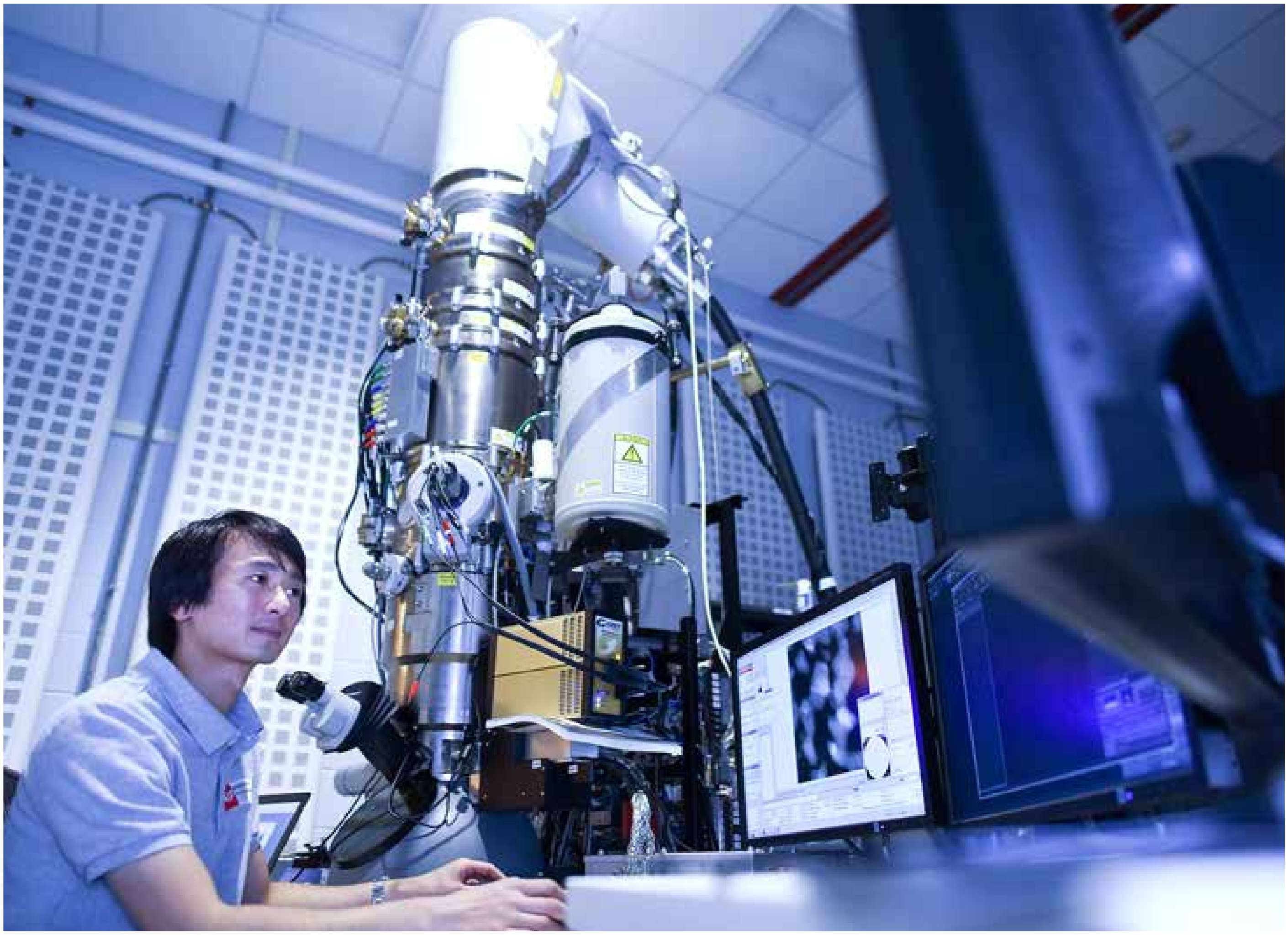
NC STATE Engineering

DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING NEWSLETTER

WINTER 2020



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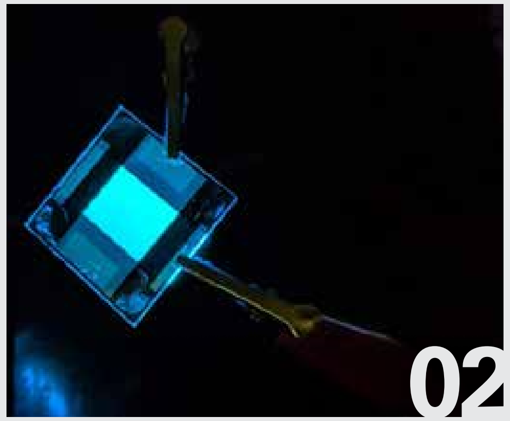

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UPDATE FROM THE **DEPARTMENT HEAD**

DEAR MSE FRIENDS AND STAKEHOLDERS,

"It's a challenging time" is probably one of the most repeated phrases over the last year, yet it does not quite capture what we have been going through. A global health crisis, lingering racial injustices and a seeming myriad of other issues keep challenging us. But we are engineers, and what we do is face challenges, work through solutions and keep moving forward.

Like many other universities, our optimism for starting classes as usual this fall were met some unsurmountable obstacles, and while we are able to keep research labs open, we were forced to go to on-line classes for our undergraduate program and to limited class sizes for our graduate program. The good news is that our students are resilient, our faculty are caring, passionate and creative, and the university has provided the technology knowhow that has proven critical to continuing our long tradition of academic excellence. We have also rededicated ourselves to enhancing diversity and fighting racial injustices with a variety of efforts and new initiatives.

Our faculty members are continuing to garner awards and recognition both inside and outside of the university. This past year a pair of our faculty members, Profs. Beth Dickey and Jacob Jones, were named distinguished professors, bringing our total number of distinguished MSE faculty members to eight. Adding to this the four University Faculty Scholars means that over half of our faculty members hold a major university recognition.

We also welcomed three new faculty members this past year. Profs. Kaveh Ahadi and Wenpei Gao joined us as assistant professors from the University of California at Santa Barbara and at Irving, respectively, and Prof. Rajeev Gupta joined us as an associate professor from the faculty of the University of Akron. We plan to add more faculty members in the coming years as we build on existing strengths and dive into new research areas. At the same time, some of our top faculty members are moving to new opportunities. Prof. Yuntian Zhu moved as a distinguished professor to the City University of Hong Kong, and Prof. Beth Dickey will become the head of the Department of Materials Science and Engineering at Carnegie Mellon University.

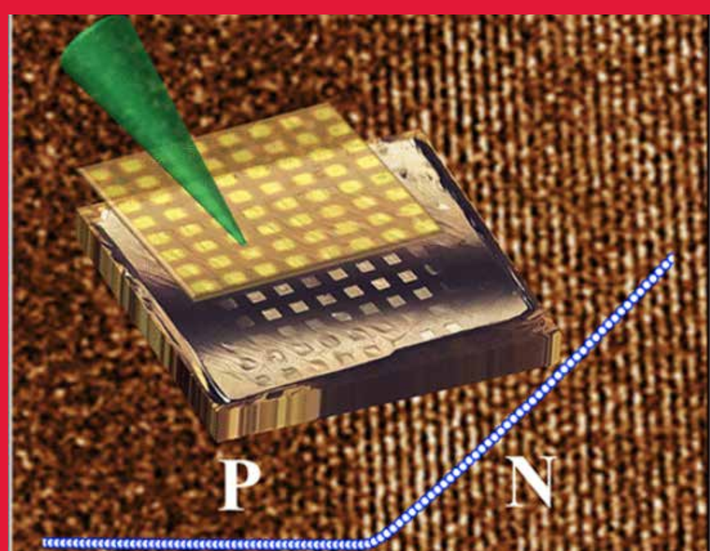
A phrase many of us are hearing too much these days is "you're on mute." This is, of course, just a minor example of the challenges that come with the opportunities that our crises demand for new ways of communicating, educating, doing research and helping each other. As we move forward we are continuing to take full advantage of these new opportunities and meeting challenges head on, because, after all, we are engineers.

Donald W. Brenner
Kobe Steel Distinguished Professor
Department Head

Donald W. Brenner

02

Research Highlights



High-resolution transmission electron microscopy image revealing the atomically-sharp interface between heavily reduced graphene oxide and amorphous carbon. The figure also reveals the PN junction IV characteristics acquired at room-temperature. The sketch at top shows the numerous PN junction diodes formed on silicon using a shadow mask to perform nanosecond laser patterning.

WAFER SCALE GRAPHENE DEVICES AT ROOM TEMPERATURE

Materials researchers have developed a technique that allows them to pattern graphene, graphene oxide (GO) and reduced graphene oxide (rGO) onto silicon wafers at room temperature by using nanosecond pulsed laser annealing. This technique has led to the formation of atomically-sharp p-n junctions between amorphous carbon and rGO. The researchers are already planning to use the technique to create ultrathin CMOS sensors and DRAM devices.

In the new technique, researchers start with silicon wafers. They top them with a layer of amorphous carbon. Then, the researchers melt the amorphous carbon with a single nanosecond laser pulse, which regrows as graphene. As heat flow is spatially and temporally confined, this technique is ideal for melt processing of carbon, which is susceptible to sublimation. If the process is done in a vacuum, the carbon forms on the surface as graphene; if it is done in oxygen, it forms GO; and if done in a humid atmosphere followed by a vacuum, it forms heavily reduced GO.

"Graphene is an excellent conductor, but it cannot be used as a semiconductor. However, rGO is a semiconductor material, which can be used to make electronic devices such as integrated smart sensors and optic-electronic devices. We are working on using this technique to develop smart CMOS sensors and to develop memory devices for computer chips," said Jagdish Narayan, John C. Fan Distinguished Chair Professor.

TECHNIQUE ALLOWS INTEGRATION OF SINGLE-CRYSTAL HYBRID PEROVSKITES INTO ELECTRONICS

An international team of researchers, including Dr. Aram Amassain, associate professor, has developed a technique that allows single-crystal hybrid perovskite materials to be integrated into electronics.

Hybrid perovskite materials contain organic and inorganic components and can be synthesized from inks, making them amenable to large-area roll-to-roll fabrication. These materials are the subject of extensive research for use in solar cells, light-emitting diodes (LEDs) and photodetectors. However, there have been challenges in integrating single-crystal hybrid perovskites into more classical electronic devices.

The challenge in incorporating single-crystal hybrid perovskites into electronics stems from the fact that these macroscopic crystals, when synthesized using conventional techniques, have rough, irregular edges. This makes it difficult to integrate with other materials in such a way that the materials make the high-quality contacts necessary in electronic devices.

The researchers got around this problem by synthesizing the hybrid perovskite crystals between two laminated surfaces, essentially creating a single-crystal hybrid perovskite sandwich. The perovskite conforms to the materials above and below, resulting in a sharp interface between the materials. The substrate and superstrate, the "bread" in the sandwich, can be anything from glass slides to silicon wafers that are already embedded with electrodes — resulting in a ready-made transistor or circuit.

The researchers can fine-tune the electrical properties of the perovskite by selecting different halides for use in the perovskite's chemical make-up. The choice of halide determines the bandgap of the material, which affects the color appearance of the resulting semiconductor and leads to transparent and even imperceptible electronic devices when using high-bandgap perovskites.

NEW METHOD ALLOWS DIRECT CONVERSION OF CARBON FIBERS AND NANOTUBES INTO DIAMOND FIBERS

Research from Jagdish Narayan, John C. Fan Distinguished Chair Professor, has demonstrated a new technique that converts carbon fibers and nanotubes into diamond fibers at ambient temperature and pressure in air using a pulsed laser method.

The conversion method involves melting the carbon using nanosecond laser pulses and then quenching, or rapidly cooling, the material. These diamond fibers could find uses in nanoscale devices with functions ranging from quantum computing, sensing and communication to diamond brushes and field-emission displays. The method can also be used to create diamond-seeded carbon fibers that can be used to grow larger diamond structures using hot-filament chemical vapor deposition and plasma-enhanced chemical vapor deposition techniques. These larger diamond structures could find uses as tool coatings for oil and gas exploration as well as deep-sea drilling, and for diamond jewelry.

"Without undercooling, you cannot convert carbon into diamond this way," Narayan said.

When heated, carbon normally goes from a solid state to a gas. Using a substrate restricts heat flow from the laser pulse enough that the carbon does not change phases.

The laser, similar to those used for LASIK eye surgery, is used for only 100 nanoseconds and heats the carbon to a temperature of 4,000 Kelvin, about 3,727 degrees Celsius.

HIGH-EFFICIENCY LOW-VOLTAGE BLUE FLUORESCENT OLEDS

OLEDs are widely used as displays for mobile phones and TVs at present and are poised to penetrate the lighting and luminary markets. It is generally assumed that the external quantum efficiency of traditional fluorescent organic light emitting diodes (OLEDs) plateaus around five percent. The So and Castellano (Chemistry) research groups at NC State discovered that under certain conditions, the external quantum efficiency for these devices can reach 10 percent whereas the power conversion efficiency of related blue fluorescent OLEDs have also been shown to be as high as that measured in blue phosphorescent OLEDs. This is due to the low drive voltages necessary to achieve blue light emission. These combined experimental findings were recently published in *Nature Communications*.

TECHNIQUE USES MAGNETS, LIGHT TO CONTROL AND RECONFIGURE SOFT ROBOTS

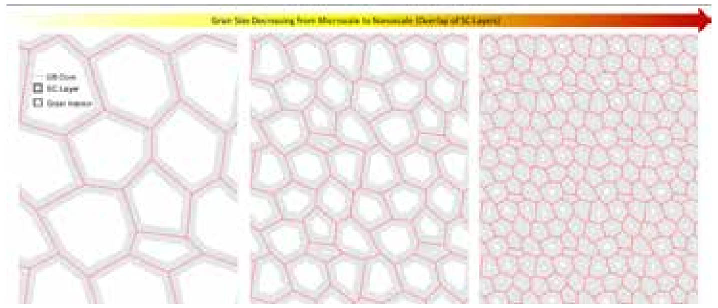
Researchers from MSE, including Dr. Joe Tracy, professor of materials science and engineering, and Elon University have developed a technique that allows them to remotely control the movement of soft robots, lock them into position for as long as needed and later reconfigure the robots into new shapes. The technique relies on light and magnetic fields.

For this work, the researchers used soft robots made of a polymer embedded with magnetic iron microparticles. Under normal conditions, the material is relatively stiff and holds its shape. However, researchers can heat up the material using light from a light-emitting diode (LED), which makes the polymer pliable. Once pliable, researchers demonstrated that they could control the shape of the robot remotely by applying a magnetic field. After forming the desired shape, researchers could remove the LED light, allowing the robot to resume its original stiffness — effectively locking the shape in place.

By applying the light a second time and removing the magnetic field, the researchers could get the soft robots to return to their original shapes. Or they could apply the light again and manipulate the magnetic field to move the robots to assume new shapes.

In experimental testing, the researchers demonstrated that the soft robots could be used to form "grabbers" for lifting and transporting objects. The soft robots could also be used as cantilevers, or folded into "flowers" with petals that bend in different directions.

"We are not limited to binary configurations, such as a grabber being either open or closed," says Jessica Liu, first author of the paper and a Ph.D. student at NC State. "We can control the light to ensure that a robot will hold its shape at any point." ■



RESEARCHERS DEVELOP COMPUTATIONAL MODEL TO BUILD BETTER CAPACITORS

Electronic devices often rely on components made of ceramic materials with a polycrystalline microstructure made up of many single crystal grains. The boundaries between these grains interact with nearby point defects (missing or misplaced atoms / atom clusters), changing the material's properties.

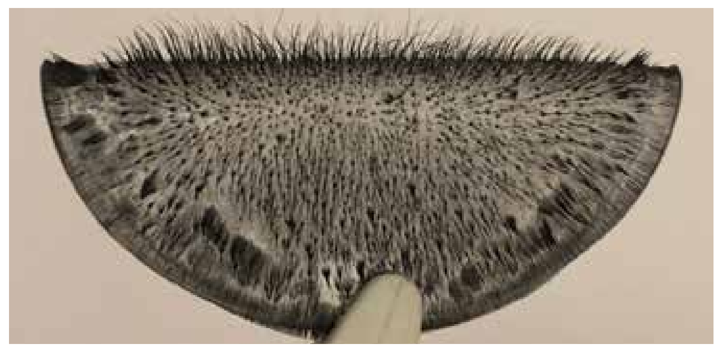
Prof. Douglas Irving's group has recently developed a multiphysics tool to study the effects of grain boundaries on the point defect chemistry and resulting electrical conductivity of polycrystalline strontium titanate. As demonstrated, the grain boundary consists of a space charge layer that dramatically perturbs the local defect chemistry and thus the resultant local conductivity. When the grain size shrinks from microscale to nanoscale, adjacent space charge layers begin to overlap and eventually cover the entire grain interior, leading to significant changes to the electrical conductivity.

The article written by Yifeng Wu, Preston Bowes, Jonathon Baker, and Douglas Irving was selected as an *Editor's Pick* and was featured as a SciLight by the *Journal of Applied Physics* and a NC State news release. The research of this paper was supported by the Materials with Extreme Properties led by Dr. Ali Sayir of the Air Force Office of Scientific Research.

WIDE BAND GAPS LABORATORY AT THE FOREFRONT OF UV DISINFECTION OF SURFACES

Research led by Profs. Ramón Collazo and Zlatko Sitar on the development of materials for portable ultraviolet light emitting diodes (UVC LEDs) for disinfection of surfaces was featured in Raleigh's ABC 11 News. The COVID-19 pandemic has only increased the urgency for such devices.

NC State's WideBandgaps Laboratory and its industry partners are actively researching ways to improve the current state of the art of these devices. These LEDs emit light in the ultraviolet part of the light spectrum. More specifically, they emit light at a wavelength of around 265 nanometers (200 nm is about 1/1000 the length of the diameter of human hair). At that wavelength range, DNA can be destroyed very efficiently and thus bacteria and some viruses can be neutralized, including COVID-19. While some UVC LEDs are currently commercially available, they suffer from short lifetime, high cost, and low power.



CONTROLLING ARTIFICIAL CILIA WITH MAGNETIC FIELDS AND LIGHT

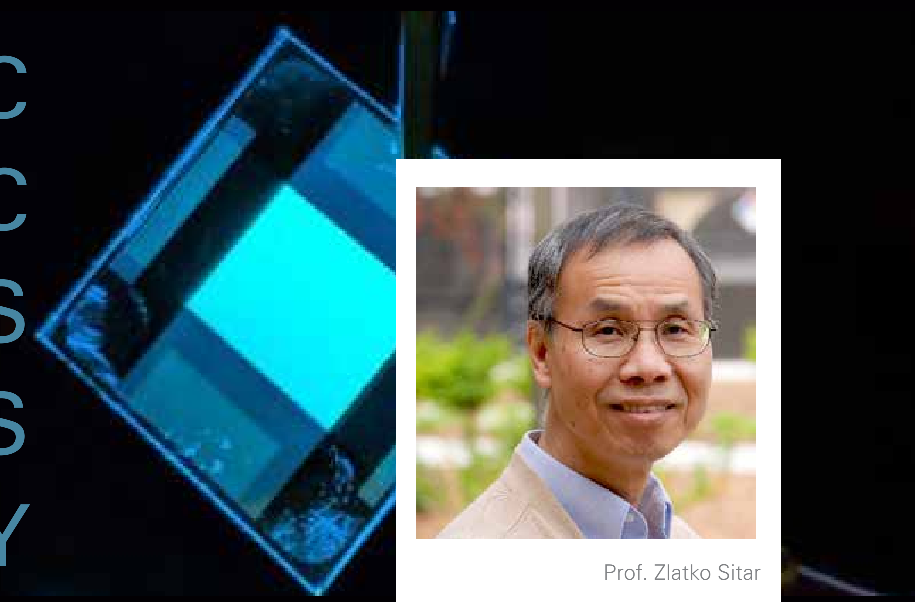
Researchers from NC State and Elon University have made artificial cilia, or hair-like structures, that can bend into new shapes in response to a magnetic field, then return to their original shape when exposed to the proper light source.

"This work expands the capabilities of magnetic cilia and our understanding of their behaviors, which has potential applications in soft robotics, including microrobotics," says Prof. Joe Tracy, corresponding author of a paper on the work and a professor in MSE. "A key point of this work is that we've demonstrated shape memory magnetic cilia whose shape can be set, locked, unlocked and reconfigured. This property will be useful for enhanced and new applications."

"These shape memory magnetic cilia are also simple to fabricate through self-assembly using inexpensive permanent magnets," says Jessica Liu, first author of the paper and a recent Ph.D. graduate from NC State. "We're optimistic that these demonstrations and our model can help the research community design ciliary systems with new capabilities for specific applications."

"We think this work will contribute to advancing the capabilities of soft robotics," Tracy says. ■

ORGANIC ELECTRONIC MATERIALS AND DEVICES LABORATORY



Prof. Zlatko Sitar

Until the 1980's, organic semiconductors were a subject of scientific curiosity to chemists. When high efficiency organic light emitting diodes were invented in the late 1990s, research in organic semiconductors started to take off. For microelectronics applications, silicon is able to meet the performance demand due to device miniaturization in the last half century. For optoelectronics applications such as light emitting diodes and lasers, advances are limited due to the availability of direct gap semiconductors and compatibility with the substrate materials. With the development of organic and hybrid semiconductors for optoelectronics applications, on the other hand, the choices become unlimited. Organic semiconductors with high fluorescent yield across the entire visible range are readily available. Today, organic light emitting diode (OLED) displays are widely used in smart phones, tablets and televisions. Dr. Franky So started his career in OLED research at the Motorola Research Laboratories and was instrumental for introducing the world's first OLED displays used in mobile phones in 1999. In 2015, he moved to NC State from the University of Florida, and continued his research in organic and hybrid semiconductors.

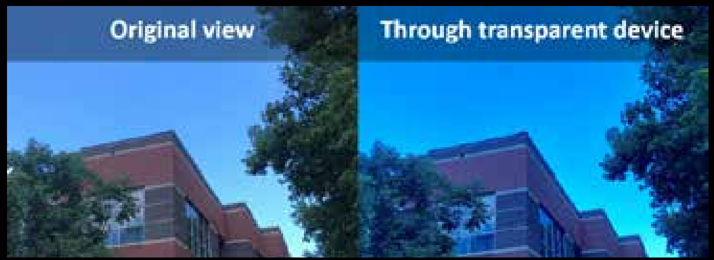
In organic molecules, light emission comes from singlet states or triplet states. Phosphorescent molecules emitting via triplet excited states can have a quantum efficiency of 100 percent while fluorescent molecules emitting via singlet excited states can have a quantum efficiency of 25 percent. Therefore, today high efficiency OLEDs are made with phosphorescent molecules emitting light via their triplet excited states. Although phosphorescent molecules emitting red and green light have sufficient lifetime for applications, the lifetime of blue OLEDs is still lacking. The reason for the short lifetime is due to the high triplet energy along with the long excited lifetime associated with the phosphorescent molecules. When these triplet excited states (called excitons) collide with each other, they generate a much higher energy excitons which can even break chemical bonds, resulting in short device lifetime.

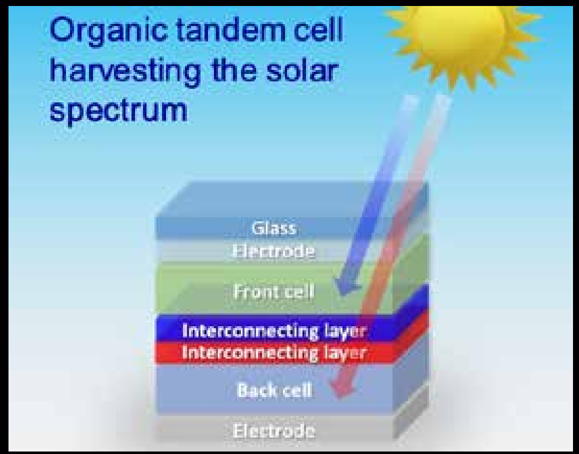
Today, commercial blue OLEDs are made with fluorescent molecules with a lower quantum efficiency. While the quantum efficiency is lower than phosphorescent OLEDs, their lifetime is much longer. In collaboration with Professor Felix Castellano's group in the NC State's Chemistry Department, the two groups discovered that with a combination of device architecture and blue fluorescent emitters, the operating voltage of the blue fluorescent OLEDs can be reduced significantly compared with the conventional phosphorescent counterpart. In fact, they found that the turn-on voltage of the device is lower than the bandgap voltage of the emitting molecule. As a result, the power efficiency of these blue fluorescent OLEDs is comparable with that of phosphorescent devices due to the reduction of the operating voltage. Specifically, the operating voltage of a blue OLED producing a luminance of 1000 candela per square meter (brightness required for a typical TV screen) is just slightly above 3 volts, which is about 50 percent of the voltage required by the phosphorescent counterpart. The low operating voltage is important because the excitons in these devices have a substantially lower energy than those in phosphorescent devices, and it is expected there will be a significant improvement in device lifetime. These findings were recently published in Nature Communications. Because of this finding, a startup is recently founded by So and Castellano to further develop this technology.

In addition to light emitting devices, the So group is also working on solar devices using organic semiconductors. Solar energy is clean, inexhaustible and sustainable. The sun provides 3000 times more energy to the earth than the total energy consumption of the entire world. For widespread development of photovoltaics, it is critical to develop solar cells that are affordable for integration into standard products and systems. Today, while silicon solar panels are widely used for commercial and residential energy harvesting, for certain applications which require aesthetically pleasing appearance, flexibility, light weight and transparency, organic solar cells are ideal for these applications. For these reasons, organic solar cells have attracted extensive attention due to their potential applications for integration into building facades, rooftops, solar windows, automobile sunroofs and green houses. In addition, organic solar cells can be fabricated on flexible substrates by roll-to-rolling printing which can lower the manufacturing costs.

With the rapid development over the past the decade, especially in the searching of photoactive organic materials, the efficiency of organic solar cells achieved a power conversion efficiency beyond 17 percent. However, the electrical conductivity of organic materials limits the photoactive layer absorption thickness and thus limits the performance of organic solar cells. Tandem-junction or multi-junction device architectures present a path toward higher device efficiencies over single-junction devices by extending the light absorption spectral range using multiple photoactive materials within a cell. In a tandem architecture, multiple photoactive layers are stacked together and interconnecting layers are inserted between them for connecting them in series with a minimum voltage loss. Practically, one can consider these multi-junction cells are stacked together with different cells harvesting a different part of the solar spectrum. While the concept of tandem cells is not new, processing of organic solar cells is extremely challenging and reproducibility is highly questionable.

The So group recently discovered that with a certain interconnection material, they developed a simple yet highly reproducible processing method to make tandem organic solar cells, and the processing is compatible with roll-to-roll processing. This method is compatible with multiple organic photoactive layers. Using this strategy, they successfully demonstrated a transparent organic solar cell with a power conversion efficiency more than 12 percent, which is one of the highest efficiency transparent solar cells demonstrated today. These exciting developments open up opportunities for organic solar cells to be used for building integrated photovoltaics (BIPV), and transparent solar cells for automobile sunroof and green house applications. A startup has also been founded to further develop and commercialize the technology ■





07 DEPARTMENT NEWS

Staff Prepares Department for COVID-19

IN MAY, George Martell, the MSE safety and security officer, worked with campus EHS to begin preparing the "Consolidated Plan for a Return to On-Campus Research" document that would become the template for the safe resumption of research on campus. These plans included community standards, PPE distribution, building traffic patterns, how to handle potential COVID-19 positive cases, and much more. Additional members of the MSE facilities team, including Joe Matthews, Toby Tung, and William Douglas, assisted in updating the plan to detail the specific phases for the reopening of labs and classrooms to allow work to continue while minimizing the spread of COVID-19. Within a period of about two weeks, the MSE facilities team had acquired, prepared, and distributed gallons of hand sanitizer and hundreds of face masks. The buildings were posted with traffic patterns, areas of congregation were modified, and the building was prepared for a return to research.

As NC State continues to advance in education and in research programs during these uncertain times, we thank our MSE staff members who helped create a safe environment for our faculty and students to continue working through the pandemic and adapt to the changing environment. George Martell and the facilities team worked diligently to create and enforce a safe environment for research to resume. These efforts have ensured the continuation of the important research and education of the MSE department. While other sectors of campus saw clusters of COVID-19 cases, to date, the materials science and engineering department has not had any positive cases in its labs. Let us all give a hand to the hard work of George Martell and his team for their continued hard work ensuring the safety of the department. ■

Q&A with Prof. Wenpei Gao

Prof. Wenpei Gao

Prof. Wenpei Gao joined the MSE Department in 2009 as an assistant professor. He was a postdoctoral fellow at the University of California, Irving, in the chemical engineering and materials science department. He received his Bachelor of Science in physics from Peking University in Beijing China, which is one of the leading universities in the world. He received his Ph.D. in materials science and engineering from the University of Illinois at Urbana Champaign, where his thesis research focused on atomic imaging of nanoparticles and nanocrystals interacting with oxide surfaces. He was also a visiting scholar at Oak Ridge National Laboratory.

Q&A WITH ASSISTANT PROF. WENPEI GAO

First, welcome to the Wolfpack, and to the Department of Materials Science and Engineering. Can you tell us a little about your early life — where you grew up, and what influences might have directed you toward science and engineering? Did you always want to be a scientist, or did you have other interests early in life?

Prof. Wenpei Gao: My hometown is Dalian, a city by the sea in northeast China. The early life for students in China is nearly the same, classes, exams, and application for schools. Luckily for me, my city offers good weather, the best seafood in China, and well-developed education systems, so I was never bored there. I picked up math and physics as my favorite majors, like most boys, and was crazy about science fictions, so it seems my career is a natural path for me. Honestly, my parents and teachers used to encourage me to be a scientist, sometimes doing well in my study made me feel that can make them proud.

What led you to study physics, and what was your experience like as a student in Peking University?

WG: I am a nature lover, my early recognition on physics was, a lot of logic, reasoning, rational means to understand nature, which I like. I also was very good at it in high school and national-wide competitions. That's why I decided to go to Peking University, arguably the best place in China to study physics, and almost everything else.

I think students in Peking University are proud: it's the oldest higher education system in China; it has the most beautiful campus; it offers the best quality of everything for students. Our teachers are extremely outstanding. Being there also means you have many motivated, intelligent classmates around you. There are always things you can learn there. Now, almost 10 years after I graduated, I still feel so.

What led you to pursue graduate studies in the U.S., and in particular at the University of Illinois at Urbana Champaign? What motivated you to switch from physics to materials science and engineering?

WG: When applying for graduate schools, those in the U.S. are no doubt the top picks. I decided to work on experiments for my Ph.D. So the applications were mostly to engineering schools. University of Illinois is especially strong in materials science and engineering, for me, that means materials physics with some flavor of engineering.

Please describe your current research interests. Are there recent advances in analytical capabilities or in modeling that are allowing you to do things that were not previously possible?

WG: My expertise is developing and applying electron microscopy techniques to study materials and their dynamics at the atomic scale. Recent progress in this field combines the advancement of aberration correction, high-speed high-sensitivity detectors, and big data processing, it is amazing that now we can image very light atoms even in soft materials in real space, and we can capture tiny events in the sub-millisecond time scale. Basically, that means we can approach some mechanisms in physics and chemistry at the level that has never been achieved before.

Where do you see materials science and engineering progressing in 10, 20 and 50 years down the road?

WG: When we think about how far our research has changed since 50 years ago, 20 years ago, and 10 years ago, we will realize it is almost not possible to predict how science will progress. Some challenges haven't been solved for a long time. On the other hand, technology is advancing rapidly, our life is changed by the quick growth of computation power, and advancement of fine machining at very tiny scale. Personally, I believe materials science and engineering will be: more healthcare oriented, soon some disease can be treated by nanodevices; more intelligent, by involving machine learning in many aspect of materials design. I also hope our research can focus on environment, applications should be more energy efficient, bio-degradable, and protect this planet from the materials science aspect.

What experimental or theoretical capabilities do you think are still needed that might lead to breakthroughs in our field?

WG: We still need a lot of effort to improve the capability to manipulate materials down to the atomic scale. Theory has predicted lots of materials properties that might revolutionize our science, but most of them are not possible because of the insufficient techniques to make those materials.

What are you most looking forward to as a faculty member, and is there anything about being a faculty member that makes you nervous or uneasy?

WG: Being a faculty member means a lot of opportunity but also a duty to make a good team to develop our science, to showcase and advocate how our research can make a difference. Besides research, I think the most fun part is to see students succeed in our team. The same thing also makes me a little nervous, because that's a lot of responsibility. However, I believe my group will do well.

Based on your experiences, what advice would you give students who are considering studying STEM fields?

WG: The later part of the story about my physics major: eventually it becomes lots of equations, calculations and simulation, just different from what I knew from the very beginning. What I'd like to say here, is, many people in STEM start from interest, curiosity, and maybe passion, but you also need focus, patience, and sometimes courage to take risks, no matter in academia, or to start your own company. ■

Awards and Recognitions

PROF. BETH DICKEY, distinguished professor and associate department head, has been selected for the Alumni Association Distinguished Graduate Professorship Award. The Alumni Association Distinguished Graduate Professorship recognizes outstanding graduate-level teaching at NC State. Prof. Dickey was one of only four awardees selected university wide. The selection committee was unanimous in its praise of Prof. Dickey's exceptional record of promoting and supporting multiple facets of graduate education at NC State.

Professor Dickey's research focuses on developing processing-structure-property relationships for material systems in which the macroscopic physical properties (mechanical, electrical, thermal, etc.) are governed by grain boundaries or internal interfaces.

Congratulations to **PROF. BETH DICKEY**, who has been named head of the Department of Materials Science and Engineering at Carnegie Mellon University effective January 2021. Prof. Dickey has spent 10 years as part of the NC State MSE Department, where she has held numerous leadership roles including associate department head, director of the Graduate Programs, director of the Center for Dielectrics and Piezoelectrics, director of the NSF Research Traineeship on Data-Enabled Science and Engineering of Atomic Structure, and associate director of the Analytical Instrumentation Facility.

The NC State MSE Department is happy to announce the addition of a new faculty member, **PROF. RAJEEV GUPTA**, who brings critical expertise in the area of corrosion and metallurgical engineering. Prof. Gupta received his B.S. in materials and metallurgical engineering from the Indian Institute of Technology Kanpur, India and his Ph.D. in materials engineering from Monash University, Australia. Prior to joining NC State, he was an assistant professor of chemical, biomolecular, and corrosion engineering at the University of Akron, Ohio.

PROF. DOUGLAS IRVING has been chosen this year as one of only six recipients of the Alumni Distinguished Undergraduate Professor Award. As one of the most prestigious undergraduate awards given on campus, it is presented to those who have proven to be an outstanding instructor and have provided distinguished service in support of undergraduate teaching.

Professor Irving has been a faculty member in the department of Materials Science and Engineering at NC State since 2008 and has distinguished himself among his peers with his passion for undergraduate teaching and the betterment of his students. He was recognized for his development of undergraduate curriculum within the MSE department, his outstanding track record in instruction of MSE undergraduate courses, and for the creation of learning opportunities for undergraduates outside the classroom. Students highlighted Professor Irving's approachability, sense of humor, ability to make difficult concepts understandable, and his passion for their education.

Outside of the classroom, his research group develops computational models that aid in the design of materials for technologically important applications. Current projects include determination of the properties of point defects in wide and ultrawide bandgap materials from density functional theory, development of first principles informed multiscale models used to study electrical conductivity in polycrystalline ceramics and properties of electronic devices, prediction of electrical and optical properties resulting from defect equilibria important to modern devices and quantum information applications, and determination of properties (mechanical and chemical) of multi-principle component and high entropy metallic alloys.

PROF. JACOB JONES has been chosen by the university to be the newest distinguished professor of materials science and engineering. Jones' research interests involve developing structure-property-processing relationships in emerging functional materials, primarily through the use of advanced X-ray and neutron scattering tools. Jones has published over 240 papers and delivered over 130 invited lectures on these topics since 2004. Jones is a Fellow of the IEEE Society and the American Ceramic Society and has received numerous awards for his research and education activities, including an NSF CAREER Award, a Presidential Early Career Award for Scientists and Engineers (PECASE), the IEEE Ferroelectrics Young Investigator Award, the 2019 NC State Alumni Association Outstanding Research Award, the 2016-17 NC State College of Engineering George H. Blessis Outstanding Undergraduate Advisor Award, a National Nuclear Security Administration (NNSA) Defense Program Award of Excellence, a UF-HHMI Science for Life Distinguished Mentor Award for his mentoring of undergraduate researchers, and two Edward C. Henry "Best Paper" awards from the Electronics Division of the American Ceramic Society. ■

New Staff

Hillary Stone

MSE DEPARTMENT WELCOMES NEW STAFF MEMBER, HILLARY STONE, UNDERGRADUATE STUDENT COORDINATOR

HILLARY STONE has joined MSE as the Undergraduate / Graduate Student Coordinator. She will be working with Prof. Yingling and will primarily focus on advising and engaging undergraduate students. She will also be assisting with scholarships, administrative duties related to the curriculum and working with the MSE student ambassadors.

She was previously the student services coordinator with the NC State Intensive English Program. During her four and a half years in that role, she coordinated admissions, marketing, and programming and supervised undergraduate student employees.

In her spare time, Stone enjoys being outdoors, running, and hiking with her goldendoodle, Watson. She loves discovering new hidden gems in Raleigh, whether they are restaurants, breweries, coffee shops, parks, or trails.

Kim Zak

MSE DEPARTMENT WELCOMES NEW STAFF MEMBER, KIM ZAK, MSE HUMAN RESOURCES SPECIALIST

KIM ZAK joined the MSE team as a human resources (HR) specialist in April 2020. She has been working at NC State University for four years in a human resource capacity. She most recently worked in International Employment processing H-1B petitions and as a university support contact for the I-9 system. Her role as an HR specialist in MSE will involve working with faculty members and staff to hire and onboard candidates in temporary and permanent positions. She will also process all visa paperwork by working with the Office of International Services. As an MSE HR contact, she works with University and College of Engineering HR to answer human resource questions. When not answering HR questions, she can be found on the American Tobacco Trail riding her bike, a new hobby. ■

NC STATE RESPONDS TO LOCAL HOSPITALS' CALL TO ACTION

NC STATE'S MSE DEPARTMENT RESPONDED TO THE CALL from local hospitals asking for help in their battle against COVID-19 by donating much needed medical supplies. On March 23rd, the MSE department donated masks, gloves and other medical supplies to help fill the void in supplies left by the fight against the Coronavirus.

Local hospitals ask for donations and they get them!

The MSE department is proud of our faculty members who rose to the challenge and donated their research supplies to help fight the spread of COVID-19, as well as the members of our staff who organized the supplies and made the delivery possible. ■

AIF analytical instrumentation facility

BY THE **NUMBERS**

174 NUMBER OF UNIQUE PRINCIPAL INVESTIGATORS (PIS)
accessing facility from across NC State

22 NUMBER OF UNIQUE MSE FACULTY MEMBERS AND FACULTY RESEARCH GROUPS ACCESSING FACILITY

433 NUMBER OF UNIQUE AIF USERS
undergraduates and graduate students, and postdocs

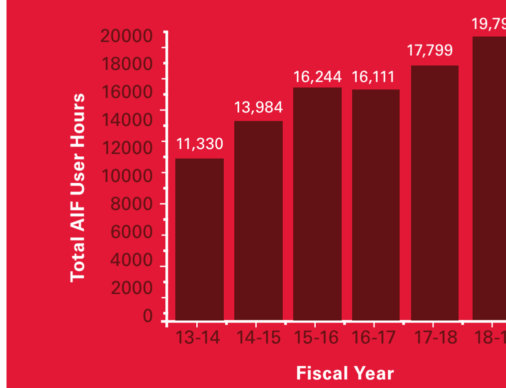
103 NUMBER OF UNIQUE MSE USERS
undergraduates and graduate students, and postdocs

5,755 TOTAL NUMBER OF HOURS SPENT AT AIF BY MSE USERS
29 percent of all usage, reflecting the interdisciplinary nature of the facility

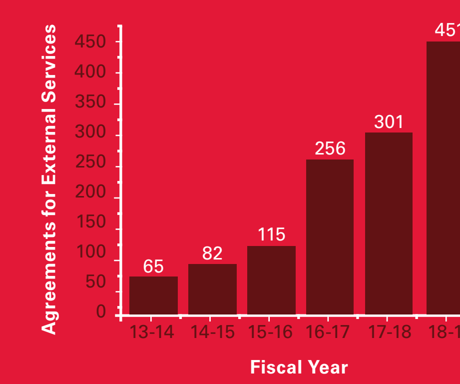
MOST USED Instruments by **MSE** at **AIF**

1. Rigaku X-ray diffractometer
2. FEI Verios field emission scanning electron microscope
3. EI Titan aberration-corrected scanning transmission electron microscope

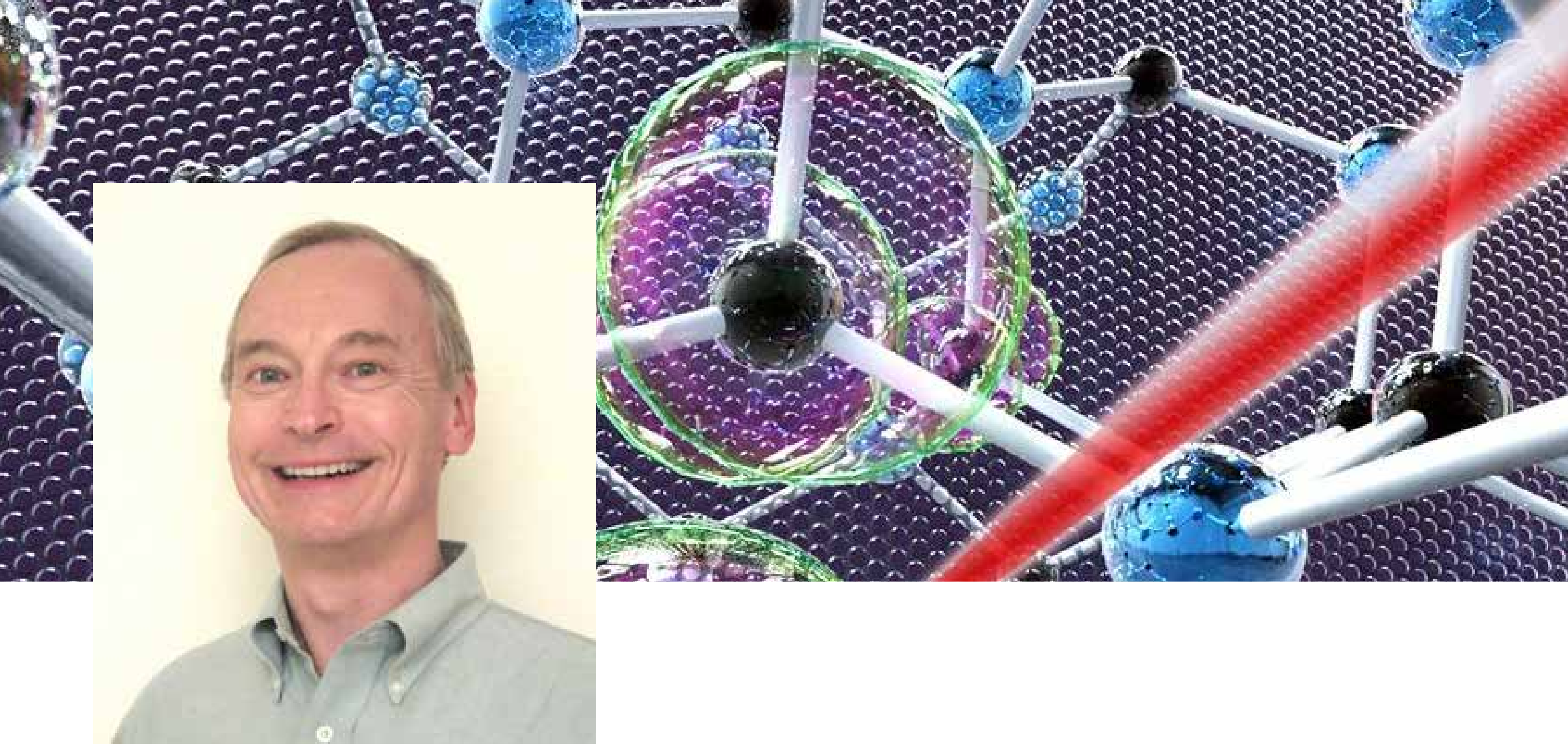
Total Usage of AIF *(by hours of use)* **has increased 75 percent in five years!**



AIF simplified the way it executed agreements with external users *(including academic, industrial, and governmental),* **resulting in substantial increases in the service of the facilities to North Carolina and United States constituencies:**



Learn more at aif.ncsu.edu



Prof. Chris G. Van de Walle

2019 ROBERT F. DAVIS DISTINGUISHED LECTURE

THE ROBERT F. DAVIS DISTINGUISHED LECTURE SERIES was created in 2010 to honor the accomplishments of Dr. Robert F. Davis, an internationally recognized semiconductor researcher who spent more than three decades as a faculty member in the Department of Materials Science and Engineering at NC State. Davis came to NC State in 1972 and was its first Kobe Steel Ltd. distinguished professor of materials science and engineering. He retired from NC State in 2004 as professor emeritus and began his current position as the John and Claire Bertucci Distinguished Professor of Materials Science and Engineering at Carnegie Mellon University.

The 2019 Davis Lecture was given by Prof. Chris G. Van de Walle, distinguished professor of materials and the Herbert Kroemer Endowed Chair in Materials Science at University of California, Santa Barbara, on March 29, 2019. Van de Walle's lecture, entitled, "Semiconductor Light Emitters: From Solid-State Lighting To Quantum Communications," focused on his group's use of first-principles computational techniques to understand the atomic and electronic structure of materials as well as their surfaces and interfaces for applications ranging from solid-state lighting to future opportunities in quantum communication. ■

DICKEY APPOINTED AS A DISTINGUISHED PROFESSOR

DR. BETH DICKEY carries a lot of titles in MSE, associate department head, director of the Center for Dielectrics and Piezoelectrics, and director of the NSF Research Traineeship on Data-Enabled Science and Engineering of Atomic Structure. Dickey now has one more title — distinguished professor. Her newest title was approved by NC State Chancellor Randy Woodson and Provost Warwick Arden effective August 1, 2019.

While the new title doesn't necessarily add any more duties to her already busy schedule, it does give Dickey long-deserved recognition for all of her contributions and accomplishments both inside and outside of NC State. To be eligible, faculty members must be known and respected nationally and internationally as one of the best scholars in their discipline. In addition to her research accomplishments and many department activities, Dickey serves on numerous outside review and advisory boards, as well as being the editor-in-chief of the *Microscopy Elements* book series, and editor of the *Journal of the American Ceramic Society*. Starting in 2020, Dickey will be the president-elect of the American Ceramic Society, and president the following year.

Dickey received her Ph.D. in materials science and engineering from Northwestern University in 1997. She joined the NC State faculty in 2011 after being on the faculty at the University of Kentucky and at Penn State University, where she was a John T. Ryan Faculty Fellow. ■

Q&A with George Martell

Can you tell is a little about your background, particularly in the service?

George Martell: In 2006, I joined the Navy, where I served as a submarine nuclear electronics technician, operating and repairing nuclear reactors. Later in my career, I served as an instructor, training the next generation of nuclear operators and technicians at the Naval Nuclear Power Training Unit in Ballston Spa, NY. In 2017, I completed an M.B.A. from Excelsior College in Albany, NY.

What leadership and teamwork skills that you learned in the service have proven to be important to what you've been able to accomplish working in the department?

GM: Teamwork is a very important concept in the Navy. When out to sea for months at a time, you have to trust that everyone is going to perform their job with heart and integrity. One person and one mistake can make the difference between coming home or not. We often say "one team, one fight," and work together to complete the mission. While most days in MSE are not a life or death scenario, it takes everyone working together to steer this ship in a positive direction.

What has been the most rewarding part of working in the MSE department?

GM: This department is at the forefront of exciting and important research, and I am grateful to be a part of that, if only in a small way. I take great pride in helping others achieve their goals and, if I am able to do my job well, it will enable others to concentrate on the things that are important to them and help to propel knowledge and understanding of the world we live in.

Were there any tasks you've worked on that proved to be impossibly difficult?

GM: The limitations of my job often involve a balance between money, time, and quality. Typically, achieving a low-cost solution, quickly, and of high quality is not possible. Trying to balance these is frequently the biggest challenge I face. How do I deliver quality in a reasonable amount of time without breaking the bank?

Please describe the type of experiences you've had working with students.

GM: I feel that the students are the most important part of this great institution. Our goal, as a team, is to support and train the next generation of professionals who are going to change the world. Along the way, they become involved in truly groundbreaking research, and their passion is inspiring. Research almost always involves a huge commitment of time and energy, with many failures along the way. I enjoy watching students achieve success after persevering through what are sometimes seemingly insurmountable challenges.

Is there any advice you would give to students looking to get into STEM fields?

GM: It will be the STEM disciplines that will help humanity meet the many challenges which we currently face. Our survival, as a species, depends on many minds and many ideas. Try to think broadly with a multidisciplinary approach, and look to attack problems from multiple perspectives.

Ions are the way biological systems signal and communicate and it is also how our nervous system signals our organs, muscles, etc. Soft carbon electronics are therefore well positioned to revolutionize medical diagnostics, therapeutics and medicine. In the future, carbon electronics may very well become a part of the fabric of our lives in a more literal sense than electronics today. ■

George Martell

***George Martell** joined the MSE facilities staff in 2017, where he has lead responsibilities for ensuring laboratory safety and security, as well as supporting the department's information technology needs and generally ensuring that the students have necessary resources and training. George brings multiple skills and experiences to the department, including electronics design and repair, safety and technical instruction, certification as a hazardous materials technician, web design and computer programming.*

Faculty Spotlight

TWO CARBON ELECTRONICS CLUSTER FACULTY MEMBERS NAMED AMONG TOP-CITED RESEARCHERS

Prof. Aram Amassian

PROF. HARALD ADE, Goodnight innovation distinguished professor in the Department of Physics, and **PROF. ARAM AMASSIAN**, associate professor of materials science and engineering, have been named to a list of the world's most highly cited researchers.

The list, compiled by Clarivate's Web of Science Group, which runs a global citation database, recognizes researchers with a sufficient number of papers that are highly cited by their peers. These highly cited papers rank in the top 1 percent of citations for a chosen field and year. In 2020, only 0.1 percent of the world's researchers across 21 research fields earned the highly-cited distinction, according to the Web of Science. Ade and Amassian were recognized in the materials science and cross-field categories, respectively.

Ade, who launched NC State's Carbon Electronics faculty cluster, has received international attention for his interdisciplinary work on understanding the physics of organic solar cells and light-emitting diodes, creating novel devices, and inventing and using new characterization methods with an emphasis on applications to organic devices.

Amassian, who joined NC State in 2018, is well-known in the area of ink-based semiconductors for printed electronics and solar cells, where he pioneered in situ characterization of coating processes and is credited with providing deeper understanding and new insights into formation of functional materials from solution with an emphasis on applications in organic and hybrid devices.

Amassian and Ade work closely with several other faculty members in the new state-of-the-art cluster facilities in Partners III. Targeted technologies include "smart" envelopes — the areas between the inside and outside of structures like buildings and greenhouses — that dynamically control heat, light and harvest energy to greatly lower environmental impact. Such technology might allow zero-energy farming with reduced use of water, fertilizers and pesticides, as well as improve climate resilience of the economy and aid with grid decarbonization.

Also making the list from NC State were Rodolphe Barrangou, Todd R. Klaenhammer distinguished scholar in probiotics research in the College of Agriculture and Life Sciences, and Robert Heath, distinguished professor of electrical and computer engineering in the College of Engineering. ■

NEW GRADUATE CERTIFICATE IN MATERIALS INFORMATICS

THE DEMAND FOR DATA-DRIVEN TECHNIQUES in the analysis, design, and development of novel materials is constantly increasing, motivating a new, interdisciplinary approach to materials education and research. However, in materials science, professionals with both domain and data science knowledge are in very short supply. This creates a disconnect between the skills of graduating students and the desires of employers who seek more interdisciplinary training among materials graduates. Nowadays, it is certain that every young scientist or engineer within their career will be exposed to data science that will drive their decisions. In response to this challenge, our department developed and launched a new Materials Informatics (MI) Graduate Certificate Program (GCP). It is designed for interdisciplinary graduate education at the intersection of materials science, engineering, and data science with the aim of preparing the next generation of materials engineers, given the growing demand for data-science skills and knowledge of artificial intelligence. The skills and knowledge obtained through this program will serve as a foundation for the understanding of materials informatics and high throughput materials discovery that will improve career prospects.

A total of four classes or 12 credit hours is required for completion of the MIGCP, including the core course Materials Informatics (MSE 723) and elective data-related courses from statistics, mathematics and materials science and engineering.

For more information please see **mse.ncsu.edu/graduate/migcp.** ■

17 STUDENT **NEWS**

NC State NanoWolves team Brings Home Awards in Biomolecular Design Competition

THE NANOWOLVES, a team of six NC State students, won five prizes at BIOMOD, an international biomolecular design competition held at University of California San Francisco. The team is comprised of students from the departments of Materials Science and Engineering, Biomedical Engineering, and Physics at NC State, as well as a student from Enloe High School in Raleigh. Their award-winning project involved the design, production, and testing of an anticoagulant based on RNA origami.

BIOMOD is an international biomolecular design competition for undergraduate students that was established at the Wyss Institute of Harvard University in 2011. This year, 20 teams with more than 100 students from the Americas, Europe, Asia, and Australia created innovative biomolecular design projects and implemented them in the laboratory during the summer months.

The NanoWolves team demonstrated a functional, self folding RNA origami that can be used to inhibit the coagulation of blood. The team presented its research to a live audience with a theme of "Red Riding Hood and the NanoWolves" and won five awards:

- 2nd Place Grand Prize, Overall Score
- Best Live Performance by Audience Choice
- 2nd Place Project Website
- 3rd Place Live Performance
- Gold Prize

Anticoagulant drugs save the lives of millions of patients with medical problems such as thrombosis, pulmonary embolism, undesired blood clots in the vital organs, and clotting control during surgery. Traditional anticoagulants such as warfarin and heparin are commonly used in clinic settings. However, they have life threatening side-effects and a high risk of tissue hemorrhage. It has been estimated that more than 65,000 patients are treated every year in U.S. emergency departments from warfarin-related hemorrhage. The NanoWolves team has created an alternative, novel anticoagulant composed of RNA origami carrying RNA aptamers which provides benefits over traditional anticoagulant drugs.

Student News

RNA is a programmable biomacromolecule, meaning it is a polymer that is able to fold itself into a specific structure based solely upon its designed nucleotide sequence. During the summer, the team designed and tested the folding of RNA computationally, and demonstrated the anticoagulation activity of RNA origami in the laboratory. (Further information can be found at **NanoWolves.org**) Additionally, they were able to reverse the anticoagulation effects of the drug by the addition of complementary DNA antidotes that set the coagulation cascade back to normal. The NanoWolves project paved the way for development of RNA origami for surgical applications.

Through the BIOMOD competition, the NanoWolves not only designed and implemented a fun project, but also contributed brand new ideas and knowledge to the field of bionanotechnology, said Dr. Thom LaBean, professor in the Department of Materials Science and Engineering and advisor to the group. After the excitement and success at BIOMOD, the NanoWolves are continuing to develop their project for clinical use by scaling up production, so that larger amounts of the anticoagulant will be available for testing in animal models. Plans are also in the works to advance RNA origami-based inhibitors for other therapeutic applications, such as HIV therapy.

"BIOMOD was an opportunity for the students to gain hands-on experience in both theoretical and experimental biomolecular design and testing," LaBean said. "They were able to contribute creative solutions to research problems and to execute a valuable biomolecular design project significant for the development of future applications of DNA and RNA nanotechnology. These young students will be marvelous assets for the future development of diverse science and technology."

The NanoWolves project would not have been possible without kind support from Danish collaborators including Prof. Ebbe S. Andersen's group and Prof. Jørgen Kjems' group at the Interdisciplinary Nanoscience Center (iNANO) at Aarhus University. This project was financially supported by grants from the National Science Foundation. ■

$1.1M GRANT FUNDS UNDERREPRESENTED STEM PH.D. STUDENTS

GREAT STRIDES HAVE BEEN MADE in creating a more diverse graduate program, recognizing that diversity enhances creativity, innovation, and the overall quality of our program. The 2019 class of incoming graduate students was the most diverse class of the MSE department based on the racial/ethnic demographics. More than half of the students have received nationally-recognized awards to support their graduate students including the GEM Fellowship and Bridge to the Doctorate Fellowship, an award to NC State by the National Science Foundation Louis Stokes Alliances for Minority Participation (LSAMP) Program.

NC State was among a select group of universities to be awarded a $1.1 million grant from the National Science Foundation's LSAMP program to support a cohort of students as a part of the Bridge to the Doctorate (BD) activity beginning this fall. With additional support from the university, a cohort of 15 students traditionally underrepresented in STEM fields (African-American, Latin/x, American Indian, Pacific Islander) receive a competitive stipend, and personalized support to enhance their academic, research, and professional skills during the first two years of Ph.D. programs across the Colleges of Engineering and Sciences. The resources provided to each student are designed to ensure successful completion of doctoral degrees and transition to the STEM workforce.

BD-eligible students were required to be accepted into their respective graduate programs, then nominated for the fellowship. MSE graduate students, Matthew Chagnot and Corrado Harper, are among the new cohort. Chagnot earned a B.S. in materials science from Rice University, and has joined Veronica Augustyn's research group. Harper earned his bachelor's degree in physics from the University of Alabama-Huntsville with interests in pursuing research in sustainable energy. This initiative is led by Dr. Joel Ducoste, professor of civil, construction, and environmental engineering and assistant dean of graduate student advancement and faculty enrichment, Dr. Ashleigh Wright, coordinator of the MSE Science and Engineering of Atomic Structure (SEAS) NSF Research Traineeship, and Dr. Roy Charles, director of diversity for the NSF FREEDM and ASSIST Engineering Research Centers.

BD fellows participated in a four-day orientation that focused on expectations of STEM graduate education, motivation and positive mindsets, developing effective study habits, time management, faculty-mentor relationships, study strategies, conducting literature searches and library resources, scientific writing, and best practices in research. Distinguished Professor Elizabeth Dickey presented to the group on Managing your Ph.D. Process. In a series of monthly meetings and special activities, fellows will explore other topics including proposal writing, securing applying for the NSF Graduate Research Fellowship, mentoring, networking, and career development. One of the key components of the BD that will contribute to the student's success is their access to external mentors beyond their research advisors, and engagement with a community of other STEM scholars across NC State and the NC-LSAMP institutions.

The BD program is a complement to ongoing efforts to increase diversity within the MSE graduate program including participating in graduate fairs at professional conferences such as the National Society of Black Engineers, Society of Hispanic Engineers, Society of Women Engineers, and Emerging Researchers National Conference, and hosting visitation programs. Many of these programs are synergistic with the College of Engineering and / or Graduate School. Last fall, Wright coordinated a visiting program co-sponsored by the Office of Institutional Equity and Diversity (OIED) for seven minority students from South Carolina State University, North Carolina A&T State University, North Carolina Central University, and Norfolk State University. It is our goal to build on the momentum by continuing to implement creative programs that increase the visibility of the program, and highlight the supportive environment cultivated by world-class faculty engaged in cutting-edge research and the graduate community. ■

Eric Knowles

> "I really enjoy the community that exists within the MSE program. The relatively small size of the department allows for better communication between students and faculty, and since most MSE students take the same classes, it doesn't take long to make friends."
>
> **ERIC KNOWLES**

MSE STUDENT SELECTED WINNER OF 2020 LEWIS C. HOFFMAN SCHOLARSHIP

ERIC KNOWLES, a senior in the materials science and engineering undergraduate program, has been named the recipient of the 2020 Lewis C. Hoffman Scholarship presented by the Awards Committee of the Electronics Division of The American Ceramic Society. This $2,000 scholarship is awarded to students who show outstanding performance in their academic and extracurricular activities.

In addition to excelling in his studies, Knowles is a five time All-American swimmer for NC State's collegiate swim team. When asked about his experience at NC State, Knowles conveyed appreciation for his work with Dr. Elizabeth Dickey and her research group; "Dr. Elizabeth Dickey has been instrumental in my progress and learning in materials science. I had the privilege of working in her research group in the summers of 2019 and 2020. It was an awesome experience, and I learned a lot from Professor Dickey as well as the graduate students I worked with. I look forward to applying the skills I learned during undergraduate research to my future career."

Knowles also expressed his fondness for the materials science department and the positive experience of working closely alongside the department faculty; "I really enjoy the community that exists within the MSE program. The relatively small size of the department allows for better communication between students and faculty, and since most MSE students take the same classes, it doesn't take long to make friends. Additionally, since nearly every professor is heavily involved in research, it's very easy for students to get involved in MSE beyond the classroom."

Knowles exemplifies what it means to be a wolfpack student both in and outside the classroom. Congratulations to Eric Knowles on his outstanding achievement. ■

Student News

ABBY CARBONE SERVED AS FALL 2019 STUDENT COMMENCEMENT SPEAKER

Abby Carbone

WITH A CHANCE TO SEND A LASTING MESSAGE TO GRADUATES who are about to take on the world by force, what may be viewed as a daunting task by some is seen by Fall 2019 Student Commencement Speaker Abigail 'Abby' Carbone as a dream come true, and an opportunity to empower fellow women in STEM.

"That's going to be me, someday," Carbone recalls thinking to herself as she watched December 2018 Student Speaker Lindsay McMillan take the podium at PNC Arena and deliver a speech about perseverance and owning your individual path to success. For Carbone, who graduated with a Bachelor of Science in materials science and engineering and a minor in nanotechnology, her own path to success has been paved with a string of impressive achievements: she has co-authored three research publications (a fourth is currently in production), won five awards for research presented at about a dozen national conferences, and became the first undergraduate staff microscopist at the Analytical Instrumentation Facility on campus.

Off campus, Carbone was hired at Eastman Chemical Company as the first intern in the Electronic Films Research Division, and participated in an undergraduate research fellowship at California Institute of Technology last summer. Oh, and she sings; from her freshman through junior years, Carbone performed alto and competed in three ICCA competitions with Acappology, one of NC State's co-ed a cappella ensembles.

JUST SHOW UP

Carbone wouldn't have gotten to where she is if she had let the fear of new challenges stop her from overcoming them. The message that she coneyed to her fellow graduates this December is simple, yet powerful: don't be afraid to show up.

Dedicated to science education and communication, Carbone says she learned "the importance of just showing up" while serving her community at a science outreach event at a local elementary school. Carbone and the other volunteers — all males — serving at the event paused during their demonstration to ask if anyone had any questions. A young girl in attendance pointed at her and asked, "How come you are the only girl up there?"

Carbone hopes that even if women feel outnumbered in whatever field they pursue that they, too, can recognize the importance of being visible representations of what achievement and boldness can look like.

BE BOLD

Carbone displayed her mantra of showing up when she applied to be the Fall 2019 student speaker, which she describes as being a "huge honor." She wants to represent a diverse and tenacious graduating class that has, as she described, "knocked down barriers that tried to tell them the 'correct way' to do what they're passionate about."

But Carbone also had a sentimental reason for applying to speak at commencement.

"My Grandpa Larkin was a pastor, and he was known for being an extremely captivating speaker," she says. "So for me, the chance to speak about things that have had an impact on me is kind of like keeping his legacy alive."

"I can't pick just one person."

Carbone says she's most looking forward to being on stage and being able to thank everyone who has helped her throughout her time at NC State, and to show them how far their support has carried her. When asked who her biggest inspiration at NC State is, Carbone can't decide on one, so she narrows it down to five who have had immeasurable influence on her academic and personal journey:

"I am inspired by Dr. Paul Maggard, for teaching me how to think like a scientist; Dr. Jacob Jones, for showing me what commitment to ensuring success for others looks like; Dr. Jeremiah Feducia, for daring me to pursue dreams that I thought

Student News

were too big; Dr. Alexander Kemper, for asking me the hard questions; and Dr. Barclay Satterfield, for encouraging me to persist through obstacles I've faced."

The kind words Carbone has for her mentors are mutual; each applicant for the student speaker position is required to have two letters of recommendation submitted to the Commencement Committee on their behalf from faculty, staff, or other university officials who can speak to their character. Dr. Jeremiah Feducia, director of Undergraduate Programs and teaching associate professor for the Department of Chemistry, wrote to the committee,

"Having been at [NC State] for over 10 years, I can say that I have never met a more opportunistic student than Abby…If our graduating students can leave commencement with even a quarter of the energy, enthusiasm, passion and optimism for the future that Abby has, they will certainly start their professional journey on the right foot."

Dr. Lex Kemper, assistant professor for the Department of Physics, also spoke to Carbone's grit, determination, resilience and thoughtfulness, and how Abby, "inspires others to find those [qualities] within themselves."

WHAT THE FUTURE HOLDS

Carbone's advice to prospective future student speakers is to be genuine and reflect on the moments at NC State that have had the biggest impact on you. Post-graduation, Carbone has her sights set on returning to Caltech to pursue a Ph.D. in materials science in the fall of 2020. ■

MSE CELEBRATION OF SENIORS ON ZOOM

THE MSE DEPARTMENT HELD A VIRTUAL CELEBRATION of seniors to note the achievements of our outstanding and inspiring class of 2020 Materials Science and Engineering students. This celebration ceremony was a culmination of the hard work and determination by our 2020 bachelor's degree recipients in materials science and engineering. During this celebration; Erica Debnam, selected by her classmates to be this year's student speaker, gave an inspiring and heartwarming speech, Prof. Balik announced the winners of the senior design final report award, which are Leah Sowers, Carmen Procida, Kevin Matthews, Ethan Gram for their work on " method for identifying the Si- or C-face on 0-4° SiC Wafers," and Several students were recognized with University and MSE awards:

2020 MSE Outstanding Undergraduate Researcher awardee, Carson Key, who demonstrated exceptional research achievements and a promise for a future research career.

University Valedictorians: Branden Hawkins Jr., Carson Key, Grace Matthews, Kevin Matthews, Emily Roe, Leah Sowers, Olivia Wander

University Scholars Program: Abhishek Kher, Emily Roe, Leah Sowers

Academic Achievement which is awarded to students who demonstrated the highest possible level of academic excellence by achieving a perfect 4.0 G.P.A. in MSE classwork: Branden Hawkins Jr, Carson Key, Kevin Matthews, Emily Roe, Leah Sowers, Olivia Wander

2020 MSE Outstanding Student Leadership awardee, Carmen Procida, who demonstrated exceptional leadership through the involvement in student organization, MSE department and NC State University, who demonstrated a commitment to leadership, and has exceeded the expectations as a departmental citizen.

Many congratulations to our students and we wish you the very best. ■

MSE AMBASSADORS HELP DEVELOP CONNECTIONS DURING COVID-19

THE MSE AMBASSADORS serve to represent the department, support MSE student organizations, and assist with undergraduate activities to improve the student experience. Historically, the ambassadors have represented the NC State MSE department at open houses and information sessions, and have organized undergraduate social activities like graduation and the senior picnic. This semester, the ambassadors will be working to virtually develop intradepartmental connections within the student body and between students and professors, and host a virtual open house and prospective student visitations.

The ambassadors are currently led by seniors Gwen Lincroft and Merve Fedai. The ambassadors welcome three new members for the 2020-21 school year, juniors Katie Shaffer and Tiernan Baucom and sophomore Ian Bower.

MSE AMBASSADOR LEADERS:


Merve Fedai

MERVE FEDAI

Hi Wolfpack! My name is Merve Fedai, and I am from Turkey. I am a senior in materials science and engineering with a concentration in nano/biomaterials. For a year, I have been conducting computational research in the department, and I eventually would like to work in experimental research before I graduate! On campus, I am a member of the Turkish Student Association as event coordinator and I am in the MSE ambassador team for another year. I enjoy volunteering and organizing events. As an international and transfer student, I believe I can help students with different backgrounds who are having trouble adapting to different communities. Off campus, I love to have home-cooked dinner with family and friends and to travel around the world.


Gwen Lincroft

GWEN LINCROFT:

Hi! My name is Gwen Lincroft, and I am a senior in materials science and engineering with a concentration in nanomaterials. I have always been inspired by emerging technology, and was determined to learn more about it and maybe have a hand in creating it one day. The breadth of MSE appealed to me, as I have a wide range of academic interests. I thoroughly enjoy the intersection of chemistry and physics in MSE and have greatly enjoyed my coursework so far. I am not sure exactly where I will go with MSE, but I appreciate all that I am learning and am certain that I will find my passion. I chose to become an MSE ambassador because I want to give back to the department that has been very welcoming to me. Outside of my studies, I enjoy video games, soccer, and being outside. ■

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ALUMNI CORNER

Jake and Jennifer Hooks

Alumnus Gifts Named Space in Engineering Building I

FROM A YOUNG AGE, Jake Hooks was drawn to NC State.

Hooks' father, J.T. Hooks Sr., was the captain of the NC State's freshman men's basketball team in 1924. So growing up, he knew where he wanted to attend school.

He graduated in 1978 with a degree in materials engineering. After graduation, he worked as a product engineer before moving into management. He retired as president of Eaton Automotive North America in 2013 after a 35-year career.

From studying engineering, Hooks says, he learned important skills that he carried into business management, including an ability to see situations as they actually are instead of the way he'd like them to be. With that clear-eyed vision, he was able to use an engineer's problem-solving skills to get things done. Put those two things together, he said, and you can have a good understanding of what is possible and what is not in a certain amount of time.

"That degree served me very well," Hooks said. "It opened a lot of doors."

Hooks has been a great supporter of his home department and the College. In 2011, he spoke to incoming first-year engineering students at the annual College of Engineering Welcome Event and has served on the NC State Engineering Foundation Board of Directors and chaired the development committee. He and his wife, Jennifer Smith Hooks, endowed the Jacob T. Hooks Scholarship in materials science and engineering in honor of his father.

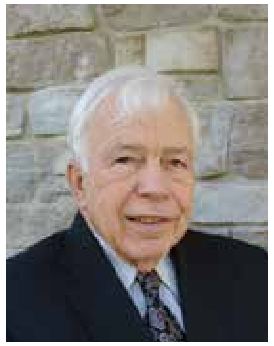
"My NC State education and experience opened many doors for me in my career," said Hooks. "When I was able to give back to the University, Jennifer and I wanted to ensure that it was impactful."

Most recently, the Hookses have gifted a named space in the Department of Materials Science and Engineering (MSE) in Engineering Building I (EBI), with the gift money going towards Fitts-Woolard Hall, the newest engineering building. The named space, the Jake and Jennifer Hooks Atrium, is located on the third floor of EBI.

"As an MSE alum, I was able to see first-hand the teaching and research conducted at State, so I am excited to see innovation continue as engineering comes together on Centennial Campus." ■

2018 **Alumni Hall of Fame**

The Materials Science and Engineering alumni hall of fame recognizes the accomplishments of our outstanding graduates who have used their education to excel in a profession, career, or service. *This is one of the most inspirational awards for our current and future students. Only a select number will be chosen as MSE Hall of Fame members, making this a truly noteworthy distinction. The department honored the 2018 class through the prestigious Alumni Hall of Fame ceremony.*



Mitchell Haller

M.S. '67, Ph.D.'71

Dr. Mitchell Haller earned his M.S. in 1967 from NC State in materials science and engineering and metallurgical engineering. He earned his Ph.D. in 1971 in materials science and engineering from NC State. Haller developed Biobond C&B, the first non-precious crown and bridge alloy introduced to the dental market. It was co-patented with Dr. Charles Richard Manning (Dental Alloy Patent #3,914,867). This widely used alloy was marketed by Dentsply International, Inc. Haller developed a non-precious alloy for producing school class rings in the mid 1970's, (a time when gold prices soared). The alloy was patented and sold extensively to all the leading school ring manufacturers.

Haller developed a brazed friction grip dental bur that has been widely acclaimed and was awarded two patents (Robotic Dental Tool and Method of Manufacture — Patent # 8337204-2012 and patent #8870571-2014). His company manufactured the burs until 2015. At that time the manufacturing rights were licensed to Brasseler USA. The burs are now being manufactured exclusively under license by Brasseler USA and being marketed under the trade names Durabraze and also Cleancut (sold by Henry Schien, Inc.). The burs were awarded the "Best New Product" by Clinical Research associates — a prominent independent dental research organization and was declared the "Fastest cutting diamond instrument" in independent testing performed by *Reality* magazine – a renowned dental product evaluation and publication firm. Brasseler USA presently sells more than 75,000 instruments per year.

Edward C. Nixon

M.S. '55

Edward Nixon grew up during the Great Depression in the small Quaker community of Whittier, California. He was the youngest of the five Nixon brothers. Richard Nixon, 17 years older than Ed, was like a second father to him, as well as a teacher and mentor. After receiving his bachelor's and master's degrees from Duke and NC State, Nixon served our country as a Naval aviator, helicopter flight instructor, and assistant professor of Naval Science at the University of Washington. In 1957, he married Gay Lynne Woods, a teacher in chemistry and mathematics. Nixon has spent the last six decades pursuing the responsible use of natural resources around the globe. During his travels and his visits to the White House, he met several world leaders. He embarked on a successful career working for and serving as an advisor to a number of cutting-edge companies in the field of earth science. In his book, "The Nixons: A Family Portrait," by reflecting on heritage, education, extensive world travel, and the encouragement of his older brother, he tells the story of an ordinary family striving to make a positive difference in the

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world. He aims to inspire young Americans, as well as young people everywhere, to reach for new thresholds of greatness.

Lisa Porter

Ph.D. '94

Lisa Porter is professor of materials science and engineering at Carnegie Mellon University in Pittsburgh, Pennsylvania. She received her B.S. and Ph.D. degrees in materials science from Cornell University and NC State University, respectively. Her research, which initially focused on metal contacts and oxide-SiC interfaces for high-temperature and high-power device applications, broadened to include fabrication, processing, and characterization of a wide range of electronic materials (e.g., transparent electrodes and organic semiconductors), with recent focus on gallium oxide as a promising new wide bandgap semiconductor.

In 2011 she co-founded SenSevere LLC, a Carnegie Mellon spin-off that is commercializing semiconductor-based chemical sensors for severe environments. Lisa holds leadership positions in a number of professional organizations. She is president of the American Vacuum Society (AVS), an international research society pertaining to the science technology of materials, interfaces, and processing; she previously served many roles within AVS, including program chair of the AVS 63rd International Symposium and chair of the Electronic Materials and Photonics Division.

Outside of AVS she completed two terms on the User Executive Committee for the Environmental Molecular Sciences Laboratory (EMSL) at the Pacific Northwest National Laboratory (PNNL) while also serving as faculty chair of the College of Engineering at Carnegie Mellon. She currently serves as secretary of the Electronic Materials Conference and is also an ABET program evaluator for materials engineering programs.

Some of her awards include an NSF Career Award, a Swedish Research Foundation Professor Award, Women in Materials Award, and CMU's Philbrook Prize in Engineering. Her work has been recognized through more than 50 invited presentations and was featured in her Plenary Talk at the Taiwan Association for Coatings and Technology Annual Meeting in Taipei, Taiwan in October.

Paul R. Stewart

B.S. '59

Paul Stewart, from Spruce Pine, NC attended two small liberal arts colleges for two years before entering the U.S. Army and serving in the USA and Germany from 1954-56. Armed with the G.I. Bill, he enrolled at NC State and graduated with a B.S. in Geological Engineering in January 1959. He then enrolled at the University of Illinois and worked at the Illinois Geological Survey and earned an M.S. in Petroleum Engineering in June 1960. Stewart then worked for Shell Oil Company in Houston and Corpus Christi, and then Denver as an Exploitation and Reservoir Engineer until he left Shell for Belco Petroleum Corporation in New York City in 1966. While working for Shell in south Texas, he was the engineer in charge of the world's largest Fracture –Treating job (on a deep gas well) at that time (1964). Current fracs are now commonly 100 times larger. At Belco, he became Vice President and General Manager of North American Operations in Houston with offices in Houston, Midland, Denver, and Calgary.

In 1975, Stewart became President and Chairman of King Resources Company in Denver, a company in Chapter X bankruptcy, and attempting to re-organize under a Chief Federal Judge, a Trustee, and Paul operating the company. KRC had been the most active oil company in drilling in the U.S. in 1969, and was considered to be the largest oil company bankruptcy at that time. The company was successfully re-organized in January 1977 and had successful drilling in New Mexico, offshore Texas, Wyoming, Montana, Dutch North Sea, and Gulf of Suez (Egypt / Israel). Control of the company was acquired by another oil company in 1978 after a year on to the board and formed Stewart Petroleum Corporation, a private company. He later merged the company with a public company and became active in drilling and production in Montana and North Dakota with oil prices increasing some 200 percent to $38 and then plummeting 75 percent to $10 per barrel.

He and his geologist son, Daryl formed the new Stewart Petroleum and weathered the price crunch with acquisitions and careful exploration and development drilling and a significant shallow gas discovery in western Colorado. After 15 years, the company's assets were sold to a Rocky Mountain electric utility and Stewart has phased into semi-retirement while still investing in drilling with the company.

Gleb Yushin

Ph.D. '03

Dr. Gleb Yushin is a professor in the School of Materials and Engineering at Georgia Institute of Technology; chief technology officer (CTO) and a member of the Board of Directors at Sila Nanotechnologies, Inc., an engineered materials company he co-founded in 2011 to dramatically improve energy storage technologies (now employing over a hundred engineers, scientists and other specialists), and an editor-in-chief for *Materials Today*, the flagship journal of the *Materials Today* family, dedicated to covering the most innovative, cutting edge and influential work of broad interest to the materials science community. Yushin received a Ph.D. degree in materials science from North Carolina State University in 2003.

Since graduation, Yushin has focused his research efforts on synthesis and characterization of nanostructured and nanocomposite materials for energy-related applications. For his contributions to this field he received numerous awards and recognitions, including NASA Nanotech Briefs® Nano 50™ Award, Petroleum Research Fund Young Investigator Award, Honda Initiation Award, Air Force Office of Scientific Research Young Investigator Program Award, R&D 100 Award, National Science Foundation CAREER Award, NASA Inventions and Contributions Board Tech Brief Award, Kavli Fellow Award, Sigma Xi Best Faculty Paper Award, among others. Most recently, he was selected by the New York Academy of Sciences as the finalist and honoree of the prestigious Blavatnik Award for Young Scientists (2017 and 2018), was recognized as one of the leading and most cited researchers in the sciences from around the world by Clarivate Analytics and was distinguished as one of the 20 members of Electrochemical Society (out of 8,000+) with the "World's Most Influential Scientific Minds."

Yushin has co-authored over 150 peer-reviewed publications, over 40 U.S. and international patents and patent applications and over 120 invited and keynote presentations and seminars. His current H-index is 68 and his work has received over 20,000 citations according to Google Scholar. The current research activities of his laboratory are focused on synthesis and characterization of nanostructured and nanocomposite materials for use in advanced lithium–ion, aqueous and solid state batteries, supercapacitors and lightweight structural materials and composites.

Bennie Ward

B.S. '59

Bennie Ward graduated from Dr. Austin's group in 1959 with a B.S. in metallurgical engineering. He was then employed by Reynolds Metals in Richmond, Virginia. He gravitated to the job of supervisor of the Pilot Equipment Lab for Reynolds Research, where he could do everything Reynolds' plants could do except extrude. Ward has 20 metallurgical patents, but his 20th is the most rewarding, U.S.P. 5,725,695, Method of Making Aluminum and Product there from. Reynolds had been making Reynolds Wrap since 1947 by ingot casting using another alloy. The problems that arose were the reroll and final anneal had to be higher than normal because the constituent size of the twin roller cast strip was too small and would not cause key dislocations to recrystallize at normal annealing temperatures. His patent of alloy 8111 overcame these problems and produces a foil that is soft (very good elongation) and tough. With his patent. Reynolds and the company that bought the foil division had 17 years of protection to make Reynolds Wrap from alloy 8111. To Ward's knowledge that company is still making the same product. ■

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