career Development (CAREER) award for her efforts to advance the understanding of degenerative diseases and how molecular behavior dictates macroscopic-scale properties of biological systems.

While many of today's most common diseases are caused by bacteria or viruses, neurodegenerative diseases such as Alzheimer's, Parkinson's, and Huntington's result from what is known as protein misfolding—instances in which proteins fail to fold into their normal configuration and thereby disrupt the function of cells, tissues, and organs of the body.

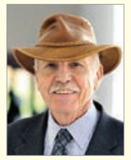
Many misfolding diseases share the same mechanism of development in that each results from an abnormal aggregation of peptides—short chains of amino acids—and proteins on cellular membranes. While researchers are still working to uncover exactly what triggers pathogenic protein-protein and protein-membrane interactions, Matysiak and the members of her Biomolecular Modeling Laboratory are hopeful that improved understanding of such interactions will provide clues on how bioengineers could design better therapeutics to inhibit toxic peptide aggregation to treat or prevent misfolding diseases.

To do this, Matysiak and her fellow researchers are using a type of molecular modeling known as coarse-grained modeling to gain insights on how membranous surfaces can shape peptide aggregation.

"If you look at other engineering disciplines such as aerospace engineering or mechanical engineering, researchers often use modeling before they carry out any type of experiment or before they design something," she said. "In bioengineering, we're not quite there yet given the complexity of biology—we don't yet use modeling as often as researchers in the other disciplines. But, it's only a matter of time until modeling allows us to have a deeper understanding of all the biomolecular processes taking place in our bodies."

FELLOWSHIPS, SOCIETIES, HONORS, AND AWARDS

Department of Mechanical Engineering Minta Martin Professor **AMR BAZ** received the University of Maryland 2015-2016 Distinguished Scholar-Teacher Award for his outstanding scholarly accomplishments and excellence in teaching.



Keystone Professor and Associate Dean of Engineering **WILLIAM FOURNEY**, who holds a joint appointment in the Department of Aerospace Engineering and the Department of Mechanical Engineering, received the Society for Experimental Mechanics (SEM) 2016 C.E. (Chuck) Taylor Award for his lifelong contributions both in dynamic response of structures and materials, and to the improvement of engineering education.

Institute for Systems Research Director and Herbert Rabin Distinguished Chair in Engineering **REZA GHODSSI** was elected a Fellow of the American Vacuum Society "for outstanding leadership in micro-systems technology achieved by combining knowledge of materials and processing, innovative device concepts, and diverse applications."

Department Chair and Minta Martin Professor of Aerospace Engineering **NORMAN M. WERELEY** was promoted to American Helicopter Society (AHS) Technical Fellow, one of the highest honors bestowed upon a professional member of the AHS. Wereley also received the National Capital Section (NCS) of the American Institute of Aeronautics and Astronautics' 2015 Marvin C. Demler Award in recognition of his outstanding support and many contributions to NCS.

The American Society of Mechanical Engineers selected three faculty members as Fellows:



Professor **REZA GHODSSI** (ECE/ISR)
Professor **JAYDEV DESAI** (ME)
Professor **JAMES E. HUBBARD, JR.** (Aero)

Chemical and Biomolecular Engineering Professor **MIKHAIL ANISIMOV** received the 2015 Yeram S. Touloukian Award from the American Society of Mechanical Engineers' (ASME) Heat Transfer Division in recognition of his "outstanding technical contributions in the field of thermophysical properties."

Department of Aerospace Engineering Glenn L. Martin Institute Professor of Engineering **ELAINE ORAN** received an Honorary Doctorate from the Institut National des Sciences Appliquées (INSA) Rouen in recognition of her work in areas closely related to themes of INSA.

Department of Mechanical Engineering George E. Dieter Professor **MICHAEL PECHT** has been awarded the 2016 Manufacturing Technology Award for his visionary leadership in the development of physics-of-failure-based and prognostics-based approaches to electronic packaging reliability. Pecht also received the Distinguished Scientist of 2015 award from the Chinese Academy of Sciences (CAS) President's International Fellowship Initiative (PIFI).

Department of Mechanical Engineering Minta Martin Professor **REINHARD RADERMACHER** was awarded the International Institute of Refrigeration's (IIR) 2015 Gustav Lorentzen Medal for his outstanding and original achievements in academic or industrial research, innovation or development, in all fields of refrigeration.

Christine Yurie Kim Eminent Professor of Information Technology **K.J. RAY LIU** of the Department of Electrical and Computer Engineering received the 2016 IEEE Leon K. Kirchmayer Graduate Teaching award for inspirational teaching and mentoring of graduate students.

Civil and Environmental Engineering Professor **ALLEN DAVIS** was named a Fellow of the Environmental and Water Resources Institute (EWRI) of the American Society of Civil Engineers (ASCE).

Civil and Environmental Engineering Professor and Ben Dyer Chair **RICHARD H. MCCUEN** was recently named the recipient of the American Society of Civil Engineers (ASCE) Ven Te Chow Award for prolific, innovative scholarship in engineering hydrology.

Mechanical Engineering Professor **MICHAEL OHADI** received the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) E.K. Campbell Award of Merit for his outstanding service and achievement in teaching.

Glenn L. Martin Institute Professor of Engineering **GERALD GALLOWAY** (CEE) was named a 2015 recipient of the U.S. Army Engineer Regiment Gold Order of the de Fleury medal for his exemplification of boldness, courage, and commitment to a strong national defense.

Department of Mechanical Engineering Distinguished University Professor **ASHWANI GUPTA** was awarded the 2015 American Society for Engineering Education (ASEE) Mechanical Engineering Division Ralph Coats Roe Award for his outstanding instruction and notable contribution to the field.

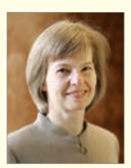
CONTINUED ON NEXT PAGE

FELLOWSHIPS, SOCIETIES, HONORS, AND AWARDS (CONT.)

Mechanical Engineering Professors **HUGH BRUCK** and **JEFFREY HERRMANN**, Chemical and Biomolecular Engineering Associate Professor **JEFFERY KLAUDA**, and Materials Science and Engineering Professor **SREERAMAMURTHY ANKEM** have been named University System of Maryland (USM) PROMISE Alliance for Graduate Education and Professoriate (AGEP) Outstanding Faculty Mentors for the 2015-2016 year. They were chosen by under-represented graduate students in STEM fields, as well as other leaders of STEM diversity programs in Maryland for their diversity and inclusion efforts and actions.




Department of Mechanical Engineering Professor **ELISABETH SMELA**, who is affiliated with the Institute for Systems Research, has been appointed a University of Maryland (UMD) ADVANCE Professor. Supported through a NSF grant, the UMD ADVANCE Program is focused on improving work environments, retention, and advancement of tenured and tenure-track women faculty in ways that improve the culture for all faculty.




Aerospace Engineering Professor **SUNG LEE** (AE) and mechanical engineering Professor Emeritus **JAMES W. DALLY** received Lifetime Achievement Medals from the International Conference on Computational and Experimental Engineering and Sciences (ICCES) for their "sustained and significant contributions in the form of research, teaching and service to the community, in any area relevant to the ICCES series of conferences."

Mechanical Engineering Professor Emeritus **RONALD ARMSTRONG** received the 2015 John Rinehart Award for his work in dynamic deformation in recognition of his outstanding efforts and creative work in the science and technology of dynamic processes in materials.

Assistant Professor **MOHAMMAD HAFEZI**, a Joint Quantum Institute Fellow jointly appointed in the Department of Electrical and Computer Engineering and the Institute for Research in Electronics and Applied Physics, has been selected as an Office of Naval Research (ONR) Young Investigator in support of his research in "Quantum Transport of Photons in Nanostructures."

The American Institute of Aeronautics and Astronautics named Aerospace Engineering Assistant Professor **ANYA JONES** an Associate Fellow for her contributions to aerodynamic research and for her STEM and outreach activities.

The American Institute of Aeronautics and Astronautics National Capitol Section (AIAA-NCS) has honored two aerospace engineering faculty members with awards.

Assistant Professor **ANYA JONES** was named the 2015 Hal Andrews Young Engineer/Scientist of the Year for her outstanding contributions to the science and engineering of biologically inspired flapping wing micro air vehicles and for her dedication to educating the next generation of aerodynamicists.

Willis H. Young Jr. Associate Professor of Aerospace Engineering Education **DEREK PALEY** received the 2015 Engineer of the Year "for pioneering research that applies methods from engineering and biology to study collective behavior in robotic and natural systems, and for dedication to teaching and mentoring students."

THE TIME IS NOW

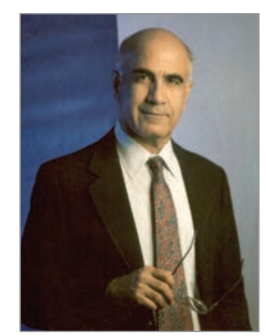
Channeling 50 years of Service to the Present

PHOTO CREDIT: LISA HELFERT

When Davinder Anand first stepped foot on the University of Maryland campus as an assistant professor, he didn't expect to be working in the same place decades later. The year was 1965 and Anand was excited to begin his career in the Department of Mechanical Engineering at the University of Maryland. But teaching engineering wasn't always part of his plan. His career—and his life—has been defined by happenstance.

"I started at Catholic University as an architecture student, and during my first semester, I did very well in physics and math," said Anand, who enjoyed building his own toys and gadgets as a child in India, where he lived until his father received a diplomatic appointment in the United States. Initially, he thought he'd return to India as an adult. At the encouragement of the architecture dean, Donald Marlowe, Anand reset his life path to study engineering at the George Washington University where he went on to earn bachelor's, master's, and doctoral degrees in mechanical engineering. It wasn't until an American Society for Mechanical Engineers (ASME) conference that academia crossed his mind as a full-time profession.

"The mechanical engineering department chair at the time, Charles Shreeve, approached me after my presentation and told me he wanted to hire me at the University of Maryland," recalled Anand, who after meeting with Shreeve, decided to take him up on his offer.



Over the course of 50 years, Anand has risen to challenges that have shaped who he is today. In the constant competition for funding, he applied his research interests in control systems and systems analysis to multiple fields, including space systems, energy, and manufacturing systems. Anand was at the helm of the Department of Mechanical Engineering as its chair from 1991 until 2002, and in 1998, he established the Center for Engineering Concepts Development (CECD), a platform for experimenting with new ideas in engineering education, future technologies, and research, as well as examining their influence on public policy.

Perhaps the greatest challenge of all was the sudden loss of his son, Neil, in 2012. A 1987 graduate of the University of Maryland business school and a serial entrepreneur, Neil placed his friends and family at the very top of his priority list and was passionate about sports and travel.

In memory of his son, Anand established the Neilom Foundation, a 501(c)(3) non-profit dedicated to improving the lives of young people through the intersection of education and technology. In 2015, the Foundation supported a new course in the mechanical engineering department, Engineering for Social Change, which was established to introduce young engineers to the ideas of social change and social entrepreneurship through the intersection of concepts from both engineering and philanthropy.

"We are facing growing social and environmental challenges where the solutions are not always profitable financially but have significant social benefit," said Anand. "We must create an environment where engineers have not only a social conscience, but also the skills and knowledge to build and work with organizations that are philanthropic or nonprofit."

Currently, Anand holds the title of professor emeritus, but he considers himself an atypical retiree. He's often working away in his office in Martin Hall and his chief goals right now are to grow the Engineering for Social Change program and to expand the reach of the Neilom Foundation. But beyond that, Anand doesn't worry too much about the future.

"I'm of the opinion that the greatest time is now," said Anand. "I've always felt that what you have in hand now is worth a lot. Yesterday is gone, and I'm not sure what tomorrow will bring. I will officially retire when the time comes and time will let me know when to retire. But for now, today is the best day I can imagine."

A. JAMES CLARK
SCHOOL OF ENGINEERING

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All Your News That's Fit to Print

The Class Notes Section of *E@M*

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WE HAVE JUST ONE REQUEST: WE NEED YOUR INPUT.

Start compiling your Class Notes entry now, and forward it to Jeffrey S. Williams, director of alumni relations at jeffsw@umd.edu. Remember to include your full name, year of graduation, degree received, major and the news you want to share with the Clark School community. High-quality, high-resolution images are welcome.

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