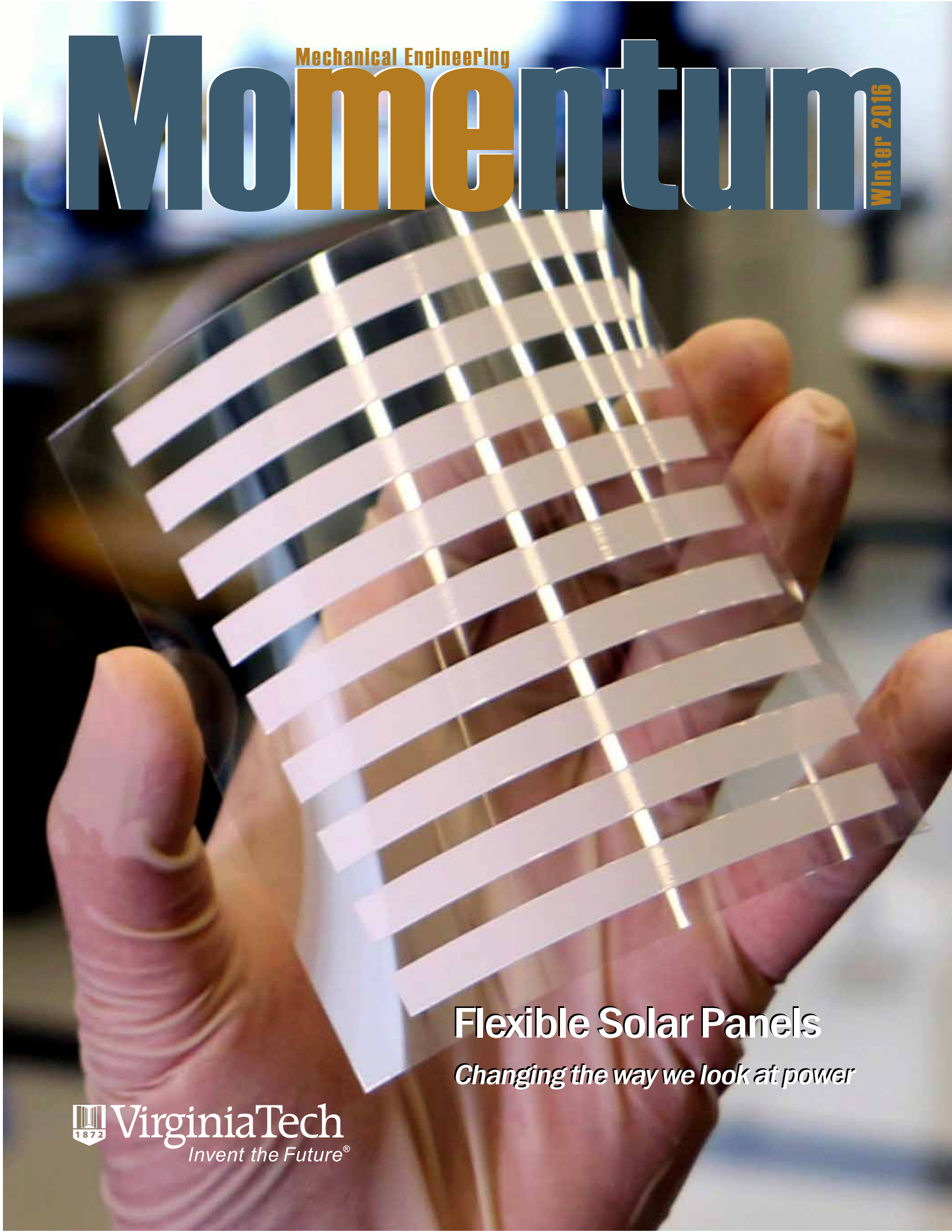
Mechanical Engineering

Momentum

Winter 2016



Flexible Solar Panels

Changing the way we look at power

VirginiaTech

1872

Invent the Future®

Azim Eskandarian
ME Department Head

2016 has been a great year for the Department and I want to thank all of you who have been a part of what we do – this includes our students, faculty, staff, alumni, and everyone who has pitched in to help us reach our goals. I would also like to recognize our Department Advisory Board who dedicate so much of their time and energy to help us realize our potential. We ended the year with most of our metrics trending positively including research expenditures, admissions, graduates, and program rankings among others.

As the year ends I want to wish everyone a happy and safe holiday season. If you are coming back to Blacksburg in the new year, I hope you are refreshed and ready to tackle another year of change and personal and professional growth. If you aren't coming back to your VT home, the entire ME Department wishes you success in your endeavors and we hope to see you back on campus in the near future to visit.

In this our fourth and final issue of Momentum for the year, we take a look at a technology that could be a game-changer in the world of solar power. Flexible solar cells that are light and can be integrated into fabric, wallpaper, and many other places where traditional heavy, rigid solar panels can't go. What's more, these cells can harvest the energy from traditional household lighting, making them electricity recyclers. The technology is now at that exciting tipping point just short of commercialization and it would be a great thing if in a couple years we were talking about how Virginia Tech mechanical engineers helped propel the shift toward greener energy for the home and workplace.

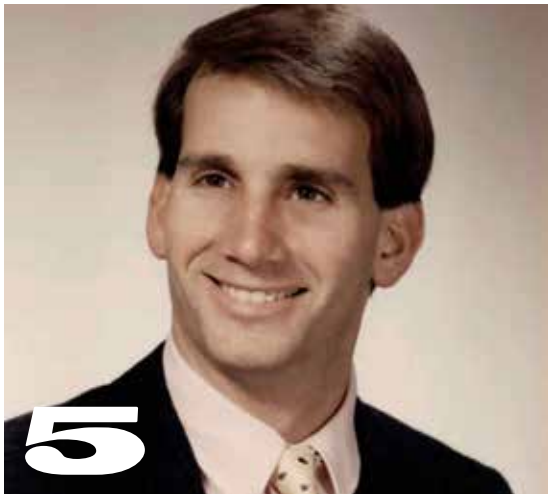
Also in this issue we 'meet' Andrew Jones. Andrew was a 1988 graduate of VT who sadly passed away recently. In his memory his mother, Nancy, and Bob Bolt, have set up a scholarship fund. Please take a few minutes and read about this amazing alum and the difference being made in his name to our up-coming engineers. There is also a link on the page if you are interested in helping maintain the scholarship for future generations of Hokies.

And finally, our students and faculty continue to do great things around the world – from speeches and talks to publishing their research in the world's most respected journals, to being recognized by major corporations like Honeywell, who think highly enough of our program to donate $1.5 million worth of aircraft engines.

I hope you enjoy spending a few minutes of your day with us and I look forward to bringing you more of ME next year. Have a happy holiday season, be safe, and we'll see you next year.

inside

Winter 2016 Vol 1.4



Connect with ME

Join the ME community through social media. Follow us for updates.

Facebook

Twitter

Dr. Azim Eskandarian
Dept. Head,
Mechanical Engineering

Rosaire Bushey
Communications & Outreach Manager; Editor

Ben-Tzvi part of team working as part of collaboration to develop casualty assistance robot for United States Army

Associate Professor Pinhas Ben-Tzvi, Director of The Robotics and Mechatronics Laboratory, has earned $200,000 of a $1 million Small Business Innovation Research grant through the U.S. Army Telemedicine and Advanced Technology Research Center.

Ben-Tzvi

The lab is working with robotics company RE2 Inc., which leads the Phase II SBIR grant, and defense partner Lockheed Martin. The three groups will help develop a system designed to assist combat medics by evacuating wounded service members under hostile conditions.

Ben-Tzvi, the principal investigator for the university, will lead research and development of a novel 'marsupial' robotic technology that will move into hostile areas, load a wounded person onto the robot and remove them from the area to be transported to a field medical facility or other treatment area.

"The task of the Robotics and Mechatronics lab is to develop a mobile robot to interface with Lockheed Martin's Squad Multipurpose Equipment Transport unmanned ground vehicle," said Ben-Tzvi. "Our mobile robot will safely retrieve, secure, and transport a casualty to the S-MET where the injured service member can be transported to a hospital or air evacuation location."

The project, signed with RE2 Inc. Oct. 13, will run for 18 months, during which time Ben-Tzvi and his team will focus on the design and development of the overall robotic system and related test components.

"It's a very difficult problem," Ben-Tzvi said. "Coordinating the motion of the robot to be able to manipulate a person and move them into the robot safely for transport will take some time, but we believe that after the initial research and development stages and testing process, we will be able to meet or perhaps even exceed the expectations required by the U.S. Army, and provide results showing an effective system."

Wasson, Hurtado attend SHPE conference in Seattle

Mechanical engineering graduate students, Mark Pastor Hurtado and Elisa Wasson, attended the Society of Hispanic Professional Engineers (SHPE) conference in Seattle in November thanks in part to support from the ME department.

The SHPE is an organization dedicated to empowering the Hispanic community to realize its fullest potential and to impact the world through STEM awareness, access, support and development.

According to Hurtado and Wasson, there is a strong network of members from the professional and academic level to the undergraduate and high school level.

About 7,000 attend the annual conference consisting of workshops aimed to help students develop both professionally and academically and concludes with a career fair with more than 200 exhibitors from industry and academic institutions.

Graduate students Andres Pico, Computer Science; Juan Lopez-Marcano, Electrical Engineering; and Mark Pastor Hurtado, Mechanical Engineering.

While at the conference, Wasson and Hurtado assisted in recruiting over 40 undergraduate students to apply to graduate engineering programs at Virginia Tech. They also attended workshops dedicated to graduate student success such as "Developing a vision for your research program," "Valuable strategies to get the most from your advanced degree," and "Call to action: the need for diverse STEM faculty."

New scholarship for ME undergraduates

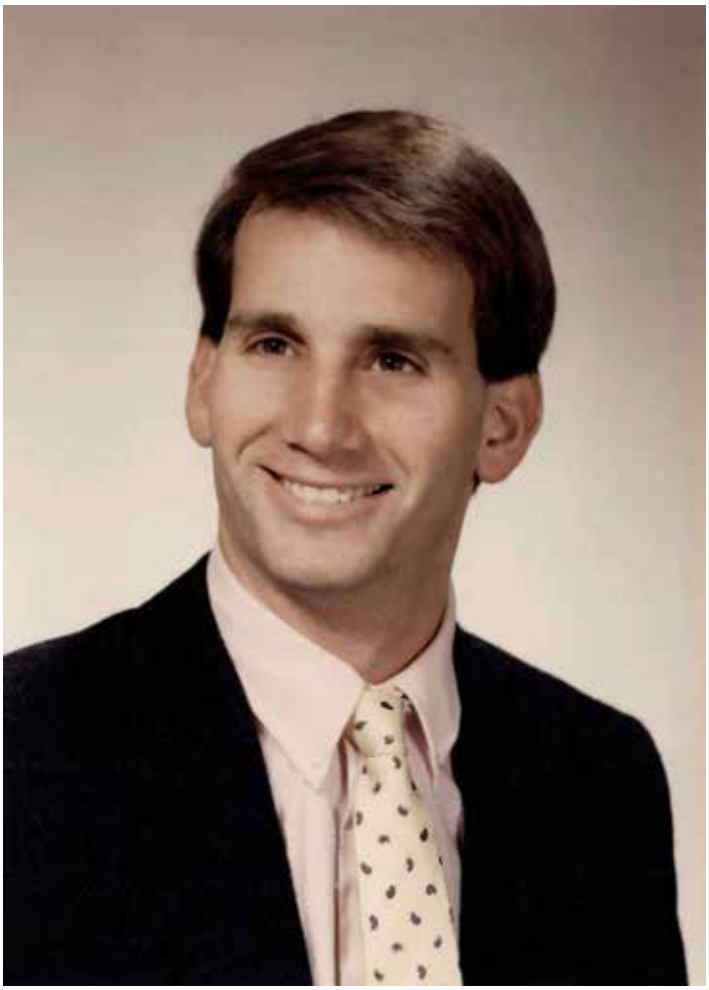
W. Andrew "Andy" Jones '88 Memorial Scholarship announced to honor avid Hokie

Nancy and Bob Bolt of Tampa, Florida, have established a scholarship in memory of their son, Andy Jones, who received his Bachelor of Science degree in Mechanical Engineering from Virginia Tech in 1988. An avid Hokie and lover of Blacksburg, he was also a member of the American Society of Mechanical Engineers and Phi Delta Theta fraternity. He earned a Master of Business Administration degree from the University of Houston in 1993.

As a mechanical engineer for Shell Oil Company in Houston, Andy began his career at the Deer Park Refinery. While working at Shell for more than 25 years, Andy's many promotions at Shell included the position of Global Engineering and Maintenance Services Team Leader, where he was responsible for projects at 28 world-wide manufacturing plants with an annual budget of more than $2 billion. At the time of his death in 2013, at the age of 47, Andy was the Cost Leadership Manager at Deer Park Refinery, one of the largest refineries in the U.S. There he found creative ways of reducing costs while balancing the interests of both Shell and its outside vendors. According to a co-worker, Andy's gift for finding savings was legendary.

Andy was a member of the Board of Trustees of the National Center for Construction Education Research, a national organization for curricula development, craft training, and certification. He was also Chairman of the Houston Business Roundtable, an industrial association of construction users that promotes safe and cost effective design, procurement, construction, and maintenance practices.

Andy was extraordinarily responsible, self-disciplined, generous and passionate about helping people less fortunate than himself. It is in the spirit of remembering Andy's work ethic, his nature of helping others, and his appreciation of what Virginia Tech gave him, that his parents have set up a scholarship in his name providing for an annual award of $10,000 payable semi-annually.



Individuals interested in making a donation to the W. Andrew "Andy" Jones '88 Memorial Scholarship can click the link below. After entering a gift amount, choose "College of Engineering" as the area of benefit; and then choose "In Memory of" and finally, add "Andy Jones Memorial Scholarship"

To donate click here

speakers

Parker in China


Parker

L.S. Randolph Professor **Robert Parker** was the keynote speaker at the International Conference on Power Transmissions held in Chongqing, China from Oct. 27-30. This is an international event with 250 participants; held every three years, it is the major conference worldwide in power transmission systems and one of the two most prominent conferences in the field. Parker's keynote was titled, “Unique Vibration Phenomena in High-Speed, Aerospace Gears."

Cheng in Germany


Cheng

Associate Professor **Jiangtao Cheng** spoke at the Light, Energy and the Environment Congress, at the Kongresshalle am Zoo in Leipzig, Germany, from Nov. 14-17. Cheng's talk was titled, "Electrowetting-controlled Optofluidic Window Shelter for Building Natural Daylighting."

Sandu in Romania


Sandu

Professor **Corina Sandu** gave a keynote lecture titled “Performance Evaluation and Modeling of Pneumatic Tires on Soft Soil and Icy Roads” at the 12th International Congress of Automotive and Transport Engineering, organized by Transilvania University of Brasov and The Society of Automotive Engineers of Romania, Oct. 26-29. A list of event speakers can be found on the conference website.

Tarazaga in Washington D.C.


Tarazaga

Assistant Professor **Pablo Tarazaga** and post-doctoral student Sriram Malladi, presented a poster, "Using Smart Infrastructure to Improve Health" to the Virginia Academy of Science, Engineering and Medicine at the VASEM's 2016 Annual Summit at the National Academy of Sciences in Washington D.C. Nov. 17-18. While there, the two met Virginia Senator Mark Warner.

Lei Zuo in California, Canada, Roanoke


Zuo

Lei Zuo, John R. Jones III Associate Professor, gave an invited seminar in the Distinguished Speaker Series, at the Dept. of Mechanical & Industrial Engineering, University of Toronto, “Energy Harvesting: from Wireless Sensing to Renewable Energy,” Sept. 23.

On Oct. 4, Zuo spoke about energy harvesting to the Roanoke County Middle School Gifted Students group. The talk was sponsored by the Center for the Enhancement of Engineering Diversity. He also gave a guest lecture Nov. 10 to first-year students in ENGR 1054-Galileo Seminar organized by CEED.

On Nov. 16 and 17 he spoke on "Mechanical Motion Rectifier: a Breakthrough for Large Scale Energy Harvesting," at IDTecEx Energy Harvesting and Storage USA conference in Santa Clara, CA; and provided a seminar, "Energy

Continued on Page 8

ME supports Engineers Without Borders mission to Uganda

The ME department recently made matching funds of $4,000 available to the Virginia Tech Chapter of **Engineers Without Borders**. The group received a $5,000 grant from Northrup Grumman to support a student-led humanitarian project in Uganda this summer

Students earn honors

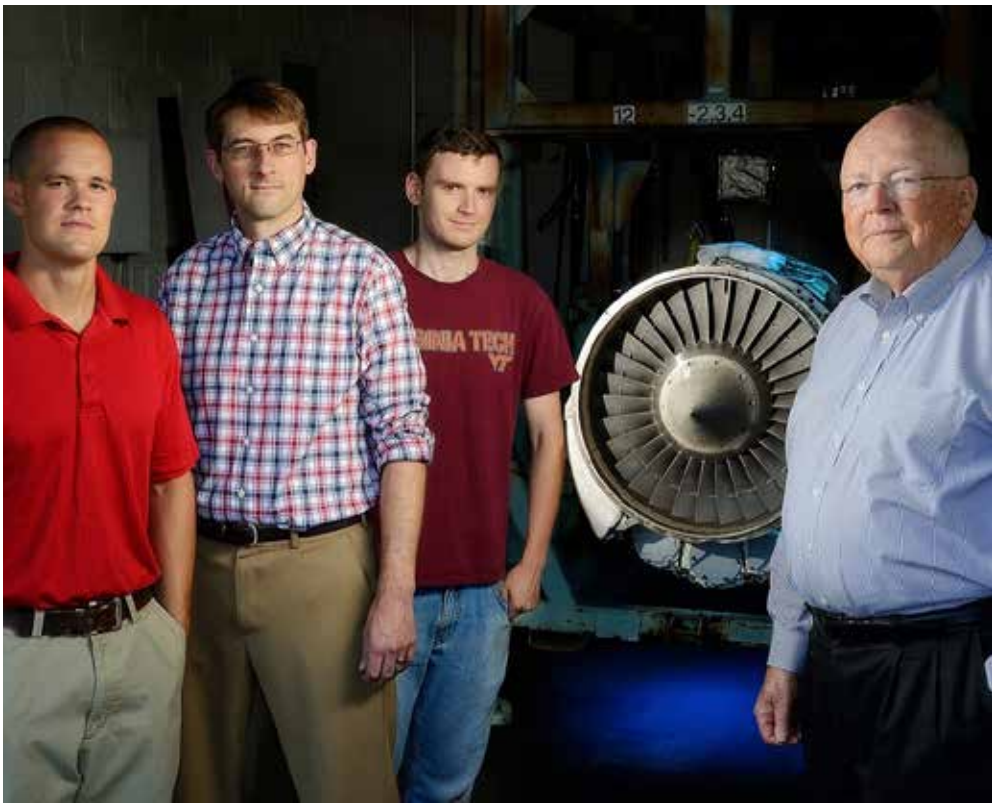
Eurydice Kanimba, a doctoral student, recently received an ASME-Energy Sources and Processing, Petroleum Division academic scholarship; and **Hao Ma**, a doctoral student, were selected to attend the Eighteenth National School on Neutron and X-ray Scattering July 30 - Aug. 13 at the Argonne National Laboratory and Oak Ridge National Laboratory. Both students are under the advisement of **Zhiting Tian**, assistant professor.

Graduate student assembly delegates

Congratulations and thanks to **Jonathan Hodges** and **Ali Roghani** for their work as Graduate Student Assembly delegates for the Mechanical Engineering Department.

ME on social media

Facebook: VTMechanicalEngineering
Twitter: @VirginiaTech_ME
Instagram: VirginiaTech_ME



From left, Justin Bailey, mechanical engineering doctoral student and research assistant in the Turbolab; Todd Lowe, associate professor of aerospace and ocean engineering and assistant director of the Turbolab; John Gillespie, project engineer in the Turbolab; and Walter O'Brien, the J. Bernard Jones Professor of Mechanical Engineering and director of the Turbolab, with one of the two Honeywell 12-to-14-passenger jet aircraft engines.

Honeywell donates two aircraft engines worth nearly $1.5 million to Turbolab

Honeywell International has donated two turbofan aircraft engines commonly found on the Learjet 31, Cessna Citation III, and Dassault Falcon 900, allowing Virginia Tech students and faculty to pursue exclusive research and experience valuable hands-on learning.

Through instrumentation techniques developed by researchers in the TurboLab, the Honeywell TFE731-2 jet engines, worth approximately $1.5 million, will be used to develop new aerodynamic technologies, targeting Honeywell's strategic areas of discovery that could impact manufacturing of engines for commercial and military aircraft.

"We are grateful for industry partners like Honeywell. Because of their generous donation, our students and faculty are able to conduct cutting-edge propulsion research that is entirely exclusive," said Walter O'Brien, the J. Bernard Jones Professor of Mechanical Engineering and director of the TurboLab. "Together with Honeywell, through innovative research, we are able to educate the best and the brightest engineers, innovators, and scientists while advancing technology and addressing critical aeronautical challenges."

Next-generation commercial airframes produce distorted airflows that compromise engine performance. Researchers will use the engines to measure their response to distorted inflows.

Read the whole story at VTNews.

Tian selected as Scholar of the Week

Tian

The Office of the Vice President for Research and Innovation recognized Zhiting Tian, assistant professor of mechanical engineering, as Scholar of the week for her investigations of nanoscale energy transport processes and their potential applications.

Tian and her ZT Group study nanoscale thermal transport properties in semiconductors, polymers, hybrid composites, and novel low-dimensional materials.

Tian's current projects include enhancing cross-plane thermal conductivity of polymer-based thin films, and nano-engineered thermo-electric systems for portable power sources.

Tian earned her Ph.D. in from MIT and was awarded an NSF ASSIST travel grant to attend the Academic Leadership in Women Engineering Program of the Society of Women Engineers in 2016.

She also received the 2016 Undergraduate Research Advisor Award for the College of Engineering.

Harvesting: From Micro Watts to Mega Watts" at the Dept. of Mechanical Engineering at the University of California, Berkeley.

Eskandarian/Zuo at DSCC


Eskandarian

Professor **Azim Eskandarian**, and John R. Jones III Associate Professor **Lei Zuo** attended the ASME 2016 Dynamic Systems and Control Conference Oct. 12-14 in Minneapolis, MN. Zuo was on the conference organizing committee as the Exhibits and Industry Chair and served as a judge for the best paper competition. The ASME 2017 Dynamic Systems and Control Conference will be chaired by Eskandarian.

Ekkad in India

Rolls Royce Professor **Srinath Ekkad** provided the keynote speech at the 2016 Asian Congress on Gas Turbines Nov. 14-16 in Mumbai, India. The title of his talk was, *Heat Transfer Behavior in Combustors: Challenges and Opportunities*.

ME represents at SAE ComVec

Professor **Corina Sandu** and three graduate students, **Rui He, Emilio Jimenez**, and **Aamir Khan**, attended the SAE Commercial Vehicles Congress and Exhibition in Rosemont, IL, Oct. 3-6. He presented the paper, *Investigating the Parameterization of Dugoff Tire Model using Experimental Tire-Ice Data*, co-authored by Jimenez, Sandu, and collaborators from the Ilmenau Technical University in Germany. The paper resulted from joint work conducted under the European Commission project EVE.

Sandu also attended several meetings at the SAE Commercial Vehicles Congress and Exhibition. She has been a member of the Society of Automotive Engineers for 19 years, served as vice-chair of the SAE Chassis and Suspension Committee for nine years and as chair for two years. She has been a member of the SAE ComVec Activity Committee for nine years. Since January she has been an elected member-at-large of the SAE Engineering Meeting Board. She has been the Editor-in-Chief of SAE's International Journal of Commercial Vehicles for the past six years and this year was elected vice-chair of the SAE International Journals Editors Committee. Prior to the conference, she co-edited a Special Issue of the journal with the Best Papers of 2016 ComVec.

Sandu, students at ISTVS

Professor **Corina Sandu** and three graduate students presented papers at the 8th Americas Regional Conference of the International Society for Terrain-Vehicle Systems Sept. 12-14 in Troy, Michigan.

Doctoral student **Emilio Jimenez** presented, *Temperature Distribution and Traction Measurements at the Tire-Ice Interface*. Doctoral student **Rui He** presented, *A Technical Survey on Equipment and Techniques of Testing and Parameterization of Soft Soil for Vehicular Applications*.

Doctoral student **Jody Priddy**, who is co-advised by Sandu, was co-author on the paper, *An Introduction to DROVE: Database Records for Off-road Vehicle Environments*.

Also attending the conference was masters student **Aamir Kahn**.

Sandu also attended the ISTVS Board of Directors meeting and co-organized and co-chaired two sessions at the conference. She has been an ISTVS member for 14 years and serves as the second vice president.

publications & awards

Ben-Tzvi & Saab


Ben-Tzvi

Associate Professor **Pinhas Ben-Tzvi** and his doctoral student **Wael Saab** have published the following peer-reviewed journal publication: *A Genderless Coupling Mechanism with 6-DOF Misalignment Capability for Modular Self-Reconfigurable Robots* in the Journal of Mechanisms and Robotics, Transactions of the ASME, Vol. 8, Issue 6, pp. 061014: 1-9, December 2016.

Ben-Tzvi & Kumar

Ben-Tzvi and doctoral student **Anil Kumar** have published the following peer-reviewed journal publication: *Spatial Object Tracking System Based on Linear Optical Sensor Arrays* in the IEEE Sensors Journal, Vol. 16, Issue 22, pp.

7933-7940, November 2016.

Ben-Tzvi & Ma

Pinhas Ben-Tzvi, former doctoral student **Zhou Ma** and collaborator Jerome Danoff from the George Washington University, had their paper, *The Design Evolution of a Sensing and Force-Feedback Exoskeleton Robotic (SAFER) Glove for Hand Rehabilitation Application*, published in the Journal of Mechanisms and Robotics, Transactions of the ASME.

Nain in Biophysical Journal


Nain

Amrinder Nain's manuscript, *Nanonet Force Microscopy for Measuring Cell Forces* was published in the Biophysical Journal. The journal also selected a movie clip involving his work to be added the journal's website as well. You can view the video clip here.

Tian has book chapter accepted

Assistant Professor **Zhiting Tian** and her doctoral student **Eurydice Kanimba** have had an invited book chapter titled, *Modeling of a Thermoelectric Generator Device* accepted for publication. The book Thermoelectric Power Generation – Advanced Materials and Devices does not yet have a publication date.

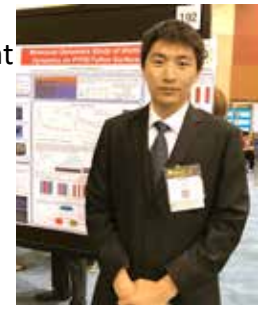
Tian, Li and Ma publish work

Chen Li, Hao Ma, and Assistant Professor **Zhiting Tian** have published a paper on *Thermoelectric Properties of Crystalline and Amorphous Polypyrrole: A Computational Study*, in the journal Applied Thermal Engineering. The results may shed light on improving the figure of merit ZT of conducting polymers for organic thermoelectric applications. Li and Ma are PhD students in the Tian lab.

Cheng awarded best paper

Jiangtao Cheng received a Best Paper Award for his paper, *Electrowetting-Controlled Dual Liquid Prism for Adaptive Beam Steering* at the 12th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics held in Costa del Sol, Spain.

Zhao takes 3rd at IMECE



Lei Zhao, a doctoral student with Jiangtao Cheng's lab, took 3rd place at the ASME International Mechanical Engineering Congress and Exposition 2016's National Science Foundation Student Competition. Zhao's poster was titled, *Molecular Dynamics Study of Contact Line Dynamics of Water Droplets on Polytetrafluoroethylene Surfaces*.

Undergraduate earns German scholarship

Mechanical engineering student **Megan Lorey** was awarded a German Academic Exchange Service, DAAD, scholarship. The group is the largest funding organization in the world supporting international exchange of students and scholars. Recipients of the highly-competitive scholarships are selected on outstanding academics and convincing project proposals.

Lorey, is enrolled in the ME Dual Degree Program with Technische Universitat, Darmstadt, where she began her semester in October.

"The scholarship was suggested to me by my program coordinator, Professor (Jan Helge) Bøhn," she said. "I was interested in learning a language and diversifying my engineering education and started learning German at Virginia Tech a little more than a year ago. I've taken three German classes at Tech and two more intensive courses in Germany."

To learn more about the dual Master of Science Programs, visit the TUD/VT website.

Ben-Tzvi, Williams invited as associate, guest journal editors

Associate Professor **Pinhas Ben-Tzvi** has been invited to serve as an associate editor of the IEEE Robotics and Automation Society's conference editorial board for the 2017 IEEE International Conference on Robotics and Automation (ICRA 2017). The 2017 conference will be held from May 29 to June 3, 2017 at Sands Expo and Convention Centre, Marina Bay Sands in Singapore. ICRA is the society's flagship conference.


Williams

Associate Professor **Christopher Williams** has been invited as a guest editor on a special issue of the ASME Journal of Mechanical Design on "Designing for Additive Manufacturing" which is scheduled to be published in October 2017.

Galipatia Living and Learning

Wing Ng, the Christopher Kraft Endowed Professor of Mechanical Engineering, poses with members of the Galipatia Living Learning Community in November. Ng discussed career development with the students there. The talk, part of Galipatia's 'Slush Rush' event, focused on what students could expect post-college in the career world, what they could expect as they moved into graduate school, and details about reaching out as an entrepreneur. Ng began the company Techsburg about 20 years ago. Today the business attracts global clients in the aerospace industry.

ME junior receives Fralin Undergraduate Fellowship

The department congratulates **Ahmed Elnahhas**, a junior ME major for his selection as one of 14 students who started work as Fralin Life Science Institute's first undergraduate research Fellows.

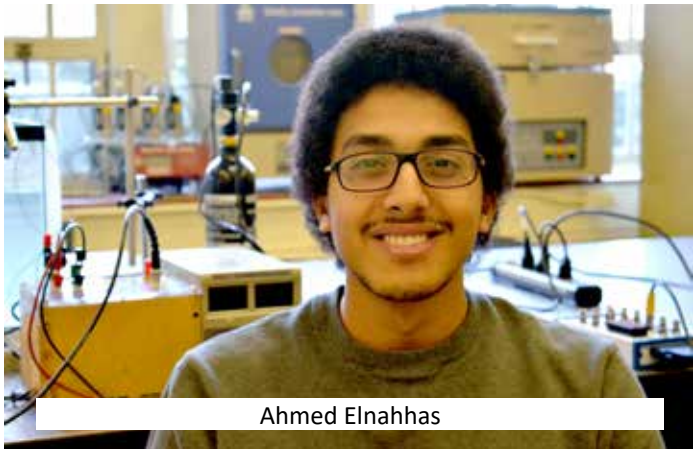
The program, created by Dennis Dean, director of the Fralin Life Science Institute and the university's Stroobants Professor of Biotechnology, in partnership with the Office of Undergraduate Research, is a competitive award open to all VT undergraduates with a goal of increasing diversity in research.

Each Fellow receives $1,000 to conduct research with a Virginia Tech faculty mentor over the course of one academic year.

"We are really pleased with this inaugural group of Fellows," said Keri Swaby, coordinator of the Office of Undergraduate Research. "In their applications, these students demonstrated academic excellence and innovative ideas for research. We can't wait to watch their projects develop throughout the year."

The fellowships will be available each year for the next decade and will be funded by donations from Dean.

Students from underrepresented groups, including, but not limited to, ethnic minorities, first-generation college students, students from low income areas, students with disabilities, and LGBTQ students, are strongly encouraged to apply.



Ahmed Elnahhas

Senior design team raises funds to help Malawi hospital

A senior design project advised by Associate Professor Kevin Kochersberger raised more than $1,500 over the course of the past year and used some of the funds to help buy 250 sets of much-needed bed linen for the Mulanje Mission Hospital in Mulanje, Malawi.

"The hospital has been involved with and welcomed a number of our senior design projects over the past several years and we asked how we could help," said Kochersberger.

Ruth Shakespeare, who has been a long-time volunteer with the hospital, informed Kochersberger that new linen is always welcome at the facility, so he and his team sent the items through a charity out of Pennsylvania. They arrived in Malawi in early December.

Currently, there are more than half a dozen senior design teams working on a variety of humanitarian-inspired projects including low-resource washing machines, and deep-well drills, to modular septic systems. Look for more on these programs in an upcoming issue of Momentum in 2017.

A nurse at the Mulanje Mission Hospital unpacks the 250 sets of sheets provided to the facility by members of Associate Professor Kevin Kochersberger's senior design teams.

To Give to the Mechanical Engineering Department...

Click here and follow the steps below:

STEP 1
Click Here

STEP 2 - Be sure to add "Mechanical Engineering" in this box and *Thank You!*

3D Additive Manufacturing projects bring ideas to life

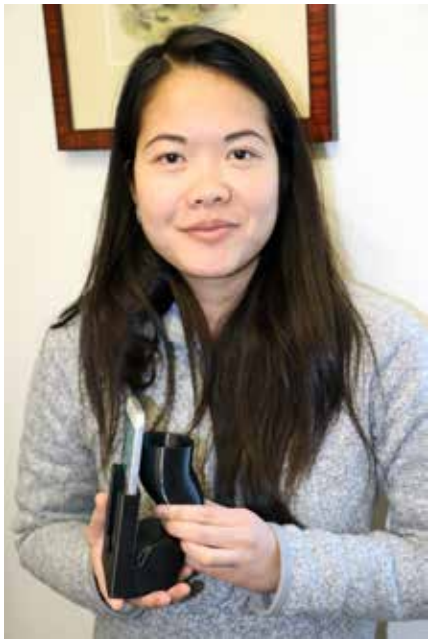
Senior undergraduate students and first year graduate students recently finished a course where members of the groups team up to design and produce items using additive manufacturing techniques.

"The course is about more than making cool stuff," says Associate Professor Chris Williams, who instructs the course. "The idea is to go beyond lecturing and have students be able to do the cost modeling, materials selection, research, and ultimately, to fabricate using an emerging technology. Industry has a need for engineers who know how to use this technology and take advantage of the strengths of additive manufacturing."

In addition to providing valuable technical skills, the class provides graduate students mentoring opportunities and undergraduates the opportunity to engage in graduate-level work.

Among the teams finishing their projects in December is Vy Nguyen, a first-year MSME student who studies gas turbines, and her teammates Olivia Heisner and Cecilia Stout, both senior undergraduates in ME. Together they designed a powerless cellphone amplifier.

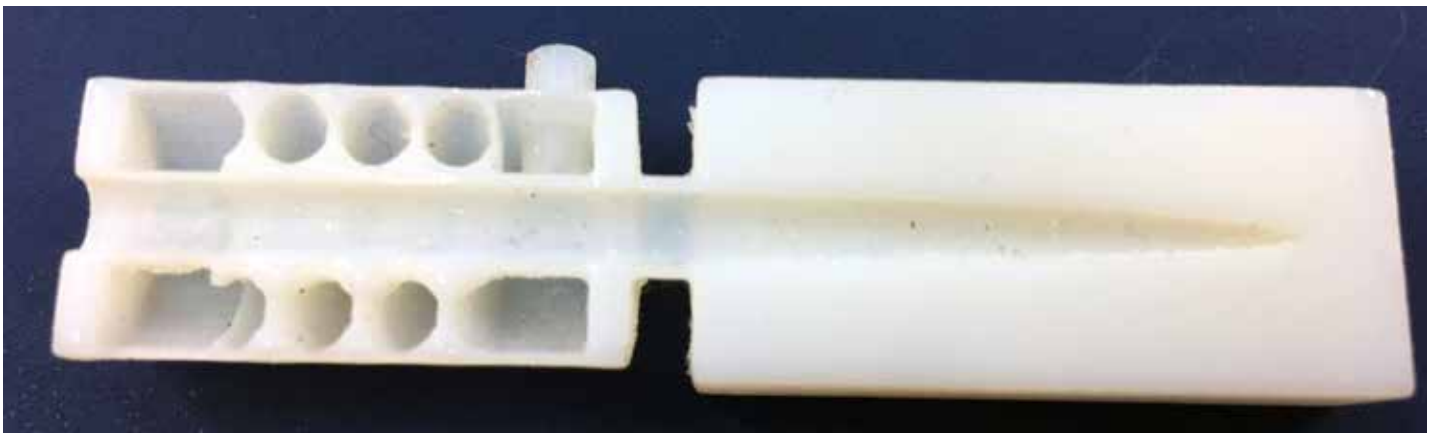
"The idea started during a trip to Uganda with Engineers Without Borders," Nguyen said. "We were watching a movie on an iPad and we placed in it a box and made holes to redirect the sound."



The simple contraption not only directed the sound but also amplified it, so the team began to look at designs to passively amplify sound from a cell phone.

The team's final product features eight holes for sound in any direction, weighs about 360 grams, and is about one-quarter of an inch thick. Nguyen says they think a redesign can reduce the weight and thickness by nearly half.

Above Vy Nguyen shows the second design for a cell phone powerless amplifier. At left the designs the group tried. The final design at far right sends sound out in all directions and Nguyen says with minor redesign, could be made nearly half as thick and at nearly half its current 360 gram weight.



Projects from the additive manufacturing class included the following clockwise from top left: A sound field microphone with embedded sensors; a topology optimized longboard truck; a computer mouse for individuals with limited motor control; a 3D-printed, 3D printing nozzle; and a waterproof keyboard. Other items (not pictured) included a DMLS axial compressor stator with sensing channels, and custom golf grips. *All photos this page courtesy of Chris Williams via Twitter @DREAMSLab*

Absorbing sunlight, household light

Flexible solar panels offer opportunity to get solar power off the roof and onto walls, curtains, clothing ...

Story-Rosaire Bushey
Mechanical Engineering

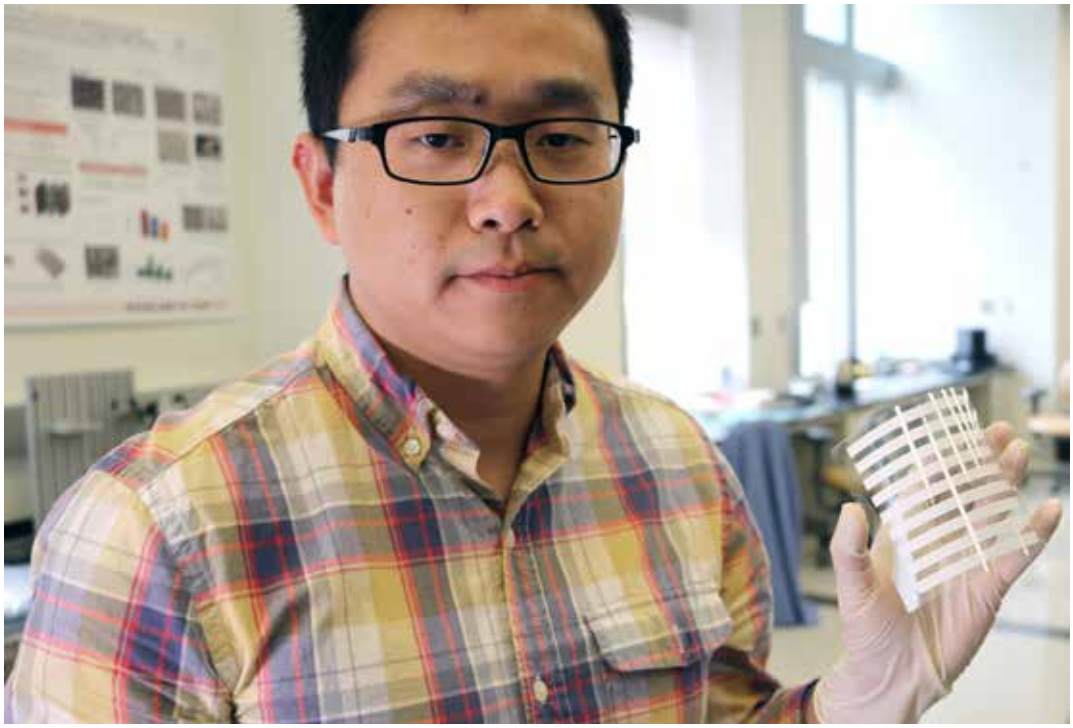
In the very near future, recycling light energy may be easier than recycling any other item in your house.

Led by Shashank Priya, the Robert E. Hord Jr. Professor of Mechanical Engineering, a team of mechanical and materials engineers and chemists at Virginia Tech, including post-doctoral researchers Xiaojia Zheng and Congcong Wu, as well as College of Science chemistry Professor Robert Moore and Assistant Professor Amanda Morris, is producing flexible solar panels that can become part of window shades or wallpaper that will capture light from the sun as well as light from sources inside buildings.

Solar modules less than half-a-millimeter thick are being created through a screen-printing process using low-temperature titanium oxide paste as part of a five-layer structure that creates thin, flexible panels similar to tiles in one's bathroom. These tiles can be combined together to cover large areas; an individual panel, roughly the size of a person's palm, provides about 75 milliwatts of power, meaning a panel the size of a standard sheet of paper could easily recharge a typical smart phone.

Most silicon-based panels can absorb only sunlight, but the flexible panels are constructed to be able to absorb diffused light, such as that produced by LED, incandescent, and fluorescent fixtures, according to Priya.

"There are several elements that make the technology very appealing," said Priya. "First, it can be manufactured easily at low temperature, so the equipment to fabricate the panels is relatively inexpensive and easy to operate. Second, the scalability of being able to create the panels in sheet rolls means you could wallpaper your home in these panels to run everything from your alarm system, to recharging



Using screen printing technology, low temperature titanium oxide paste is applied to the plastic in a process that takes mere seconds. These panels make up multiple layers of the five layer finished product.

your devices, to powering your LED lights."

The panels, Priya said, can also be made to any design, so they could become window shades and curtains as well, absorbing sunlight through windows.

"The properties of the panels are such that there are really few limitations in terms of light source," Priya said. "And the fact that we are dealing with an emerging technology, means we will be able to expand the utility of the panels as we go forward."

Currently, the efficiency of the cells is nearly on par with the heavier, rigid silicon structures, but, Priya said, at panel-level there is some research required. Still, it is likely the new flexible panels will overtake their rigid cousins soon.

"Amorphous silicon is a fairly mature technology running at about 13-15 percent efficiency," he said. "Our panels right now operate around 10 percent at the panel size. At smaller, less-useful sizes, the efficiency increases, and so we can see a potential for much greater energy collection efficiencies."

The flexible panels, as they approach the conversion efficiency of rigid silicon and glass, can also be incorporated into products that the older technology cannot compete with – such as military uniforms and backpacks, items Priya's lab is working on now with the U.S. Army's Communications-Electronics Research, Development, and Engineering Center. By adding flexible panels to these items, soldiers will become their own recharging stations, resulting in reduction of the logistical footprint of a fighting force in the field, as well as the weight each individual soldier must carry on his or her back.

"Right now we are on the cutting edge of this technology," Priya said. "Our edge is in the ability to fabricate large-area modules with high efficiency. We are actively working to integrate the product with the market and we see a wide variety of uses for the technology, from clothing to windows, to smart buildings to UAVs to mobile charging stations."

The work of Priya and his team is detailed in the papers, *The Controlling Mechanism for Potential Loss in CH3NH3PbBr3 Hybrid Solar Cells*, published in the July issue of ACS Energy Letters, and *Scaling of the Flexible Dye Sensitized Solar Cell Module*, available online now in the journal Solar Energy Materials and Solar Cells. The article was published in the journal's December edition.

By creating panels that capture a wide variety of light wavelengths, Virginia Tech engineers are opening a door to an entirely new area of light and energy recycling that could make saving energy as easy as hanging a curtain. Another paper demonstrating the stability of the cells was published by ACS Energy Letters in October under the title, *Improved Phase Stability of Formamidinium Lead Triiodide Perovskite by Strain Relaxation*.

High-performance piezoelectric material could make smart sensors more sensitive

Story-Eleanor Nelsen
Institute for Critical Technology and Applied Science

As gathering and transmitting detailed information about the environment becomes an integrated feature of mobile devices, cars, and homes, the race is on among materials scientists to create more sensitive materials for finely tuned sensors.

"The tiniest amount of stress you can detect determines how competitive you are with other sensing technologies," said Shashank Priya, the Robert E. Hord Jr. Professor of Mechanical Engineering in the College of Engineering and the associate director for research and scholarship at the Institute for Critical Technology and Applied Science.

In a study recently published in Nature Communications, Priya and research assistant professor Yongke Yan report a new composition and synthesis technique for piezoelectric materials that, by controlling the material's microstructure, increases its sensitivity by three to five times. The technique, developed in collaboration with researchers at Michigan Tech, could enable high-performance sensors for a wide range of applications.

Piezoelectric materials can make ideal sensors because they turn mechanical input, such as sound or pressure changes, into electricity.

"In a smart home, automotive, or industrial environment, for example, you want to measure everything: temperature, pressure, strain, fluid flow, acceleration, wind flow, light. All this can be done by piezoelectric devices," Priya said.

These sensors don't need electricity to run, and can generate the power required to transmit data by harvesting mechanical energy from routine movements in the environment — footsteps, for example.

These properties, along with a relatively simple manufacturing process, have led to the ubiquitous use of piezoelectric materials in an array of devices, from speakers to touch-activated light switches to robots for medical applications.

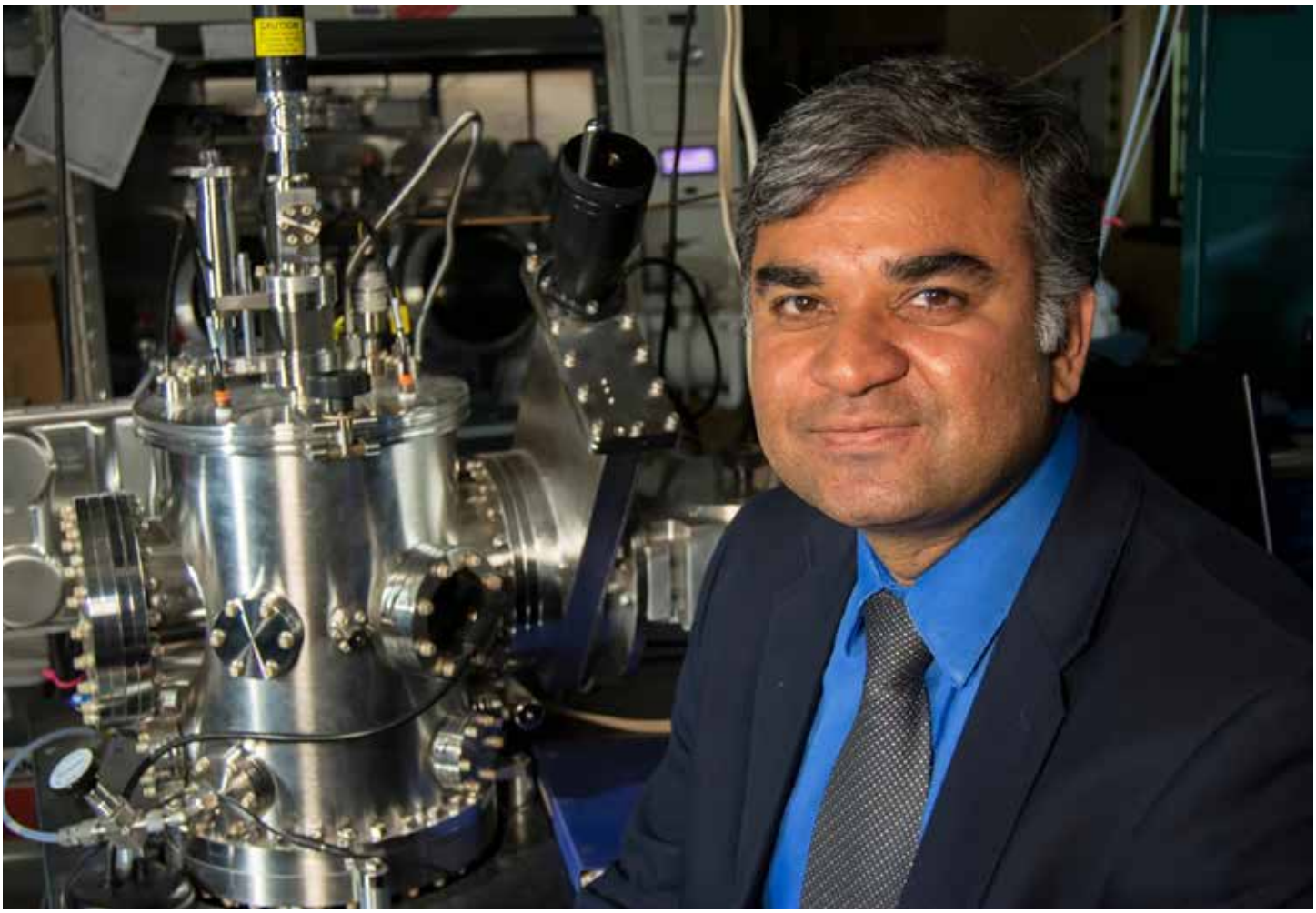
The greater the mechanical input, or stress, on a piezoelectric material, the larger the voltage it generates. Some materials are more sensitive than others, generating larger voltages from the same amount of stress; these make the most precise sensors.

To achieve huge gains in sensitivity for their piezoelectric material, Priya and his coworkers targeted its texture.

Ceramic piezoelectric materials, including the lead titanate used in Priya's study, are made up of grains, similar to the bricks in a wall, that give the material a three-dimensional texture. The orientation of the grains helps determines how well the material converts mechanical stress into electricity.

In most piezoelectric materials, these grains are randomly aligned. To create a ceramic with a more organized texture, the team added a small percentage of "seed" crystals that acted like a template, allowing the grains to form and grow with similar orientations.

Thanks to the seed crystals and other additives that modified the material's electromechanical behavior,



the new material is more than three times as sensitive to mechanical input compared to other piezoelectric ceramics.

These additions can be easily incorporated into the standard procedures that are already used to manufacture these materials industrially.

"That's the beauty of this research: we didn't have to change what people are already using," said Priya. "We used exactly the same machine, the same process, the same chemicals — all we do is mix this small seed crystal in the powder. But the end result is that 99 percent or more of the grains are aligned. And that gives you a 300 to 500 percent improvement in properties."

The material is also stable at high temperatures, making it useful for automotive or aerospace applications.

Companies are already working with Virginia Tech to apply the texturing technique in their manufacturing facilities.

"We are hoping that this manufacturing process can offer U.S. companies a way to capture some new markets and design some really competitive devices," Priya said.

Priya's group has also developed lead-free piezoelectric ceramics, which could reduce the environmental impact of these materials.