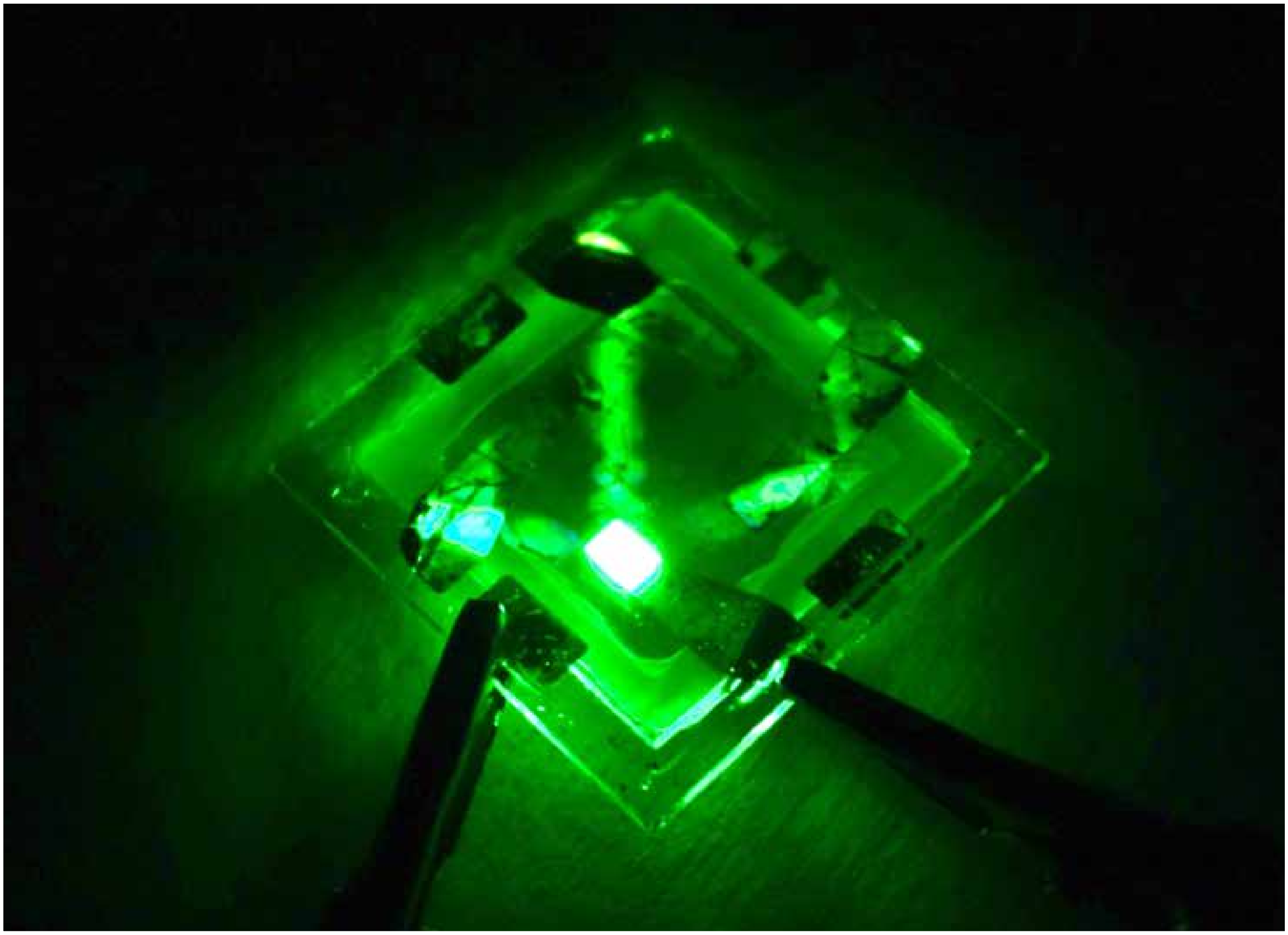
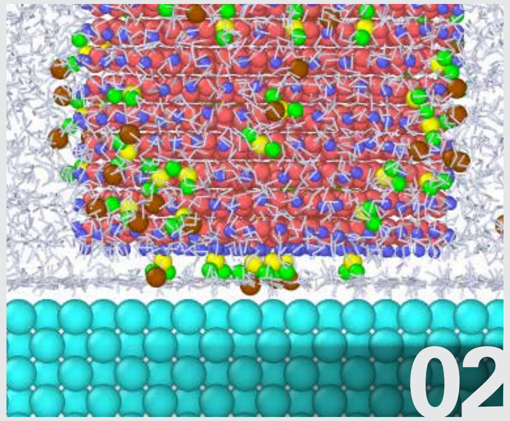
NC STATE Engineering

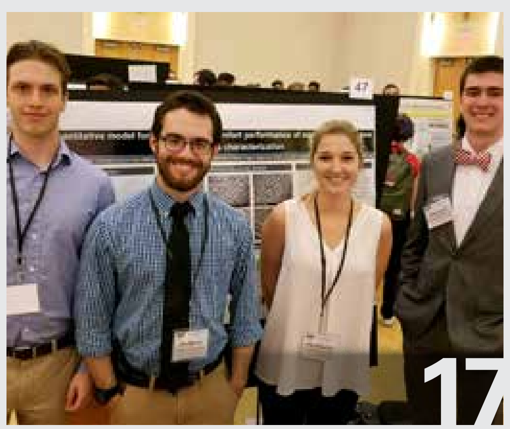
DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING NEWSLETTER

FALL/WINTER 2018



IN THIS ISSUE





01

UPDATE FROM THE **DEPARTMENT HEAD**

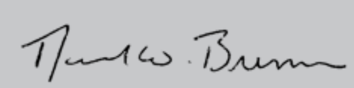
DEAR MSE FRIENDS AND STAKEHOLDERS,

Welcome to the fall 2018 newsletter. We are very proud to be able to share with you the many accomplishments of our faculty and students, the quality and impact of our research, the innovations in our education and outreach activities, and the most important product of our department — our graduates. All of these have come together to create an exciting and vibrant community of learning, research and service that continues to push the frontiers of science and engineering, while turning out the leaders of tomorrow who will shape our community for the decades to come.

There have been a number of personnel changes this past year. Prof. Beth Dickey and I transitioned from interim associate department head and interim department head into our respective permanent positions. Prof. Albena Ivanisevic has taken over as our director of graduate programs. With the addition of Prof. Aram Amassian to our faculty, we continue to solidify our leadership in the area of flexible electronics. An interview with Amassian is included in this newsletter on **page 11**.

Our faculty members continue to add new research initiatives and directions, and we are continuing to expand our world-class research facilities on which our department, the university and the broader research communities have come to rely. Along with our research accomplishments and infrastructure, our department continues to ensure that our students have the opportunities to expand their education through international programs, internships and activities such as senior design. We are excited to be able to bring you many of the details of these efforts in the following pages.

Achievements like those highlighted in this newsletter are only possible through the hard work and commitment of our faculty, students, alumni and friends like you who remain dedicated to supporting our mission. We appreciate your interest in our department and thank you for giving us a chance to share our enthusiasm. We look forward to continuing our relationship with you.



Donald W. Brenner
Kobe Steel Distinguished Professor
Department Head

Donald W. Brenner

02

Research Highlights

NEW MODEL DESCRIBING DEFECTS IN SIMILAR OXIDES PROVIDES INSIGHT INTO THE STABILIZATION OF VACANCIES

Barium and strontium titanium oxides are very similar in structure and behavior, and both are used to make the capacitors used in all modern electronics, as well as more specialized components in radio frequency and memory devices. These materials are often modeled similarly when engineering processing-property relationships. It turns out, however, that subtle differences in underlying structure can have markedly larger implications on the performance of each material.

Density functional theory and point defect thermodynamics calculations performed in Dr. Douglas Irving's research group were used to characterize the differences in the vacancy behaviors of these two materials, and how the differences manifested when doped in various processing conditions. The combined modeling demonstrated that neither the vacancies nor all dopants of the same type behave similarly in the two materials, implying that treating the two oxides the same, as has been done in the past, can lead to lower quality materials if used to guide processing.

The paper describing this work, "Mechanisms governing metal vacancy formation in $BaTiO_3$ and $SrTiO_3$," by J. N. Baker, P. C. Bowes, J.S. Harris, and D.L. Irving, J. Appl. Phys. 124, 114101 (2018), was a featured article in the *Journal of Applied Physics*.

A NOVEL WAY TO INCREASE LIGHT EXTRACTION IN ORGANIC LIGHT-EMITTING DIODE (OLED) PANELS

Research in Prof. Franky So's laboratory addressed the issue of extracting light trapped in OLED devices. For basic OLED devices on planar glass substrates, only 17-25 percent of the generated light is extracted from the panel. This inefficiency is due to trapping of photons in the electrodes, transparent substrate and inner layers resulting from mismatches in the index of refraction along the photon path. This research explored using a corrugated substrate coupled with a low-index of refraction buffer layer to minimize total internal reflection. Development focused on optimal feature pitch and depth for maximum extraction without creating current leakage or shorting pathways.

So also investigated using a microlens array to extract light from the substrate mode. The overall goal is to achieve an extraction efficiency >70 percent. By using a hemispherical lens to extract light from OLEDs made on corrugated substrates, So's laboratory was able to achieve more than a 2x enhancement in external quantum efficiency (EQE). The efficiency enhancement mainly comes from the diffraction of the surface plasmon polariton (SPP) mode into air mode, due to the corrugated substrate. With the application of the hemispherical lens, the planar device EQE is increased to 40 percent (an additional 18 percent), which is attributed to extraction of substrate mode, and the corrugated device EQE is increased to 60 percent (an additional 32 percent). Considering the simulated mode distribution, the enhancement comes from the extraction of the substrate mode and additional trapped modes. This research was funded by the Department of Energy.

USING GOLD NANOPARTICLES TO TRIGGER SEQUENTIAL UNFOLDING OF 3-D STRUCTURES

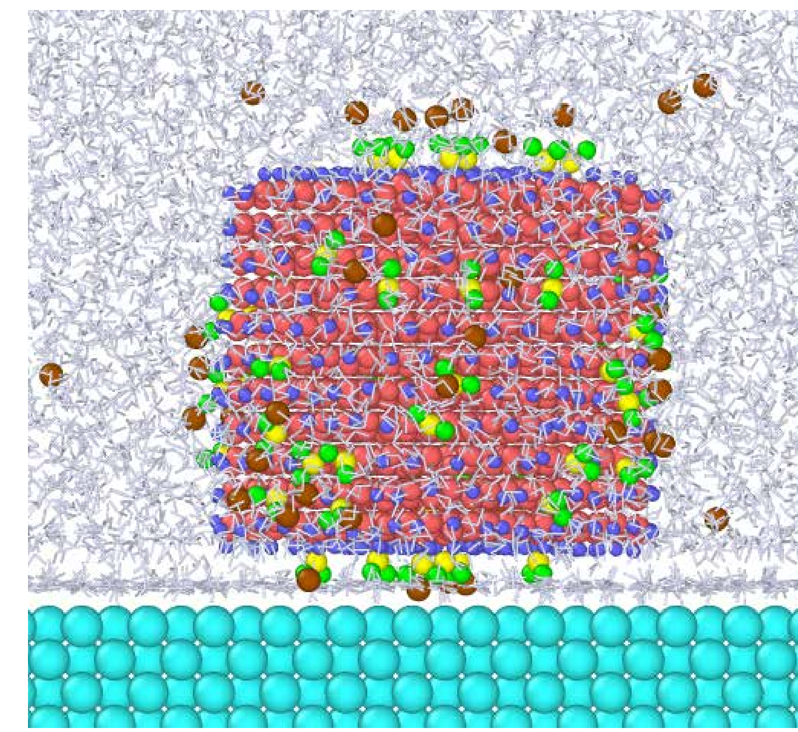
Prof. Joseph Tracy and his research group developed a new technique that takes advantage of gold nanoparticles to trigger the sequential unfolding of three-dimensional structures using different wavelengths of light. The technique uses different shapes of gold nanoparticles to convert different wavelengths of light into heat. Tracy and his students embedded gold nanospheres and nanorods into different areas of a shape memory polymer, which can then be folded into a desired shape. When exposed to green light, the folds in the part embedded with nanospheres unfold. When exposed to near infrared light, the nanorod-embedded regions unfold.

This approach, which can be used at room temperature, directly connects the tunable optical properties of noble metal nanoparticles with remote triggering of sequential processes for applications in soft robotics, such as biomedical implants.

A NEW MODEL EXPLAINS ELECTROSTATIC BONDING OF CHARGED NANODIAMOND PARTICLES WITH GOLD SURFACE

Prof. Donald Brenner's collaborators in the NC State Physics Department had noticed something unusual when measuring the adhesion strength of charged nanodiamond particles with gold surfaces: the positively charged particles appeared to bind more strongly to the gold than the negatively charge particles. Simple electro-statics suggest that the adhesion of ideal particles of the same size to an ideal metal should depend only on the magnitude of the charge and not the sign, so something else must be going on that controls adhesion.

Nanodiamond particles are small pieces of diamond with diameters of a few to hundreds of nanometers. To create different charges, different chemical groups are attached to the surface of the particles. Negative nanodiamonds are created by adding carboxylic acid groups missing a proton, COO^-, while positive nanodiamonds are created by adding surface amino groups with an extra proton, NH_3^+. Using molecular modeling, Brenner's research group found an extra layer of water between the negative nanodiamond and the gold surface that is not present for the positive nanodiamond. This occurs because the carboxylic acid group is larger than the amino group, which provides more room for the water to slip between the nanoparticle and the surface. Charged sodium ions can also fit in this single water layer, which together with the water helps to screen the electrostatic interaction between the negative particles and the surface. This synergy between surface functional group size, the presence of water and electro-static interactions had not been previously recognized.



MICROSCOPY ADVANCE REVEALS UNEXPECTED ROLE FOR WATER IN ENERGY STORAGE MATERIAL

Materials with atomically thin layers of water hold promise for energy storage technologies, and Prof. Veronica Augustyn and co-workers discovered that the water is performing an unanticipated role. The finding was possible due to a new atomic force microscopy (AFM) method that measures the sub-nanoscale deformation rate in response to changes in the material caused by energy storage. Augustyn and her co-workers studied crystalline tungsten oxide dihydrate, which consists of crystalline tungsten oxide layers separated by atomically thin layers of water. This material holds promise for helping to store and release energy quickly and efficiently. However, it has not been clear what role the water plays in this process.

To address this question, Augustyn and her co-workers used a new methodology that relies on an AFM to track expansion and contraction at the atomic scale as charge is moved in and out of the material. This technique allowed the team to detect even minor deformations in the material as charge moved through it. Both crystalline tungsten oxide dihydrate and crystalline tungsten oxide — which lacks the water layers — were studied, and it was found that the water layers appear to play a significant role in how the material responds mechanically to energy storage. The water layers were found to do two things: minimize deformation, meaning that the material expands and contracts less as ions move in and out of the material when there are water layers, and make the deformation more reversible so that the material returns to its original dimensions more easily.

UPDATE ON HIGH-TEMPERATURE SUPERCONDUCTIVITY IN B-DOPED Q-CARBON

Research in Prof. Jay Narayan's laboratory significantly increased the temperature at which carbon-based materials act as superconductors, using a novel, boron-doped Q-carbon material. The previous record for superconductivity in boron-doped diamond was 11 Kelvin. Narayan's research group found boron-doped Q-carbon to be superconductive from 37 to 57 Kelvin. To make the boron-doped Q-carbon, they coated a substrate with a mixture of amorphous carbon and boron layers. The mixture was then hit with a single laser pulse lasting for only a few nanoseconds. During this pulse, the temperature of the carbon was raised to 4,000 Kelvin and then rapidly quenched.

Using equilibrium methods, boron can be incorporated into Q-carbon only up to 2 atomic percent. Using the laser-based, non-equilibrium process, Narayan reported levels as high as 50 atomic percent. That higher concentration of boron appears to be what gives the material its superconductivity characteristics at a higher temperature.

ATOMIC STRUCTURE OF ULTRASOUND MATERIAL NOT WHAT ANYONE EXPECTED

Lead magnesium niobate (PMN) is a prototypical "relaxor" material, used in a wide variety of applications, from ultrasound to sonar. Prof. James LeBeau, Prof. Elizabeth Dickey and collaborators in Australia used state-of-the-art microscopy techniques to see exactly how atoms are arranged in PMN — and it's not what anyone expected. They found that the atom arrangement in PMN gradually shifts along a gradient, from areas of high order to areas of low order throughout the material. That observation is substantially different than what conventional wisdom predicted, which was that there would be alternating areas of high order and no order, right next to each other.

IN-SITU OBSERVATION OF INTERFACE AFFECTED ZONES PROVIDES A PUZZLE PIECE FOR HETERO-STRUCTURED MATERIALS

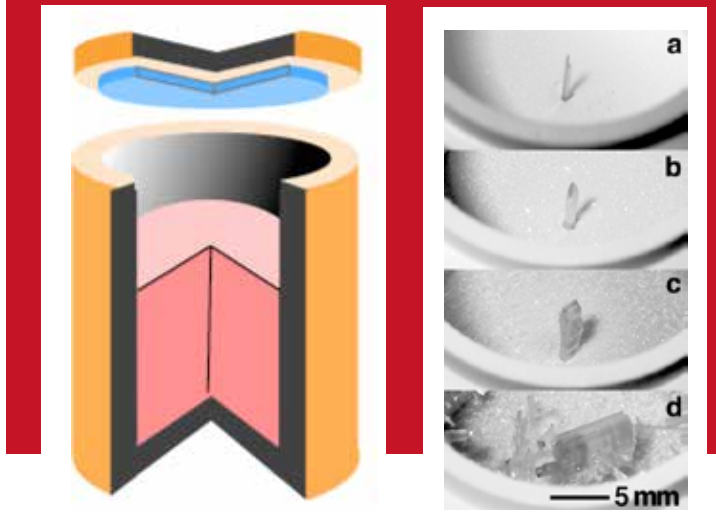
Mechanical properties of materials are largely controlled by their internal interfaces such as grain and phase boundaries. In second century China, for example, strong and tough swords were created from Beilian steel by repeated forging and folding. Similarly, Damascus steel was used to make blades with superior properties from the fifth to the eighteenth century. A common feature of these ancient materials is their layered structures with high densities of internal interfaces.

There has been a long controversy on whether an interface-affected-zone (IAZ), defined as a characteristic zone with a strain gradient near an interface, exists and how it affects mechanical properties. Using an innovative in-situ high-resolution digital-image-correlation technique, Prof. Yuntian Zhu and his colleagues verified the existence of an IAZ in hetero-structured laminates. The IAZ width was found to remain constant with increasing applied strain. The study revealed an optimum interface spacing that produces the best combination of strength and ductility. This discovery represents a critical piece of the puzzle toward understanding the fundamental science of hetero-structured materials, which possess desirable properties that are not accessible to conventional homogeneous materials. ■

WideBandgaps Laboratory

AT THE FOREFRONT OF THE ULTRA-WIDE BANDGAP SEMICONDUCTOR REVOLUTION

FOLLOWING LEGACY RESEARCH on SiC and GaN led by Prof Robert Davis, Prof. Zlatko Sitar founded the WideBandgaps Laboratory upon joining NC State in 1995. It soon became one of the globally leading research laboratories focusing on ultra-wide bandgap semiconductors. Early research efforts focused on the development of processes for the growth of diamond and its integration on silicon technology. This was complemented by research on field emission phenomena based on wide bandgap materials and carbon nanostructures such as carbon nanotubes and nano-diamond. At the time, III-nitrides semiconductors were already recognized as an important technology with successful commercialization efforts in the upcoming solid-state lighting revolution. However, these efforts were based on highly defective material achieved by growth on foreign, highly mismatched substrates. It soon became clear that in order to harness the full potential of these materials, significant improvements in the crystal quality were necessary, which were achievable only on native III-nitride substrates. This recognition led to preliminary work on the growth of GaN and AlN single crystal. These early efforts provided data and momentum that eventually led to the world-class achievements that place the WideBandgaps Laboratory at the forefront of III-nitride research.



(left) Schematic of a TaC crucible used for the growth of AlN crystals containing the source material and seed attached to the cap. (right) Example of the first AlN seeded growth showing expansion of an AlN needle.

Prof. Zlatko Sitar

AlN BECOMES A VIABLE SEMICONDUCTOR

One early success from the laboratory was the development of the world's first scalable process and equipment for the growth of AlN single crystals and processes for fabrication of epi-ready wafers thereof. This is an extremely challenging process that has eluded researchers around the world for decades due to the required high temperature (2400°C or 4400°F) and related materials compatibility issues. As a way to deal with these challenges, a process for the fabrication of high density TaC crucibles was developed. TaC is inert at high temperatures and features the highest melting point (3990°C) of any material known to man. This comprehensive one-of-a-kind work on III-nitride substrate technology is internationally recognized; many aspects of this work are patented, and a spinoff company from the laboratory, HexaTech Inc., is licensing and commercializing this technology. Despite numerous efforts around the world, this remains the only process capable of reproducible growth of large, high-quality AlN crystals and the only commercial outlet for epi-ready AlN wafers.

CREATION OF THE MISSING PIECES

With a perfect platform in hand, there was time to put the understanding of crystal growth to the test and broaden the scope of research on III-nitrides, first to homo- and hetero-epitaxial thin films, the basic building blocks of devices, and

Prof.. Ramón Collazo

control of their interfaces, then to studies and invention of processes for control of point defects which give functionality to electronic materials, and finally to design and fabrication of optoelectronic and electronic devices themselves. Early during this expansion time, Prof. Ramón Collazo joined the WideBandgaps Laboratory and played an instrumental role in bringing the laboratory from crystal growth to device development, the complete process chain of any semiconductor technology. As a part of this effort, a second spinoff company was founded, Adroit Materials Inc., to further develop and commercialize many aspects of this technology, while at the same time offering one-of-a-kind and state-of-the-art foundry services to strategic partners and collaborators.

WORLD-CLASS ACHIEVEMENTS

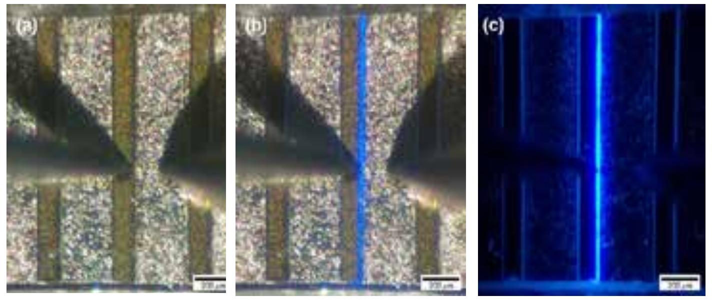
Together with the spinoff companies, the WideBandgaps Laboratory demonstrated the first true lasing in the UV spectral range, showing more than 10 times lower lasing threshold than the closest competitors, complete polarization of light, and, for the first time, laser cavity modes. Currently, the laboratory has undergone a significant expansion, with a state-of-the-art epitaxy and device growth facility that includes three custom-made high-temperature and one industrial metalorganic chemical vapor deposition (MOCVD) reactor along with diverse and complementary materials characterization capabilities. This makes the WideBandgaps Laboratory a world-class facility and one of the premier places in the world for the synthesis of world-class III-nitride materials and to learn about this significant and ground-breaking materials technology.

BRANCHING OUT

Based on these successes and needs for additional complementary expertise, the WideBandgaps Laboratory has established strong collaboration with a few key faculty members from the MSE, Electrical and Computer Engineering (ECE), and Physics departments, and formed a natural NC State faculty cluster with common interest in pursuing complementary and holistic research on III-nitrides materials. This has allowed the lab to branch the developed technology into other areas of interest while providing focus, expertise and guidance in experimental and process design. Prof.. Douglas Irving, a computational materials scientist, supports the efforts on developing computational models on point defects associated with determining the properties of these materials and how to control them based on different processing schemes. Based on this intimate collaboration, the puzzle of unwanted UV absorption in AlN was finally solved, settling a more than 30-year debate in the open literature; this is a key finding that enables this technology to move forward. Prof. James Lebeau, an electron microscopist, developed advanced techniques to image for the first time the interface between an AlN single crystal and the epitaxial layers grown on it. These efforts helped established the basic technology necessary to obtain state-of-the-art device structures with the highest efficiencies and reliabilities. Furthermore, using the high quality material, he was able to image for the first time point defects associated with the electronic properties of these wide bandgap semiconductors.

AlN single crystal boule (left) and wafer (right) currently commercialized by HexaTech Inc.

Scanning transmission electron micrograph of an AlGaN/AlN multiple quantum well 3 nm wide used for deep-UV light emitting diodes.



Fabricated deep-UV laser diode structures under operation (left and center) and under dark conditions to highlight the top emitted light.

INTERFACING WITH LIVING CELLS

A unique research activity within the WideBandgaps cluster is a collaboration with Prof. Albena Ivanisevic, a surface chemist with interest in bio-interfacing with semiconductor materials. Initial work on the necessary semiconductor surface modifications to allow for efficient electronic-based biosensors led to the realization that the inertness of these materials makes them suitable for platforms for direct interfacing with biological entities at the cellular level. In this way, the properties of these semiconductors are used for the manipulation of cellular processes in a novel biotronics platform.

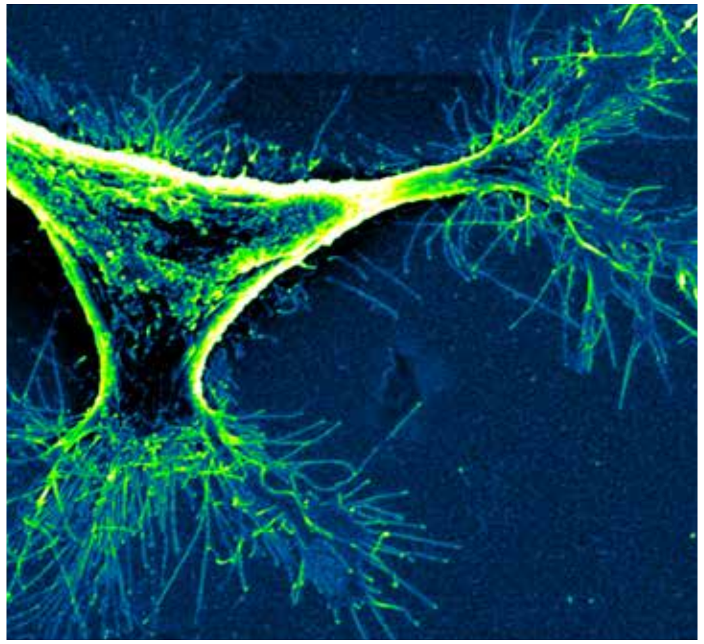
CREATION OF A QUANTUM PLATFORM

Prof. Kenan Gundogdu from the Physics Department joined the WideBandgaps group motivated by the realization that these wide bandgap semiconductors serve as a discovery platform for new physical phenomena based on fundamental electron-electron and light-electron interactions. His efforts support the lab's exploration of interactions with other types of materials and the possibility of developing a room temperature platform for quantum computing.

POWER BEYOND SiC

Several professors from ECE are also part of the WideBandgaps Cluster. Profs. Spyridon Pavlidis and Leda Lunardi support the technological efforts focused on electronics. As part of their efforts, they are involved in the design and fabrication of state-of-the-art devices that lead to potential applications in power electronics based on wide bandgap semiconductors. This offers the opportunity to revolutionize the way we distribute and generate power as a technological infrastructure. Furthermore, the potential implementation of these devices into systems is pursued by Prof. Subhashish Bhattacharya, another collaborator of the WideBandgaps group. This helps realize the vision of the technology development ladder, from materials to devices and ultimately systems.

Rooted in a long history of advanced semiconductors at NC State, the WideBandgaps Faculty Cluster continues the legacy in the development of challenging semiconducting materials with transformative impact. The department's research into novel and interesting fundamental scientific problems coupled with entrepreneurship is enabling practical implementation of ultra-wide bandgap III-nitrides in commercial applications and at the same time providing cutting-edge training and out-of-the-box thinking for the next generation of researchers and engineers. ■



Neuron model cell interacting with a GaN surface, highlighting the possible biointerfacing possibilities of these semiconductors.

Research In Depth

Research In Depth

New AIF Tools for MSE

Keyence VKx1100 CLSM
source: www.keyence.com

Horiba XploRA PLUS
source: www.horiba.com

IN THE PAST YEAR, the Analytical Instrumentation Facility (AIF) has acquired significant new instrumentation that continues to expand its already extensive departmental research and education activities.

NEW TRANSMISSION ELECTRON MICROSCOPE:
A proposal to the National Science Foundation's (NSF) Major Research Instrumentation program led by MSE faculty members was funded in 2017 to acquire a new Transmission Electron Microscope costing over $2 million. The instrument purchased, an FEI Talos, will provide access to a complement of in-situ sample holders to explore materials as a function of temperature, atmosphere (liquid or gas) and electrical biasing, a high-speed camera to capture detailed structural changes during in-situ experiments, cryogenic sample preparation and holders to image beam-sensitive materials, electron energy loss spectroscopy and energy-dispersive X-ray spectroscopy to correlate nanoscale structure and chemistry, and tilt-tomography to measure three dimensional structural details.

TITAN MICROSCOPE UPGRADE:
In early 2018, the Titan aberration-corrected Scanning Transmission Electron Microscope (STEM) underwent a major hardware and software upgrade valued at over $500,000. Most notably, it was upgraded to a 64-bit operating system and hardware, and a 4D STEM direct electron detector was added that can detect from one to a million primary electrons per pixel (1,000 times current dynamic range) at 100 times the speed of conventional detectors. Moreover, the new detector will enable researchers to form any STEM image in post-processing.

NEW ATOMIC FORCE MICROSCOPE:
Through partnership with the Office of Research and Innovation (ORI), AIF acquired a new Asylum MFP-3D classic Atomic Force Microscope (AFM) in the fall of 2017. The instrument comes with a variety of advanced capabilities, including variable magnetic field module for in- and out-of-plane measurements, a probe station adapter for concurrent 2- and 3-point probe electrical measurements, viscoelastic mapping mode, conductive AFM and a closed fluid cell for measurement in gases or liquids.

NEW RAMAN CONFOCAL MICROSCOPE:
The AIF acquired a new Horiba XploRA PLUS Confocal Raman Microscope in fall 2017 through partnership with the ORI. The instrument has a variable temperature stage with the range -196 to 600 degrees Celsius and automated x/y/z stage for mapping. It is an ideal technique for non-destructive, non-contact, water/aqueous phase sampling in pharmaceuticals, semiconductor, geology, polymers and forensic applications.

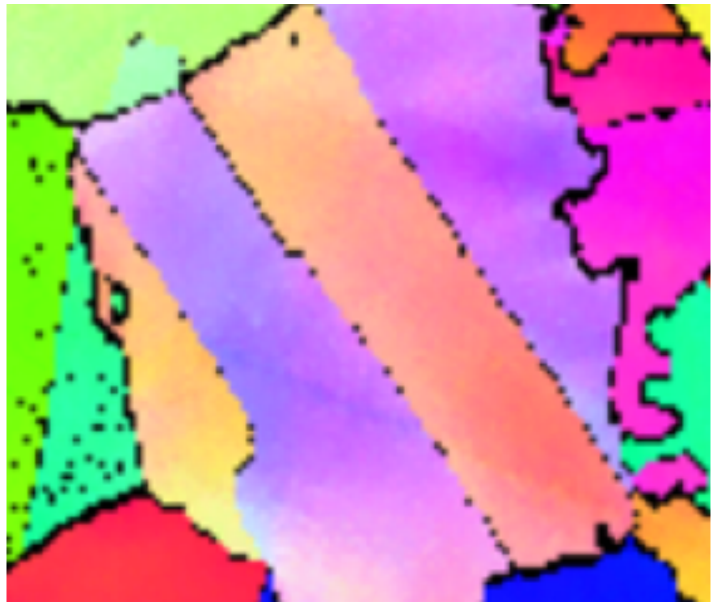
CONFOCAL LASER SCANNING MICROSCOPE:
Using funding from the College of Engineering, the AIF acquired a Keyence VKx1100 Confocal Laser Scanning Microscope (CLSM) in the summer of 2018. This microscope combines optical microscopy with laser profilometry, making it possible to obtain high resolution optical images and subsequently measure profile and surface roughness. It can be used for almost any type of material and is especially suited to measure surface features and roughness of samples which would not be feasible with traditional stylus profilometry.

BRUKER HYSITRON TI980 TRIBOINDENTER:
In the summer of 2018, the AIF acquired a Bruker Hysitron TI980 Triboindenter; this is a quasistatic indentation system for nanomechanical testing of mechanical properties, including Young's modulus, hardness and fracture toughness. It is ideal for measuring mechanical properties of coatings and thin films, as well as the spatial dependence of hardness and elastic modulus. Its three-plate capacitive transducer design allows for a high displacement sensitivity and a low thermal drift. It is also capable of tribological testing including nanoscratch testing and wear testing. The triboindenter was acquired using funds from the College of Engineering.

X-RAY NANOTOMOGRAPHY (NANO-CT) INSTRUMENT:
AIF received notice in the summer of 2018 that an NSF MRI proposal was awarded to acquire an X-ray nano-CT instrument valued at nearly $1 million. The PI of the proposal, Prof. Jacque Cole, is in the UNC/NC State Joint Department of Biomedical Engineering. Co-investigators include Profs. Jacob Jones (MSE), Ola Harrysson (Industrial and Systems Engineering), Mark Pankow (Mechanical and Aerospace Engineering) and Mary Schweitzer (Biology). The nano-CT system uses X-rays to visualize and measure the internal structure of many types of objects non-destructively. It functions similar to medical CT scanners that hospitals use to obtain 3D images of the inside of the body, but it provides details at a much smaller scale — down to less than 1 micrometer. It enables the study of internal structures in a variety of materials, providing measurements like porosity, connectivity and permeability. This instrument will fill a critical gap in CT and microscopy equipment in the region and will facilitate a broad array of structural and material measurements not currently possible. This technology will add nondestructive volumetric imaging at the nanoscale that requires minimal sample preparation, has a relatively large field of view, can distinguish low- and high-density materials simultaneously, and can incorporate environmental conditions such as mechanical and thermal stages.

NEW ORIENTATION DETECTOR:
A new detector named "Symmetry" is now available on the FEI Verios scanning electron microscope, providing superior orientation microscopy capabilities. The image to the right is more than an order of magnitude faster than possible with the other detector. Speeds up to 3,200 pixels/second are achievable, even at reduced operating voltages and beam currents, allowing data collection on poorly conducting specimens. The detector was made possible by Assistant Professor Tori Miller.

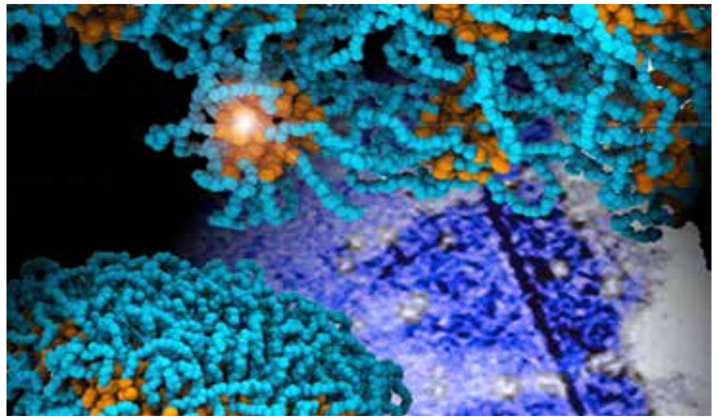
NEW CATHODOLUMINESCENCE (CL) DETECTOR:
The Horiba H-CLUE Spectroscopy & Imaging CL system is now available for users on the JEOL 7600 scanning electron microscope, an acquisition made possible through a DURIP grant to Prof. Beth Dickey. CL is a non-destructive spectroscopy technique that provides electronic-structure information via optical emissions induced by the electron-beam excitation. Similar to photoluminescence spectroscopy, but performed in an SEM, CL spectra can be collected at nanometer spatial resolution to probe electronic-structure inhomogeneities in materials. The technique can be used to induce and image surface plasmon resonances in nanostructured materials. The H-Clue offers wide spectral range from UV to IR, 200-2200 nm (6.2 – 0.56 eV). The technique is particularly suitable for analysis of wide-band semiconductors, photonic and polaritonic nanostructures, dielectric oxides and minerals. ■



The image above is a representative Electron Backscatter Diffraction (EBSD) map of a deformed Ni alloy specimen collected at ~1500 pixels per second.

Research In Depth | PROF. YAROSLAVA YINGLING

***Prof. Yaroslava Yingling**, professor and NC State Faculty Scholar, joined the MSE department in 2007. She serves as a editor-in-chief for AIMS Materials Science journal, as an associate editor at RNA and DNA Nanotechnology and on the editorial advisory board of ACS Biomaterials Science & Engineering. She received the National Science Foundation (NSF) CAREER award and American Chemical Society Open Eye Young Investigator Award. She received her university diploma in computer science and engineering from St. Petersburg State Technical University of Russia and her Ph.D. in materials engineering and high performance computing from the Pennsylvania State University in 2002.*



Describe the type of problems you address in your research, the techniques used and a few major research results over the last year or so.

Y: My group's research interests focus on computer simulations of various materials within the field of soft matter, such as polymers and biopolymers, liquids, emulsions, colloids and gels. We use multiscale modeling techniques that can yield a wealth of data on the structure and properties of soft materials and assist with the formulation of the design rules for the development of novel materials. One of our recent endeavors is to understand and predict how the properties of responsive materials will play an increasingly important part in a diverse range of applications, such as drug delivery, tissue engineering, artificial organs and soft actuators. Most of the biological materials are innately responsive. For example, in the Venus flytrap, it is believed that mechanical stimuli of plant follicles transfer into electrical signal that causes the leaf to close. However, the mechanisms of responsiveness are difficult to characterize due to its inherent complexity and multiscale nature. Modeling a responsive material presents a challenge with a large number of unknown variable parameters, such as chemical reactions and kinetic or conformational changes as a function of environment that is hard to measure directly. We developed a new implicit solvent ionic strength methodology for the dissipative particle dynamics method for prediction of the stimulus-responsive behavior of polyelectrolyte materials, which are used in a number of promising applications such as drug and gene delivery systems, tissue engineering, biosensors, oil and water clean up and numerous nanoscale devices. The model is designed for studies of large-scale systems that involve the ionic strength-dependent behavior of strong polyelectrolytes, which is currently unreachable by other computational methods. The application of this model to a systematic analysis of polyelectrolytes diblock and triblock materials resulted in determination of salt-dependent morphological diagrams for micelles and gels, determination of the conditions for the morphological transition into a specific shape and derivation of general scaling laws and equations for responsive properties of a variety of polyelectrolytic systems. Our methodology opens up tremendous new opportunities for rational design of polyelectrolyte materials with predictable responsive properties. This work was supported by NSF, selected for two journal covers, and was featured in *Materials Today, Science Daily* and *NSF*.

Describe projects that are upcoming, and scientific problems/ challenges that you and your group are looking to solve.

Y: We have entered the age of big data, and my group is actively involved in data-driven materials discovery or materials informatics (MI), which will enable massively accelerated ability to predict and optimize materials properties toward a specific application. In more classical areas of materials science, MI has seen a remarkable rate in adoption over the past decade alone. In soft matter, however, the application of informatics principles has somewhat lagged behind that of its hard-materials counterpart largely because soft materials exhibit complex mesoscopic ordering that is extremely difficult to predict from chemical structure and composition alone. While the field of soft materials informatics is new, we are looking forward to using the power of machine learning in order to speed up the materials discovery. ■

Q&A WITH PROF. ARAM AMASSIAN

Prof. Aram Amassian

***Prof. Aram Amassian** joined our department in the summer of 2018. Amassian comes to us from the King Abdullah University of Science and Technology (KAUST), where he was a faculty member for nine years. He received his bachelor's and doctoral degrees from the École Polytechnique de Montréal, QC, Canada and was postdoctoral researcher at Cornell University before starting his career at KAUST. Amassian is part of a university cluster hire in Carbon Electronics that spans multiple departments across the Colleges of Engineering and Sciences. The cluster effort is currently lead by Dr. Franky So in the MSE department.*

Can you please give us a little more background on your life experiences and how they led you to science and engineering?

Prof. Aram Amassian: I've been curious about the world around me and by the inner workings of things as long as I can remember. As a visual person, I had a particular fondness for making, assembling and constructing structures, although I admit — as a kid — to doing a lot more breaking than constructing. Later in life, courses in mechanics, electricity and magnetism helped me make sense of the world and gave me sense of gratification that I had as a child. I was hooked.

My early training was in applied and engineering physics and my home department at Ecole Polytechnique in Montreal was heavily skewed toward materials had important strengths in the area of thin films and coatings. It was only natural migrate toward materials science and engineering later in my career. MSE has allowed me to satisfy my curiosity in understanding and controlling how atoms and molecules assemble to form the functional materials we use in everyday technologies, from optics to displays, to electronics and energy harvesting.

My natural inclination to "see" how materials form has been a thread throughout two decades of research, first as an undergraduate researcher and a graduate student apprentice, and then as a post-doctoral fellow. This has only intensified in my formal academic career as assistant and associate professor.

Q&A with Prof. Aram Amassian

Can you describe the type of research that you've done, and what you plan to undertake at NC State?

A: During the first decade of research (1999-2009), my focus has on vacuum deposition as a mature and well-established process for the fabrication of functional inorganic materials (e.g., optics, photonics, sensing, hard coatings). I focused on studying highly non-equilibrium deposition processes and them to create complex material morphologies, ranging from compact and nanocomposite materials to nanostructured porous films. This was done, for instance, by leveraging ion-surface interactions in plasma enhanced CVD, or by using geometric self-shadowing effects in glancing angle deposition. Near the end of this period, I became fascinated by a new paradigm in thin film science, the opportunity to utilize complex molecular building blocks with weak intermolecular interactions, but exhibiting shape and interaction anisotropy, to assemble organic semiconductor films with a wide range of exciting properties and a slew of applications on the horizon, ranging from electronics and displays to sensors and solar cells. I joined the Malliaras group at Cornell University and began investigating molecular thin film formation by vacuum deposition.

In the second decade (2009-present), I joined the faculty in materials science and engineering at KAUST. My focus shifted to ink-based processing of thin films, which can be coated using low-cost, high throughput, continuous fabrication methods in ambient air. In addition to investigating how organic and hybrid semiconductor thin films form from solution, using in situ diagnostics techniques, research focused heavily on understanding structure-property relationships, on interfaces, and on the fabrication and testing of model electronic and optoelectronic devices, such as field-effect transistors and organic solar cells.

Where do you think your research has had the biggest impact, and what impacts do you see for your future research?

A: The future of ink-based manufacturing of electronics continues to pose important materials science and engineering challenges, ranging from materials design to processing and self-assembly, interfaces, properties and devices. It is an interdisciplinary, exciting and rewarding field to be working in the years to come as our work is not yet done.

More than anything else, I think that my group's research has shed some light on the mysterious mechanisms of ink-based electronic materials, including organic, colloidal quantum dot and hybrid perovskites. When I first started in this area, solution-processing of films was entirely based on trial-and-error and empirical understanding. My students and I have introduced new tools to the field, some based on x-ray and light probes and others using sensitive microbalances, to investigate the solution-to-solid transformation. Many of these tools are now being used by others around the world, including in the U.S. However, our work is far from complete. There is more to be done before solution processing of semiconductors matures into a viable manufacturing platform and to see products on the market. However, there are tremendous materials being made by solution-processing and I am more optimistic and bullish than ever about the remarkable opportunities presented by ink-based manufacturing in general.

A second area is the interface between soft matter semiconductors, which is crucial to many emerging device applications, such as plastic solar cells. These have notoriously complex interfaces distributed three-dimensionally. I'm proud of tackling this complex problem by breaking it down to simple model interfaces which could be interrogated to provide us with meaningful insights that will help us continue to improve plastic solar cells.

What opportunities do you see being involved with the Carbon Electronics Cluster, and with your other new colleagues at NC State?

A: My postdoc years at Cornell University provided me with a unique opportunity to work collaboratively as part of an IRG (NSF MRSEC) on Growth of Complex Materials. I interacted with researchers from MSE, applied and engineering physics, chemical and biomolecular engineering, and the Cornell High Energy Synchrotron Source (CHESS). From this experience, I have since sought out interdisciplinary environments where societal problems are addressed from different angles and disciplinary perspectives. In many ways, this made joining NC State and the Carbon Electronics Cluster a no brainer. I'm very thankful to all levels of leadership at NC State, from Chancellor Woodson, Provost Arden and their teams, to the leadership teams of the Colleges of Sciences and Engineering for supporting the clusters.

It's ironic that in many ways, carbon and silicon are very similar given their proximity in the periodic table, but they couldn't be more different in their properties as materials. Silicon is a building block of modern electronics in its crystalline form, whereas carbon forms the diamond crystals we value as a society: esthetically beautiful, the hardest material and the most insulating one at that. But carbon also comes in other exciting forms, which motivate the Carbon Electronic Cluster. Graphite, a form of layered carbon, can be intercalated to achieve conductivity superior to any metal. Meanwhile, hydrocarbons, which have given us fuels and commodity plastics, have also given us conjugated plastics which are an exciting new class of semiconductors that can be printed. Organic LED (OLED) displays use these exciting materials for light emission. Organic semiconductors also promise low-cost electronics, sensors and solar cells by high throughput printing in ambient air conditions. Recently, these materials have been shown to be very good mixed conductors, meaning transporters of both electrical and ionic charges. 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.

Can you describe how you like to interact with students in your research group and in the classroom, and what you hope to see your students achieve in each?

A: As an academic and an educator, I measure my success in large part through the success of my students, both while they are under my direct supervision and later on when they move up in the world. In mentoring a student my aim is to help her/him achieve their professional ambitions, which should be sky high for NC State students. I look forward to my students and mentees becoming my professional peers in academia, leaders in technology, industry and government, as well as successful entrepreneurs.

Can you describe your experiences at NC State so far, and how they compare to your time at KAUST?

A: Being a founding faculty member at KAUST was a singular life experience that comes once in a lifetime. It was an academic startup in the desert with seemingly endless vision and resources. It was certainly challenging at times and a complete culture shock, but also thrilling, life-changing and ultimately very rewarding. The work continues, but I'm proud of my role as one of the 75 founding faculty members who came from all around the world to help KAUST become a successful graduate research institution in under a decade. The university has reached a world-class standing and has become a wonderful destination for entrepreneurial students and faculty members to spend time to build an exciting endeavor. KAUST now has the mission of helping transform the economy of Saudi Arabia, which I believe will be a multi-generational task.

My brief experience at NC State has been wonderful. Folks have been welcoming, supportive and nurturing at all levels and I couldn't be happier to be here. Colleagues are highly accomplished, motivated, and very collaborative. We have already generated exciting new ideas and are seeding collaborative projects after a handful of interactions since my arrival. There is a pervading sense that we have the freedom to organize into interdisciplinary teams to tackle important, transdisciplinary scientific and engineering challenges. NC State provides support and resources at all leadership levels, including departments, colleges and the university as a whole to help these teams fund and grow these activities toward becoming hubs of research excellence.

What opportunities do you see at NC State, and in the Triangle region both in terms of research and in technology transfer?

A: NC State and the Triangle region have become a destination for bright, talented and entrepreneurial minds. Since moving here, I can see why. There is an energy and a dynamism in the Triangle region, infrastructure, opportunities, leadership, vision and resources. NC State and the Triangle region is already a rich ecosystem in additive manufacturing with research infrastructure as well as academic and industrial players. This ecosystem is a fertile ground for new additive manufacturing initiatives which can include ink-based semiconductor manufacturing.

What advice would you give to students and postdocs who may be starting out their careers?

A: Many students and postdocs are eager to graduate and get into the job market. This is completely understandable and necessary. I would like to challenge them to recalibrate their long-term goals and seek ways to be tomorrow's job creators. They have tremendous opportunities in science, engineering and technology to do so through innovation and entrepreneurial efforts. ■

Awards and **Recognitions**

PROF. ARAM AMASSIAN has joined our department from KAUST, where he headed the organic Electronics and Photovoltaics group.

PROF. VERONICA AUGUSTYN was one of six finalists for the prestigious 2017 BASF/VW Science Award Electrochemistry. She also received a Chemistry of Materials Reviewer Excellence Award, and gave 14 invited lectures over the last year. She also organized the symposium "Materials Education, International Networking, & Entrepreneurship/Innovation," at the 9th International Conference of the African Materials Research Society, Gaborone, Botswana, December 2017.

PROF. DON BRENNER transitioned from interim to full-time department head. He also continues to lead a large Multi-Discipline University Research Initiative on high-entropy ceramics.

PROF. BETH DICKEY has stepped down from being director of graduate programs, and has stepped into a new role as full-time associate department head after being interim over the last year. She continues as director of the Center for Dielectric and Piezoelectrics and as director of the NSF Research Traineeship on Science and Engineering of Atomic Structure, as well as an editor of the *Journal of the American Ceramic Society.* Together with graduate student John Wang, she developed and taught a course on scanning electron microscopy at the 2017 Africa Materials Research Society meeting in Botswana. She was a committee member on the National Academies Panel on Materials Science and Engineering at the Army Research Laboratory, 2018. She also holds a number of other professional positions, including the physical sciences director, Microscopy Society of America, 2017-19, steering committee member for the American Ceramic Society, 10th International Congress, and panel of experts, Anders Gustaf Ekeberg Tanatalum Prize, Tantalum-Niobium International Study Center (T.I.C.), 2018.

PROF. NADIA EL-MASRY has returned to the department from the National Science Foundation, where she was program director for the electronic photonic and magnetic devices in the division of electrical communication and cyber system/engineering directorate.

PROF. VICTORIA MILLER won the TMS Young Leaders Professional Development Award for the Light Metals Division and was invited to be on the Executive Committee of the ASM Central Carolinas Chapter. She is also guest editing a special topic in JOM related to an emerging issue in magnesium alloy research, and was invited to be a panelist at the NC Comicon on "The Science of Venom."

PROF. ALBENA IVANISEVIC has become the director of graduate programs. She was also promoted from associate to executive editor for the *ACS Applied Materials and Interfaces.*

PROF. JACOB JONES gave 15 invited talks since November 2017, including two keynote and two plenary talks. He is continuing as the director and principal investigator of the Research Triangle Nanotechnology Network and as director of the Analytical Instrumentation Facility.

PROF. CARL KOCH was honored with a symposium, "Mechanical properties of nanocrystalline and high entropy alloy materials in honor of Carl Koch," at the 2018 Plasticity Conference held in Puerto Rico in January 2018. He was also a member of the steering committee for the workshop, "Manufacturing High Entropy Alloys: Pathway to Industrial Competitivenes," that was held in Washington, D.C. in December 2017.

PROF. JAY NARAYAN was officially inducted into the National Academy of Engineering, and was a member of the Peer Committee of National Academy of Inventors. His discoveries of Q-carbon and diamond related products received a 2017 R&D-100 Award.

PROF. SRIKANTH PATALA was named an outstanding reviewer for the journal *Acta Materialia.*

PROF. FRANKY SO continues as the editor-in-chief of *Materials Science and Engineering Reports,* as well as an associate editor for six other journals.

PROF. JOE TRACY was promoted to full professor. He also received a Humboldt Research Fellowship for Experienced Researchers.

PROF. YARA YINGLING received the 2018 Robert W. Cahn Best Paper Prize (Finalist & April's Best Paper) for the *Journal of Materials Science.*

PROF. YUNTIAN ZHU continues as the editor-in-chief of *Materials Research Letters* (MRL), a Taylor and Francis journal that he founded. Under his leadership the MRL impact factor has risen to 6.151 this year. He is also on the editorial board of seven other journals.

GRADUATE STUDENTS

Our outstanding graduate students continue to receive wide recognition for their research excellence and accomplishments. This recognition includes the following:

PRESENTATION AND POSTER AWARDS:

ANAGH BHAUMIK received a best poster award at the TMS annual meeting. **ADELE MOATTI** and **SIDDHARTH GUPTA** received second and third prizes, respectively, for oral presentations at the same meeting. **HOSHIN KIM** received the Best Student Oral Presentation award at the Computer-Based Modeling and Experiment for the Design of Soft Materials symposium at a national meeting of the Materials Research Society. **NINA MILLIKEN** won best poster at the Triangle Soft Matter Workshop. **SHELBY BOYD** had a first-place poster at the RTNN & PANalytical Non-ambient XRD Workshop as well as at the department Science as Art Contest. **MICHAEL SPENCER** had a first-place poster at the Carolina Science Symposium and a third-place poster at the North Carolina State Energy Conference. **JAMES MITCHELL** had a second-place oral presentation at the 18th Annual Graduate Research Symposium at UNC Charlotte, 2018.

TRAVEL AWARDS:

JAMES PEERLESS received two travel awards, a Machine Learning in Science and Engineering Travel Award from the National Science Foundation and a Materials Science Conference Travel Award from the Society for Industrial and Applied Mathematics. **SHELBY BOYD** and **JAMES MITCHELL** both received Travel Awards to the 2018 Univ. of Illinois, Chicago Next Generation Electrochemistry (NGenE) Workshop.

ADDITIONAL RECOGNITIONS:

HOSHIN KIM won the ACS COMP The Chemical Computing Group Graduate Research Excellence Award. **MATTHEW MANNING** received a Grant in Aid of Research from the Sigma Xi society, while **TAD DEATON** received a Mentored Teaching Fellowship from the NC State College of Engineering.

UNDERGRADUATE STUDENTS

Our undergraduate students also continue to excel beyond the classroom. Highlights of their recent accomplishments include the following:

EMAN ALHAJJI received a first place Undergraduate Research Award from BASF; a third Place City of Future ePoster Award from KAUST Library and was selected for the NAE Grand Challenge Scholars Program at NC State. **NATE BROWN** was recognized for Outstanding Achievement in Undergraduate Research from the NC State Undergraduate Research Symposium. **WILL BROWN**, **IAN DOWDING** and **BAILEY REVELS** were recognized as NC State Caterpillar Scholar-Athletes, and named to the Atlantic Coast Conference Academic Honor Roll. **ABBY CARBONE** received an Office of Undergraduate Research grant and a first-place Undergraduate Poster Award at the North Carolina ACS conference. She was also selected to represent NC State at the ACC Meeting of the Minds Conference in Boston. **GRIFFIN DRYE** received the Litwack Day Award for the NC State College of Veterinary Medicine summer undergraduate research symposium. **ALEX HSAIN** received an NSF Graduate Research Fellowship, a Washington Internship for Students of Engineering (WISE) fellowship sponsored by ASTM International and an International Symposium on Applications of Ferroelectrics National Science Foundation Travel Grant. **ABHISHEK KHER** was awarded an ASSIST Center Fellowship. **GRACE MATTHEWS** participated in the Yale Summer Undergraduate Research Fellowship (SURF) program, and presented summer research at the Leadership

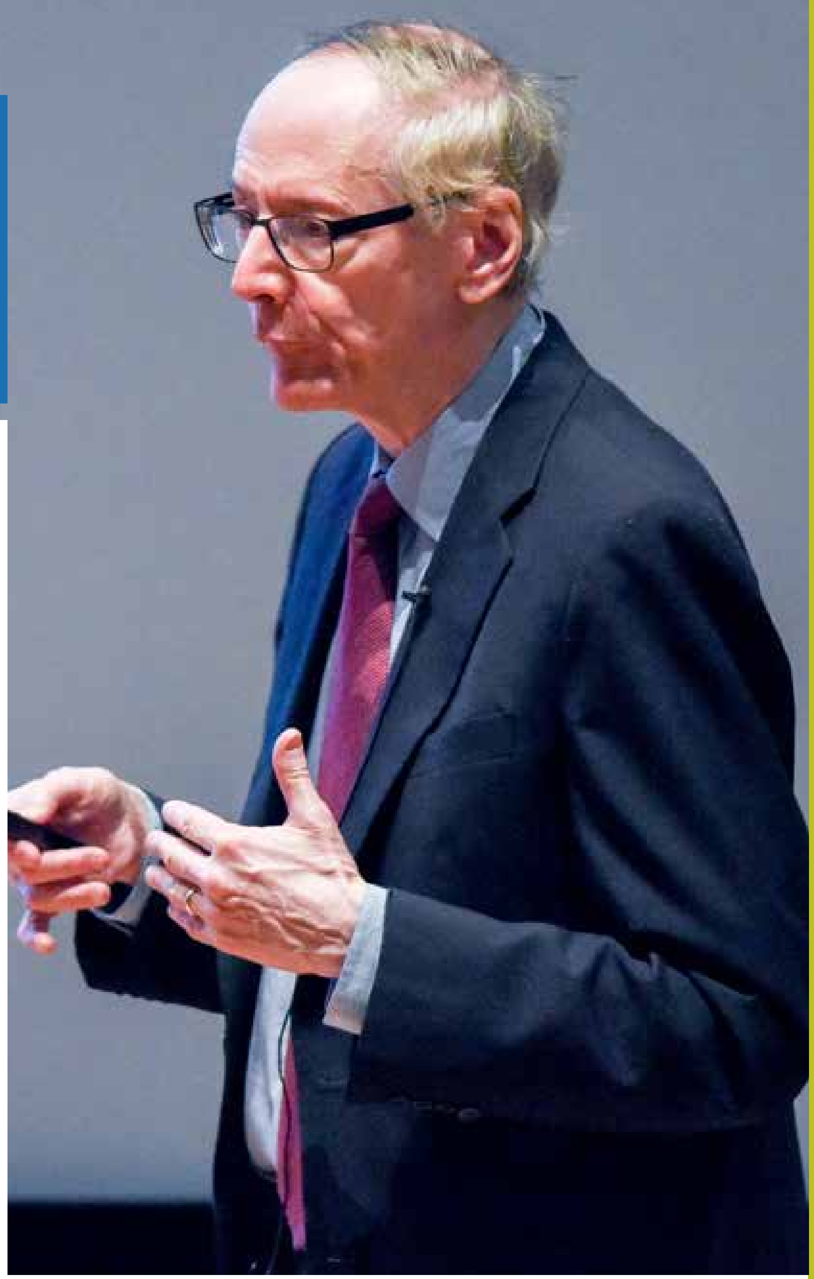
2018
ROBERT F. DAVIS DISTINGUISHED LECTURE

PROFESSOR TOBIN MARKS gave the 2018 Robert Davis Lecture. Endowed by Prof. Robert Davis, a former member of our faculty, this yearly lecture series has grown to one of the most prestigious public lectures in materials science and engineering in the U.S.

Marks is the Ipatieff Professor of Catalytic Chemistry, Professor of Materials Science and Engineering, Professor of Applied Physics and Professor of Chemical and Biological Engineering at Northwestern University. His scientific recognitions include the U.S. National Medal of Science, the Spanish Principe de Asturias Prize, the MRS Von Hippel Award, the Dreyfus Prize in the Chemical Sciences, the National Academy of Sciences Award in Chemical Sciences and the ACS Joseph Priestley Medal. He is a member of the U.S., German and Indian National Academies of Sciences, the U.S. National Academy of Engineering, the American Academy of Arts and Sciences, and the U.S. National Academy of Inventors. Marks has published more than 1,200 peer-reviewed articles and holds 260 issued U.S. patents. He holds honorary doctorate degrees from several universities in the U.S., Germany and Hong Kong.

His lecture, "How do we create and process materials for flexible, transparent electronic circuitry?" was held on March 2, 2018, in the Hunt Auditorium, James B. Hunt Library on NC State's Centennial Campus. This year's lecture was heavily advertised in local high schools, colleges and universities, as well as during Science Friday on WUNC, the local outlet of National Public Radio. The audience of well over 300 attendees included not only faculty members, graduate and undergraduate students from the MSE Department, but people from many other departments in the Colleges of Engineering and Sciences at NC State as well as from local academia, industry and high schools. The feedback from the audience was excellent, and we were especially pleased to see many undergraduate students asked questions after the lecture.

Prof. Chris Van de Walle is scheduled to give the 2019 Robert Davis Lecture. Van de Walle is the Herbert Kroemer Chair and a Distinguished Professor in Materials Science at the University of California at Santa Barbara. With over 400 publications and 24 patents, Van de Walle is one of the world's leading experts in use of computational methods for advanced materials development. ■



17 STUDENT NEWS

Senior Design Students Continue to Tackle Real-World Problems

FOR MORE THAN 20 YEARS, the MSE undergraduate program has maintained a senior design capstone program that brings together students and corporate sponsors to tackle real world materials-related problems in an industry setting. Teams of four to five students work closely with their faculty advisors and industrial liaisons to complete the project work, while strategically utilizing state-of-the-art analytical and testing facilities across campus. The two semester senior design program begins in the fall semester with a focus on teamwork, materials selection concepts and proposal development. Students then begin to work toward their project goals in early November, and the program culminates in May with student presentations and final report preparation. In previous years, many teams have participated in the annual NC State Undergraduate Research Symposium while others have even been successful in publishing their results in academic journals and patenting their new product designs, all at the discretion of the project sponsor.

This is the fourth year that Professors Maury Balik and Cheryl Cass will co-teach the course, merging their expertise in traditional materials science and engineering education. Both have served as MSE's director of undergraduate programs (Balik 2001-11; Cass 2011-present) and have been instrumental in undergraduate curriculum development, accreditation and advising. Since Balik and Cass took over this course, 18 different companies have sponsored 43 senior design projects. Senior design funds have also been used to purchase a new Shimadzu tensile tester for use by senior design teams and the undergraduate MSE labs.

"We work with our sponsors to develop projects that have a high probability of successful completion by a group of students within a five-month time frame," says Balik, MSE professor and coordinator of Graduate Distance Education. "We want the experience to be equally beneficial to our partners as it has proven to be for our students."

"Our sponsors pay a fee of $7,500 per project or $15,000 for three projects, which can be spread across one, two or three years," says Cass, MSE teaching associate professor. "With a small investment, our sponsors have seen significant returns in areas of process improvement, materials testing and characterization and product innovation." ■

Prospective sponsors can contact **Profs. Balik (balik@ncsu.edu)** and **Cass (cheryl_cass@ncsu.edu)** at any time during the year to discuss company needs and goals.

Study Abroad in Prague

> "I would tell the freshmen engineers that they should study abroad as soon as they can go, as often as they can go, and for as long as they can go, because it's the experience of a lifetime."
>
> **JILL NOONAN**

DURING THE FIRST SUMMER SESSION of 2018, Prof. Cheryl Cass, teaching associate professor and MSE's director of undergraduate programs, took a group of 14 rising sophomore engineering students to study abroad in Prague. For three weeks, students were enrolled in E 102, Engineering in the 21st Century, a new course recently developed by the College of Engineering and implemented into all NC State engineering curricula as a required interdisciplinary perspectives course. The purpose of the course is to introduce students to the 14 engineering grand challenges, as described by the U.S. National Academy of Engineering, and their relationships to all of the separate disciplines in the College of Engineering. The course was integrated into the longstanding study abroad program through the NC State European Center in Prague, so students also benefited from other course offerings, housing in student dorms and program amenities including trips to Vienna, Austria and Lednice, Czech Republic.

When asked how she would describe the study abroad experience to a group of freshmen engineers, Jill Noonan, MSE undergraduate student participant, said, "I think that the opportunities afforded to us through this program — such as excursions, a beautiful place to study, classes with local professors and easy immersion into Czech culture — are worth their weight in gold and really only accessible to college students. So, I would tell the freshmen engineers that they should study abroad as soon as they can go, as often as they can go and for as long as they can go, because it's the experience of a lifetime."

As part of the study abroad experience, Cass designed the course to take advantage of the history of the engineering landscape in the Czech Republic and incorporated a variety of tours and excursions around the city. The class visited the Skoda factory and museum in Mlada Boleslav as well as the National Technical Museum, the Faculty of Civil Engineering at Czech Technical University, the Old Wastewater Treatment Plant Museum, the Czech Academy of Sciences and a nuclear bunker museum, all located within Prague.

When recalling the details of her experience abroad, Cass said, "Getting an opportunity to learn new things alongside your students is a gift. We found our way together, we stood in awe together, and I am fortunate to have worked with such an incredibly enthusiastic and engaged group of students."

This is the second time Cass has brought an engineering course to NC State study abroad. In the summer of 2016, she offered the MSE department's sophomore-level introductory class (MSE 201, Structure and Properties of Engineering Materials) in London, where she led an excursion to the BMW MINI plant in Oxford, UK and also worked with colleagues from the Royal Academy of Engineering to provide a walking tour of the history of science and engineering in London.

Due to the success of E 102 this summer, NC State Prague currently plans to continue offering the course on an annual basis, which will be led by a College of Engineering faculty member who typically has a strong focus on undergraduate education. ■

Alumni **Corner**

19

Q&A WITH DR. NATALIE GIBSON

__Dr. Natalie Gibson__ graduated from the MSE Department with a Ph.D. in 2010. Under the direction of Drs. Mark Luo and Don Brenner, and with guidance from Dr. Olga Shenderova, of the International Technology Center, Gibson conducted research on the use of nanodiamonds to reduce the effects of aflatoxin (a toxic byproduct of mold) in the gastrointestinal tract for agricultural and pharmaceutical applications. In addition to her research at NC State, Gibson managed communication with collaborators from the Russian Academy of Sciences; this experience included trips to Russia to meet with her research counterparts.

During her studies, Gibson developed expertise in colloidal chemistry, analyzing factors such as particle size, zeta potential, surface chemistry and environmental conditions. As a result, she found ways to enhance the binding efficiency of select aflatoxin and aflatoxin simulators. Her research resulted in four publications, with the most notable being Colloidal Stability of Modified Nanodiamond Particles, where she illustrated the dependence of pH titration direction on particle agglomeration and disaggregation.

Dr. Natalie Gibson
Ph.D. 2010

What career path did you envision for yourself during your time as a student in MSE?

Dr. Natalie Gibson: Honestly, I wasn't sure. I loved science, but also knew I wouldn't spend my career in the lab. I enjoyed teaching non-technical people or those outside of my field about my work. I didn't know that I'd later build my career on bridging technical and non-technical worlds.

Q&A with Dr. Natalie Gibson

Did you do anything special to prepare for that career?

G: I took classes in the TEC program (Technology, Entrepreneurship, and Commercialization). This taught me to view applied technology through a different lens. By working with MBA students, I got to see how they invested in and grew ideas.

How did your career progress after graduating? Were there any unexpected turns in your career, and if so how did you deal with those?

G: I've had so many unexpected turns that I stopped trying to predict my path. I learned instead to work toward a North Star and take roles that focus on building needed skills or experiences.

After graduating, I joined INVISTA developing new polymer additives and coating formulations for STAINMASTER® flooring. There I started collaborating with marketing and developed products based on consumer insights. This led me to a role in Innovation Business Development, where I learned how to economically assess ideas and accelerate their transition into dollars. While at INVISTA I launched Livewell™ carpet and PetProtect™ luxury vinyl tile assisted in the development of STAINMASTER™ cleaners, and am hopeful to hear that one more of my inventions will launch this year.

In early 2017, I moved to Georgia-Pacific (a sister company) to startup a new digital print packaging business, now called Hummingbird, and am working with some of the largest consumer brands.

How did your time at NC State help prepare you for your career, including your current position?

G: Without a doubt, I know graduate school helped me develop my critical thinking skills. It taught me to be comfortable with navigating through the unknown. And I developed an aptitude to learn new concepts quickly.

My colloidal chemistry knowledge also came in handy, as it is the core of so many products. It's always fun to flex that muscle, and surprise people, when I get the chance.

Please describe the type of research you do now.

G: My job today is about figuring out where to focus company time, energy and resources. To determine that, I'm always "researching" something, but it normally centers around technical or market trends, data analytics and marketing insights.

Are there any memories of your time at NC State that stand out for you now?

G: The program shaped me into who I am today, and I am thankful for that. I often reflect on my time at NC State to get me through times of uncertainty. When questions pop into my mind, like "can I figure this out?" or "am I smart enough?", I think about how I also had those through the program. Many of my memories are of the positive support I had from my husband and family during that time.

The trips to Russia were fun too!

What advice would you give to a student in graduate school today? Is there any advice that you wish you had received while you were a graduate student?

G: Don't worry so much! You don't know what life has in store for you, so focus on building experiences and being a student of learning. Become skilled in that, you are set up for our fast-changing world. ■

> "You don't know what life has in store for you, so focus on building experiences and being a student of learning. Become skilled in that, you are set up for our fast-changing world."
>
> **DR. NATALIE GIBSON**

Alumni Corner

FAMILY HISTORY OF GIVING INSPIRED ALUMNA TO GIVE BACK

Michelle Morse graduated from NC State's Department of Materials Science and Engineering in 1996. After being inspired by her grandfather's support of her education, Morse and her family decided to pay it forward for future NC State students. In March of 2018, she established the "Learn More Joyously Scholarship" endowment to support need-based scholarships for undergraduate students in the MSE Department.

"My grandfather, Lewis Morse, is the main inspiration for this gift," shared Morse. "He taught me, and my whole family really, how important an education is. How having a good education will enable you to do the things you truly want in life."

Morse said that, whenever a child was born into their family, her grandfather started a college fund for them. His generosity allowed many in their family to obtain some sort of post-secondary education. "We are a blessed happy family, and I credit that to my grandparents," she shared. "I want to share some of this happiness and opportunity with others, especially those who are struggling financially. Money should never be an obstacle to learning. This is why we named the fund The Learn More Joyously Scholarship."

Her gift to NC State will ensure that her grandfather's legacy will live on through future scholarship recipients, forever helping them to learn more joyously.

"I am, and always will be, thankful to The Wolfpack for my education. NC State helped me obtain financial assistance when I needed it and this scholarship is a way to give a little back. I am able to live a successful, happy, and financially comfortable life now... and I believe I owe much of that to NC State University," said Morse. "I have no doubt my grandfather would be proud to have his name associated with NC State." ■

ALUMNUS ORIGINATOR OF REYNOLDS WRAP

Bennie Ward Jr. fondly remembers his time at NC State.

"I went to NC State when the slide rule was the instrument for engineering, the Dixie Classic was held at Reynolds Coliseum, and it was still a college," shared Ward, who earned his B.S. in metallurgical engineering in 1959.

Post-graduation, Ward was employed by Reynolds Metals in Richmond, Virginia, where he held the job of supervisor of the Pilot Equipment Lab for Reynolds Research.

Ward has 20 metallurgical patents, but he finds his 20th one to be the most rewarding: U.S.P. 5,725,695 Method of Making Aluminum Alloy Foil and Product Therefrom. Reynolds registered his alloy as AA 8111 by the Aluminum Association.

According to Ward, Reynolds has been making Reynolds Wrap since 1947 by ingot casting (30-40" thick) using another alloy. "They built a twin roll casting plan in Alabama (.240-.500" strip thickness) to take in the cast advantage of having a cast gauge closer to the gauge of the final product."

There were problems that came about from this process, where the reroll and final anneal had to be higher than normal due to the constituent size of the twin roller cast strip being too small, which would not cause key dislocation to recrystallize at normal annealing temperatures.

Ward's patent of 8111 overcame these problems and produces a foil that is soft, tough and has good elongation.

"With my patent, Reynolds and the company that bought the foil division had 17 years of protection to make Reynolds Wrap from 8111. To my knowledge, the company is still making the same product." ■

2017 **Alumni Hall of Fame**

2017 **Alumni Hall of Fame**

This past year, four new exceptional alumni were inducted into the MSE Hall of Fame. *The ceremony was held on November 3rd, 2017 during Red and White week, the university's celebration of the Wolfpack community. The inductees were:*

Bill Chinnis

B.S. '83

Bill Chinnis began his career at Allvac, an aerospace metals company located in Monroe, NC, and worked primarily in the area of titanium melting technology. Responding to the needs of the commercial jet engine market, Allvac invested in a new titanium melting technique known as plasma cold hearth melting (PAM) in the late 1980s. Bill led the installation, development, and industry certification of this new technology. Later, Bill partnered with NC State MSE graduates Hal Lindsay ('81) and John Hoffman ('82) to form AlloyWorks LLC in Salisbury, NC. Through the use of a custom designed PAM furnace, AlloyWorks simplified the manufacture of custom sized ingots for the aerospace investment casting industry. Further, AlloyWorks commercialized the production of the new generation lightweight titanium aluminide (TiAl) alloys, gaining GE's approval in 2009 for their GeNX engine application, powering Boeing's 787. TiAl materials replaced heavier nickel alloys used in low pressure turbine blades, contributing significantly to the increased fuel efficiency claimed by GE. Today, Bill continues to assist companies worldwide with their design and operation of titanium PAM furnaces. Bill is widely recognized in the specialty metals industry for his knowledge of sophisticated melting techniques including VAR and especially PAM, where he is one of a few experts in this technology. Bill has published and presented technical papers at many of the industry's national and world conferences.

Dr. Richard Ricker

B.S. '75, M.S. '78

Dr. Richard Ricker earned his B.S. and M.S. degrees in materials science and engineering. While at NC State, he participated in the cooperative education program working with NASA at the Marshall Space Flight Center on the Skylab and Shuttle programs. After graduation, he worked at the Babcock & Wilcox Company's Lynchburg Research Center evaluating the performance of nuclear reactor components before attending Rensselaer Polytechnic Institute. At RPI he received a Ph.D. for his research into the mechanisms of corrosion fatigue in aluminum alloys in 1983. He then held a position at the University of Notre Dame before joining the National Institute of Standards and Technology (NIST) in 1986. At NIST, he held numerous positions including corrosion group leader, materials performance group leader, director of the NACE-NIST Corrosion Data Program, program analyst for the Director's Office, director of the National Rockwell Hardness Standards Program, and senior scientific adviser for the Materials Science and Engineering Laboratory. He has been active in a number of professional societies including TMS, ASM, ASTM, MRS, NACE, and Sigma Xi, and was a member of the Board of Trustees for Alpha Sigma Mu the international academic and professional society for the field of materials science and engineering. He is currently the manufacturing program director for the Material Measurement Laboratory of NIST where he is best known for conceiving and directing a research program into the materials science of additive manufacturing. He has organized over 40 scientific meetings, edited two books, and published over 75 scientific papers and 60 technical reports. He has made over 55 invited presentations at technical meetings, sat on 28 special committees or review panels, and co-authored two chapters for the ASM Metals Handbook (Stress Corrosion Cracking and Corrosion of Intermetallics).

Dr. Mike Rigsbee

B.S. '69, M.S. '71, Ph.D. '74

Dr. Mike Rigsbee received his B.S., M.S. and Ph.D. from NC State. Mike earned his post doc at Michigan Tech with Dr. Hubert Aaronson and worked at Republic Steel Research Lab in Cleveland, Ohio for 6 years. He worked in the Metallurgy Department at University of Illinois for 14 years. Mike became department head of Mechanical and Materials Engineering at University of Alabama before returning to NC State. From 1998 to 2009, he was department head of the Department of Materials Science and Engineering at NC State. He continued as a professor with a specialty in electron microscopy until his passing in 2015. As the online program emerged, Mike helped to develop the materials science portion of the Distance Education Program and with the MSE 500 course as the first online course within the department. This course was expanded even further by Mike and it became of value to all engineering students, not just MSE students. Mike was known in the department as a department head who was focused on helping faculty members and students with their research and always had his door open. He was a people-focused department head. His wife, Donna, accepted the award on his behalf.

Dr. Andy Thomas

B.S. '90

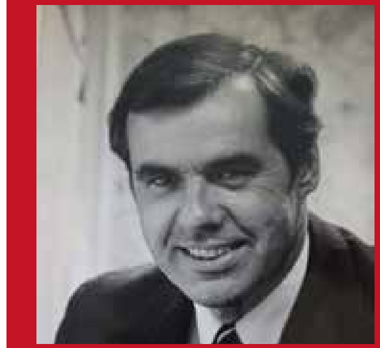
Dr. Warren "Andy" Thomas graduated summa cum laude from NC State University in 1990 with a B.S. in materials science and engineering. He also earned his M.S. (1992) and Ph.D. (1994) degrees from The University of Texas at Austin in materials science and engineering. During his time at NC State, Andy was fortunate to work as an undergrad research assistant for Dr. Hayne Palmour III and Dr. Robert Davis and was named the recipient of the COE Faculty Senior Scholarship. These research opportunities stoked a passion for research and technology development. He has 10 years of aerospace experience at Bell Helicopter where he initially led new material development efforts and transitioned into an engineering management role as the manager of technology IRAD/CRAD programs. In this position, he oversaw all early-stage technology scouting and development for military and commercial rotorcraft. Andy is currently serving as the senior director of Global R&D Operations at CoorsTek. Headquartered in Golden, CO, CoorsTek is a leading global engineered ceramics manufacturer with over 30 manufacturing facilities spread across four continents. In this role, he has responsibility for the coordination of research activities across multiple research centers in the U.S. Japan and Europe. Andy is married to his college sweetheart, Jennifer Cotten Thomas (B.A. in business administration, NC State 1988), and has two children. In addition to his love for technology development and travel, Andy enjoys mentoring young people to find their niche in STEM fields.

The 2018 Hall of Fame Ceremony was held November 3 during Red and White Week, and featured the induction of seven more outstanding alumni: Mitchell Haller (M.S. 1967, Ph.D. 1971), Edward Nixon (M.S. 1955), Lisa Porter (Ph.D. 1994), Paul Stewart (B.S., 1959), Bennie Ward (B.S., 1959), and Gleb Yushin (Ph.D., 2003). ■

Alumni Corner

Department Head Office Named

Family honors longtime ceramic engineering department head with naming



Gerald Kriegel

Dr. William Wurth Kriegel

ROOM 3010 IN ENGINEERING BUILDING I on NC State's Centennial Campus is occupied by the head of the Department of Materials Science and Engineering (MSE).

Dr. Donald Brenner, Kobe Steel Distinguished Professor and MSE department head, is the current occupant. **Gerald Kriegel** hopes that whomever sits in that office adopts an open-door policy for students. After all, that's what his father did.

Dr. William Wurth Kriegel spent 32 years at NC State as an instructor, professor and then department head in the Department of Ceramic Engineering, which grew into today's MSE.

"It was largely in that one room, supporting students," Gerald Kriegel said of his late father's office, and the career he made occupying it.

Wurth Kriegel always made students a priority and always wanted them to feel comfortable visiting him in his office. So, in making a donation to support MSE and put his father's name on the department head's office, Gerald Kriegel hopes that its occupant will do the same.

Wurth Kriegel enjoyed teaching, primarily graduate students, his son said. But he also enjoyed the research and the administrative duties that went along with the department head position.

Ceramic engineering was not as large a department on campus in those days as the departments of civil, mechanical and nuclear engineering.

Today, it's still one of the College of Engineering's smaller departments but in the last few years has seen a marked increase in research expenditures, faculty hiring, enrollment and national rankings.

"It's in a smaller arena. They're excellent in that smaller arena," Gerald Kriegel said in describing his motivations for supporting the department.

A native of Seattle, Wash., Wurth Kriegel earned bachelor's degrees from the University of Washington and a master's degree from the Montana School of Mines before earning a Ph.D. in ceramic engineering from the Technische Hochschule in Hanover, Germany.

After returning to the United States, he served as an instructor at Montana School of Mines. In 1939, he and his wife, Evelyn, moved to Raleigh, where he took a position as an instructor at North Carolina State College. Duty called in 1941, though, and Kriegel served as a first lieutenant and later lieutenant colonel in the Army Artillery during World War II. He returned to campus after the war and was named head of the Department of Ceramic Engineering in 1946.

An authority on the mechanical properties of ceramic materials, Wurth Kriegel was a charter member of Keramos, the professional ceramic engineering fraternity, and a Fellow in the American Ceramic Society. He helped found the University Conference on Ceramic Science and served as a consultant to several private companies and governmental agencies, including the Atomic Energy Commission's Oak Ridge National Laboratory and the U.S. Army's Office of Ordnance Research. Kriegel retired from the NC State faculty in 1971 and died in Seattle in May 1980.

Gerald Kriegel grew up in Raleigh's Hayes Barton neighborhood and earned a degree in civil engineering from NC State as an ROTC student and commissioned second lieutenant. After graduation, he worked for DuPont at facilities in South Carolina and Tennessee before entering the Army as an artillery officer. ■

Materials at NC State Centennial

We have a birthday coming up, and it's a big one!
The roots of our department can be traced to the first Ceramics Program established in the southeast in 1923. In a few short years we will be celebrating our 100th birthday, and we need help making this a celebration to be remembered. We are looking for volunteers to help research, plan and coordinate support for this momentous occasion.

If you want to help or even nominate someone else to help, please contact **Dr. Don Brenner** at **brenner@ncsu.edu**.

NC STATE Engineering

NC State University
Department of Materials Science and Engineering
Campus Box 7907
Raleigh, NC 27695-7907

GIVE TODAY.
IMPACT TOMORROW.
SUPPORT THE MSE DEPARTMENT.

THE DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING provides the highest quality of education for future engineers, and creates a research environment that drives innovation in North Carolina and beyond. The generosity of alumni and friends helps safeguard the department's ability to extend educational opportunities to bright, deserving students and recruit and retain outstanding faculty members to teach these future scholars.

Gifts to the MSE Enhancement Fund, endowment opportunities, undergraduate scholarships, graduate scholarships, and distinguished professorships help provide an impact felt on current and future students, retaining and recruiting exceptional faculty members, and providing resources to the department to continue to respond to emerging needs and exciting challenges.

To learn more about supporting the department, contact the NC State Engineering Foundation at **919.515.7458** or **engr-foundation@ncsu.edu**.