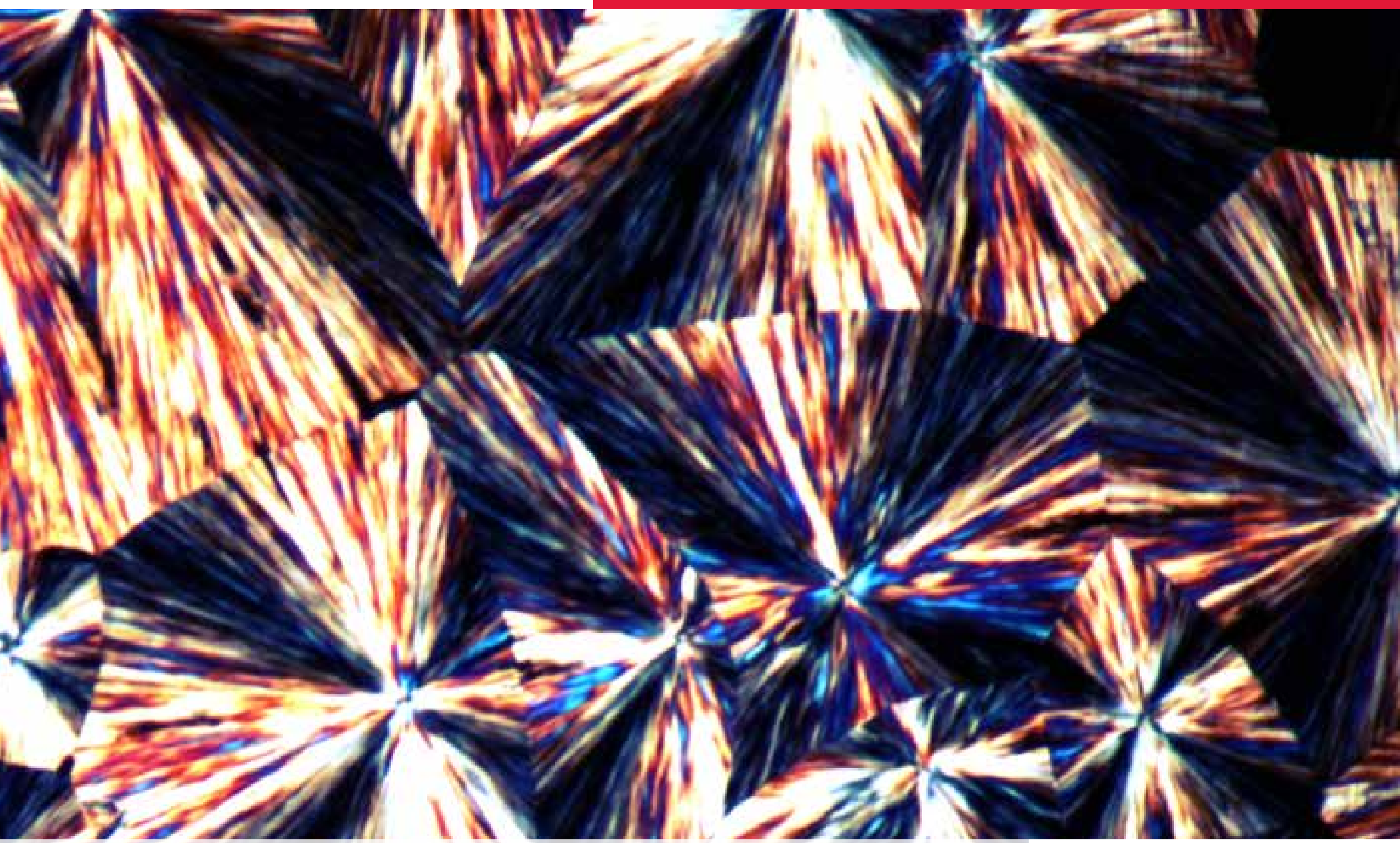
MSE NEWS

DEPARTMENT OF
MATERIALS SCIENCE AND ENGINEERING

COLLEGE OF ENGINEERING
NORTH CAROLINA STATE UNIVERSITY | FALL 2015

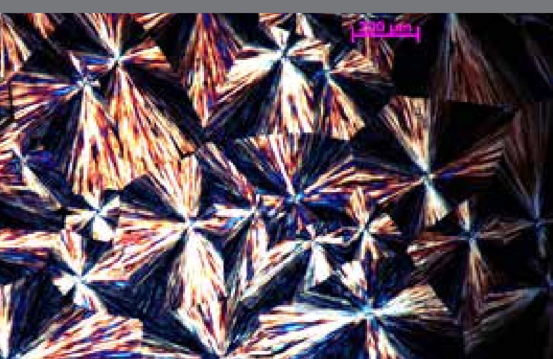


NC STATE
Engineering

IN THIS ISSUE

IN THE SPOTLIGHT

Undercover Colors is developing a clear fingernail polish that detects the presence of a date-rape drug in a drink.



ABOUT THE COVER

Department students and faculty members submitted research images for this newsletter, including the image on the cover submitted by undergraduate student Balaji Lenin. See more image submissions on page 29

A MESSAGE FROM THE DEPARTMENT HEAD

I hope you'll enjoy the fall 2015 newsletter, which clearly shows why Materials Science and Engineering at NC State continues to grow not only in student numbers but also in faculty and research areas and is the up and coming MSE department in the United States.

Since the 2010-11 academic year, we have added 12 new faculty members; two began teaching at NC State this fall.

Professor Franky So, an endowed professor from the University of Florida, comes to NC State in the research area of carbon electronics, a field that the University of North Carolina General Administration has selected as one of six to receive three-year grants that involve game-changing faculty research in areas of strategic importance to the state. The NC Carbon Materials Initiative, a $2,829,994 grant, is led by NC State, with NC Central University and UNC-Chapel Hill as partners.

This initiative award came at a good time with the addition of Professor So to the department. We see carbon electronics as a long-term impact area that bridges our past history of electronic materials and the future of next-generation and generation-after-next organic materials. NC State has made carbon electronics the focus of a "cluster hire," meaning that it will be hiring at least five faculty members in the field spread across multiple departments and colleges.

Professor Veronica Augustyn joins us from the Texas Materials Institute at the University of Texas at Austin. Her research focuses on the field of electrochemistry, with interest in how materials store charge via intercalation reactions and the mechanisms by which these materials degrade during long-term operation and the evolution of next generation metal/air batteries. She will be taking the department into an area in which we have not been active previously. As the department has grown, we have examined research areas in which we have not been involved and decided it was time to include electrochemistry.

With the department expanding into new research areas, the search is on to recruit four new faculty positions. The research areas include: metallurgy; the carbon electronic cluster; photonic, plasmonic; and optoelectronic materials; surface science/spectroscopy; soft composites; solid state chemistry and ionics; and thermal transport. Generally, the department seeks the most outstanding faculty members regardless of specialization.

One step the department has taken to remain in the forefront of research is to lead one of the chosen sites for the National Science Foundation's (NSF) National Nanotechnology Coordinated Infrastructure (NNCI). The NNCI is part of the National Nanotechnology Initiative 2014 Strategic Plan emphasizing the importance and need for the United States to sustain a dynamic infrastructure and toolset to advance nanotechnology, particularly the academic infrastructure represented by the National Nanotechnology Infrastructure Network. A strong role in the NNCI demonstrates the department's and NC State's impact and bright future in nanomaterials, nanoscience and nanotechnology.

As we continue to grow and transform into one of the nation's and world's leaders in characterization, the strong partnerships we have formed with the Analytical Instrumentation Facility, the talented and strong new hires made in the past few years and equipment received from the university and the NSF have catapulted us into the limelight and toward greater success.

Since our last newsletter, we have had an increase in visibility that is seen in the department's graduate program moving from 31st to 18th in *U.S. News & World Report* rankings. I foresee that number moving up further as we are going to experience continued growth in both the quantity and quality of our graduate students.

We appreciate your interest in our department and look forward to continuing our relationship with you.

Justin Schwartz
Kobe Steel Distinguished Professor
MSE Department Head

More students, and more opportunities, for materials science and engineering

NC State's Department of Materials Science and Engineering is going through a period of remarkable growth in its student body, and that growth is creating opportunities for alumni and others in the materials community to become involved with the next generation of materials engineers and scientists.

In fall of 2010, MSE had 66 full-time undergraduates. By fall 2015, that number had more than doubled to 134 students. The quality of those students is also increasing. For example, as of fall 2014, the NC State grade point average of students entering MSE in 2010 was 3.2, while students who entered in 2013 had a GPA of 3.6.

"And we've found that students tend to get higher grades as they get closer to graduation, so we don't expect the trend to change for these students," says Professor Cheryl Cass, MSE's director of undergraduate programs.

In addition, the makeup of the student body is also changing. While only 13 percent of MSE's undergraduates were women in fall 2011, 31 percent of the undergrads in fall 2015 are women – no small feat when you consider that the national average for engineering undergraduates hovers around 20 percent.

One reason for the growth of the MSE student body is the creation of optional concentrations that allow students with specific interests to prepare themselves for future research endeavors and the workplace. A concentration in nanomaterials was launched in January 2015, and a concentration in biomaterials has been in place since January 2014.

"The concentrations have garnered significant interest from students, with seven undergraduates enrolling in the first six months of the nanomaterials concentration and 24 undergraduates enrolling in the first 18 months of the biomaterials program," Cass said. "And the biomaterials concentration is also a significant factor in our increased enrollment of women."

To support and sustain this growth, MSE has identified two areas of need for the future – and this is where the MSE community can make a significant impact.

"Thanks to the great efforts of Professor Cass, our undergraduate program has shown tremendous growth in the number and quality of students," said Professor Justin Schwartz, department head. "Having a strong cohort of such outstanding students is important to all department stakeholders, but sustaining this level of excellence will require substantial growth in scholarship funds. The very best students have lots of options – at other universities and in other departments within NC State. Honoring and supporting these students with scholarships is an important part of our success."

But the department also needs to identify industry partners to work with students on senior design projects.

"These projects benefit both students and industry partners," Cass said. "Students get experience applying skills they learned in the classroom to real-world problems, on a budget, with a deadline. Our industry partners get a dedicated team devoted to solving a problem or developing a product they can use – as well as the opportunity to cultivate a new generation of skilled employees."

"The future of MSE at NC State is bright, and one of the driving forces behind our bright future is the annual influx of incredible new undergraduate students," Schwartz said. "Every day I marvel at what they are able to accomplish and look forward to seeing what they will create next." ▪

Research Triangle MRSEC: tackling the challenges of soft matter research

Professor Yaroslava Yingling

The NSF-funded Research Triangle Materials Research Science and Engineering Center (MRSEC) is focused on addressing significant research questions about soft matter and involves faculty members from Duke, NC State, UNC-Chapel Hill and NC Central – and while the center is housed at Duke University, NC State's MSE faculty members are important contributors to the MRSEC's work.

The Triangle MRSEC's research is divided between two interdisciplinary research groups (IRGs). IRG-1 focuses on improving our understanding of self-assembly of materials in colloidal suspensions. IRG-2 focuses on self-assembly of "syntactomers," or macromolecules that consist of specific sequences of monomers, into supramolecular structures.

The work of researchers in IRG-1 is aimed at understanding how to control the assembly of materials in a colloidal suspension using electrical or magnetic fields, as well as understanding what kind of properties the controlled assemblies give to a material.

MSE Associate Professor Joe Tracy is part of IRG-1, and his group is looking at a very practical aspect of the problem: how can researchers "fix" a specific assembly in the suspension in order to retain the desired structure (and its properties), and what are the properties of these composite materials?

"This work advances our fundamental understanding of the mechanisms behind self-assembly and of the opportunities for developing whole new materials – with desirable combinations of properties – and of means to manufacture materials more efficiently," Tracy says.

And the work being done in IRG-2 is just as promising.

MSE Associate Professor Yaroslava Yingling is bringing her computational research expertise to help design, predict and explain the properties of new smart, self-assembling materials that contain specific sequences of peptides and DNA and are capable of responding to changes in their environment. These materials have promise for use in applications from drug delivery to bioelectronics to tissue engineering.

"The work we're doing with the Triangle MRSEC could lead to new areas of research for years to come," Yingling says. ▪

Jones in the Analytical Instrumentation Facility.

Jones will lead new Research Triangle Nanotechnology Network

Professor Jacob Jones

NC State University, Duke University and UNC-Chapel Hill are launching a partnership to give businesses and educators access to expertise and facilities that will speed the development of new nanotechnology-based products and educational opportunities. The partnership, called the Research Triangle Nanotechnology Network (RTNN), is led by NC State and is supported by a five-year, $5.5-million grant from the National Science Foundation's National Nanotechnology Coordinated Infrastructure.

"The grant will fund efforts to open our doors and work more effectively with the public, from major corporations and start-ups to community colleges and K-12 educators," says Professor Jacob Jones, MSE professor and principal investigator of the grant.

The bulk of the funding will be used to hire staff that will be dedicated to reaching out to potential industry and educational partners to identify ways that RTNN can address their specific needs.

"For businesses, our goal is to help them develop new products, improve existing ones, and help them move discoveries to market," said Jones, who is also director of the university's Analytical Instrumentation Facility (AIF). "For educators, we want to introduce them to nanotechnology and give them resources they can use in the classroom."

The RTNN will also make laboratories and entrepreneurs better at what they do. David Berube, a professor of communication at NC State and lead of the social science component of the grant, says, "We hope that this will allow us to develop best practices that can be used to ensure that future partnerships for innovation will be successful."

And the RTNN has a variety of resources that will be used to help achieve those goals.

"NC State has an enormous amount of expertise in nanotech-related fields, from agriculture and plant biology to textiles and materials science and electrical engineering," Jones says. "And across all three universities, our expertise touches on almost any area of nanotechnology you can think of. So, regardless of the challenges a corporation or entrepreneur may be facing, we will be in a position to connect them with relevant subject matter experts."

In addition to providing expertise, it will also give the public access to a wide array of powerful tools to help them advance their innovations from concept to prototype and, ultimately, through manufacturing for the marketplace.

For example, the AIF has the ability to look at the structure of nanoparticles in three dimensions and the individual positions of atoms in a nano-device. The latter is done using a technique pioneered at NC State called "revolving STEM" and a state-of-the-art aberration-corrected scanning transmission electron microscope, the Titan.

"This will be used to help develop and fine-tune technologies in fields from drug delivery to water purification to nanoelectronic devices," Jones says.

Between NC State, Duke and UNC-Chapel Hill, RTNN has a suite of world-class facilities that will be valuable to outside groups. These facilities have capacities including nanofabrication of electronics, textiles fabrication and characterization, sophisticated materials characterization and labs that evaluate interactions between nanotechnologies and the environment.

To learn more visit, **www.rttn.org**. ▪

Stacked 2D materials as a pathway to lower-cost semiconductor devices

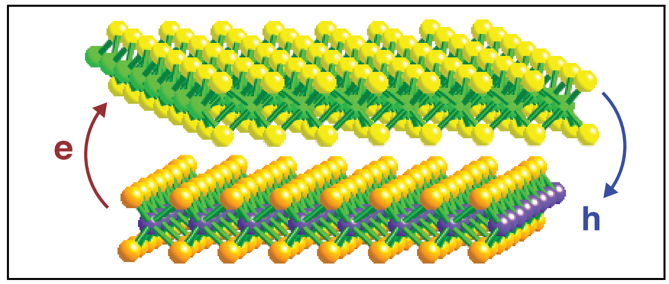
Researchers from MSE and colleagues have found that stacking materials that are only one atom thick can create semiconductor junctions that transfer charge efficiently, regardless of whether the crystalline structure of the materials is mismatched — lowering the manufacturing cost for a wide variety of semiconductor devices such as solar cells, lasers and LEDs.

"This work demonstrates that by stacking multiple two-dimensional (2-D) materials in random ways we can create semiconductor junctions that are as functional as those with perfect alignment," says MSE's Professor Linyou Cao, senior author of a paper on the work.

"This could make the manufacture of semiconductor devices an order of magnitude less expensive."

For most semiconductor electronic or photonic devices to work, they need to have a junction, which is where two semiconductor materials are bound together. For example, in photonic devices like solar cells, lasers and LEDs, the junction is where photons are converted into electrons, or vice versa.

All semiconductor junctions rely on efficient charge transfer between materials, to ensure that current flows smoothly and that a minimum of energy is lost during the transfer. To do that in conventional semiconductor junctions, the crystalline structures of both materials need to match. However, that limits the materials that can be used, because you need to make sure the crystalline structures are compatible. And that limited number of material matches restricts the complexity and range of possible functions for semiconductor junctions.



Efficient charge transfer in randomly stacked two-dimensional heterostructures.

"But we found that the crystalline structure doesn't matter if you use atomically thin, 2-D materials," Cao says. "We used molybdenum sulfide and tungsten sulfide for this experiment, but this is a fundamental discovery that we think applies to any 2-D semiconductor material. That means you can use any combination of two or more semiconductor materials, and you can stack them randomly but still get efficient charge transfer between the materials."

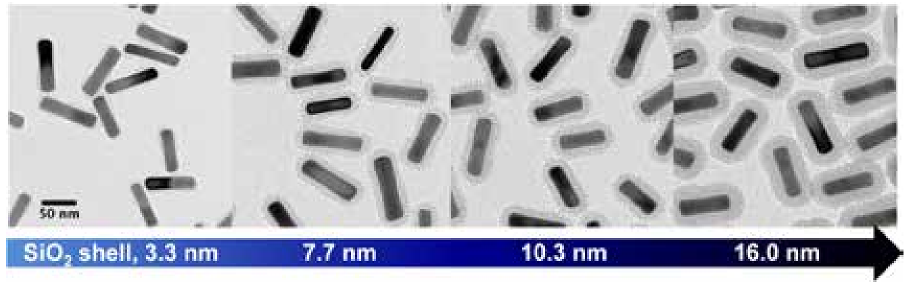
Currently, creating semiconductor junctions means perfectly matching crystalline structures between materials — which requires expensive equipment, sophisticated processing methods and user expertise. This manufacturing cost is a major reason why semiconductor devices such as solar cells, lasers and LEDs remain expensive. But stacking 2-D materials doesn't require the crystalline structures to match.

"It's as simple as stacking pieces of paper on top of each other — it doesn't even matter if the edges of the paper line up," Cao says.

The paper, "Equally Efficient Interlayer Exciton Relaxation and Improved Absorption in Epitaxial and Non-epitaxial MoS_2/WS_2 Heterostructures," was published in *Nano Letters*. ▪

An improved method for coating gold nanorods

Professor Joseph Tracy



Micrographs of gold nanorods with silica shells of varying thicknesses.

Researchers have fine-tuned a technique for coating gold nanorods with silica shells, allowing engineers to create large quantities of the nanorods and giving them more control over the thickness of the shell. Gold nanorods are being investigated for use in a wide variety of biomedical applications, and this advance paves the way for more stable gold nanorods and for chemically functionalizing the surface of the shells.

Gold nanorods have a lot of potential applications, because they have a surface plasmon resonance — meaning they can absorb and scatter light. And by controlling the dimensions of the nanorods, specifically their aspect ratio (or length divided by width), you can control the wavelength of light they absorb.

"This characteristic makes gold nanorods attractive for use in catalysis, security materials and a range of biomedical applications, such as diagnostics, imaging, and cancer therapy," said MSE's Professor Joseph Tracy, who is senior author of a recent paper on the improved technique.

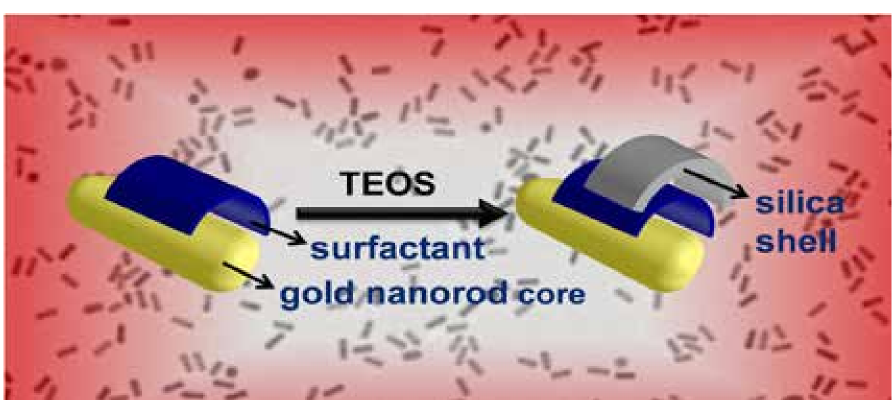
Gold nanorods are efficient for photothermal heating, the process of converting absorbed light into heat. If too much light shines on gold nanorods, however, they can lose their rod shape and change into spheres, losing their desirable optical properties.

One way to help gold nanorods retain their shape during photothermal heating is to coat them with silica shells, which confine the nanorods to their original shape but allow light to pass through. For different applications, it is important to be able to control the shell thicknesses. With thin shells, the change in size of the nanorods is minimal, and the gold nanorods can still pack into dense assemblies. On the other hand, thicker shells can act as buffers, preventing nanorods from bunching closely together and shielding them from their environment.

Silica shells also provide a surface that can be functionalized using well-understood chemical techniques. For example, the shells could be functionalized to fluoresce in the presence of specific proteins or to target tumors.

"The silica shells offer multiple benefits — and our modified approach to coating gold nanorods with silica shells has two distinct advantages," Tracy says.

"First, we have demonstrated that our technique can be carried out on a large scale — up to 190 milligrams," Tracy says. "Second, we offer improved control over shell thickness. We can consistently create uniform shells as thin as 2 nanometers."



Overview of deposition of silica shells on gold nanorods.

The modified technique has two steps.

"First we apply a reagent called TEOS to the gold nanorods in solution," says Wei-Chen Wu, a Ph.D. student in Tracy's lab and lead author of the paper. "Once in solution, the TEOS begins to form a silica shell on the nanorods. We then introduce another reagent called PEG-silane into the solution. This stops the shell from growing thicker."

The paper, "Large-Scale Silica Overcoating of Gold Nanorods with Tunable Shell Thicknesses," is published online in the journal *Chemistry of Materials*. ▪

Augustyn brings research in electrochemistry of materials to the department

Professor Veronica Augustyn

PROFESSOR VERONICA AUGUSTYN has joined the department's faculty as an assistant professor. Her research focuses on the field of electrochemistry, with interest in how materials store charge via intercalation reactions, the mechanisms by which these materials degrade during long-term operation and the evolution of next-generation metal/air batteries.

"I am happy to be at NC State for a number of different reasons," says Augustyn. "First off, I really enjoy my colleagues in the MSE department. The department is very dynamic. It's growing – there are several faculty members that joined over the past few years, and it's just a very exciting place to be."

Augustyn received her B.S. in materials science and engineering from the University of Arizona (2007) and her M.S. and Ph.D. in materials science and engineering from the University of California, Los Angeles (2013).

During her time as a Ph.D. candidate, she worked with Professor Bruce Dunn on nanostructured materials for electrochemical energy storage. Their research into transition metal oxides for pseudocapacitance, a type of capacitive charge storage that utilizes redox reactions, would allow users to charge and discharge their electronic devices in a matter of seconds.

Her postdoctoral work at the University of Texas at Austin with Professor Arumugam Manthiram focused on finding better electrocatalysts for sustainable hydrogen production for fuel cells and efficient metal/air batteries. The objective of this research was to characterize a new class of oxygen evolution reaction electrocatalysts, layered lithium metal oxides.

Augustyn's current research focuses on understanding materials at electrochemical interfaces during energy storage and conversion. She sees the global need for sustainable, secure and efficient energy as one of the biggest problems now facing mankind. A key challenge is finding ways to couple electrochemical energy storage such as batteries into the power grid, to make existing plants more efficient and to enable future sustainable power grids utilizing wind turbines or solar cells. Today's batteries are simply too expensive and have low cycling lifetimes. Through her research, she hopes to improve the energy density, power density, efficiency and cost of batteries and fuel cells by developing new materials and electrochemical mechanisms.

In addition to her research interests, she leads SciBridge, a multi-university project that seeks to increase renewable energy collaborations between researchers in Africa and the U.S. This research collaboration is currently focused on the East African countries of Uganda, Ethiopia and Tanzania. To give university students in Africa a better understanding of current research in renewable energy, 25 experiment kits on dye-sensitized solar cells and metal-air batteries were sent out last year. Once the students do the hands-on experiment with their class, they attend a web seminar featuring a U.S. researcher, which helps connect U.S. researchers with students and researchers in Africa, as well as foster collaborations and generate new knowledge.

> "The department is very dynamic. It's growing – there are several faculty members that joined over the past few years, and it's just a very exciting place to be."
>
> Professor Augustyn

Augustyn is teaching MSE 201 – Structure and Properties of Engineering Materials during the fall 2015 semester. Her newly formed research group consists of MSE graduate students William Lo and Ruocun-Wang and undergraduate student Eowyn Lucas. ▪

Q&A with Professor Jon-Paul Maria

MSE: What is your research focus?

JON-PAUL MARIA: Our group works broadly in the area of new materials discovery for applications in electronics, optics, thermodynamics and energy. Group research consists of 30 percent synthesis science, i.e., learning how to make difficult materials; 30 percent structure-property relationships, i.e., how do we understand the origins of interesting material properties; 20 percent fundamental studies of properties/phenomena; and 20 percent applications.

Most of our research involves thin layers/coatings that are prepared by physical vapor deposition techniques like sputtering, laser ablation, molecular beam epitaxy and evaporation. But we also work in the realm of bulk materials. From time to time, the science that we study is best performed using bulk techniques, for our group this means conventional ceramic processing.

I purposefully attempt to maintain a hierarchy of research topics that span the spectrum connecting pure scientific discovery and application-driven development. Our programs today, organized in that way, include:

- Entropy stabilized oxides – we can make 100 percent new crystals, things no one has made before (soon to be published in *Nature Communications*). We have no idea how they will be used, but the results are completely novel and exciting.
- Oxide/nitride heterostructures – we can make "perfect" interfaces between oxides and nitrides like none have done before, and we have reason to believe these interfaces will host extremely high mobility electron gasses, which may be key components to future microelectronic devices. Similar to why people are interested in 2D materials like graphene.
- Extreme-mobility oxide semiconductors: Dy-doped cadmium oxide – this material exhibits properties that are in a sense between those of classical semiconductors like GaAs and metals. They have exciting opportunities for understanding defect chemistry in oxides, and for making next generation infrared technologies.
- Energetic nanolaminates – we create ultrathin stacks of materials that comprise conventional thermites (Al metal and Fe_2O_3 – one of the methods we used to use to join railroad tracks). In so doing, we can regulate the natural reaction of these two materials so that the heat produced comes out in regulated fashion. The structures we create have the potential to become key elements that improve the safety of munitions used by our armed forces.

Professor Jon-Paul Maria

- Extreme-high temperature refractories – we are exploring the science of solid materials at very high temperatures, and how to make new ones that are more resilient. Such materials, while under the radar to most, are extremely practically important. They include the liners of tanks that contain molten steel and glass, the insulation of furnaces and the leading edges of hypersonic aircraft.

For almost all of our projects, it works like this:

- We identify, or become aware of, a property of interest, or an application of interest that is currently materials limited. For us, this usually occurs in the realm of electrical/optical properties and devices.
- We try to imagine new materials (usually new crystals) that offer the potential for a better property response; we try to imagine new ways to synthesize existing materials so that the properties can be best exploited (usually the ability to extract/

optimize/exploit a property of interest is limited by our ability to make them with arbitrary levels of control); or we try to integrate multiple dissimilar materials to achieve a composite performance metric of interest that cannot be achieved in a single material.

It is important to note that research is not the primary product of our group. A highly trained cohort of scientists and engineers is the most important product. The U.S. needs more science-champions, and we do our best to create them. I am most proud of the graduates that leave our group, and I can say from experience that they are in extreme demand.

MSE: What is it about that field/those fields that is exciting to you?

MARIA: In my opinion, electronic and optical applications, and the discovery of new materials, offer the best balance between fundamental materials physics, crystal chemistry and application science. Simply put, we can study very fundamental things (which is always fun) but do so in the context of applications that address well-defined defense, commercial and societal needs.

The most exciting thing for me is to believe that the work accomplished by our group will make the transition between high end scientific discovery in our laboratory to a manufacturing line somewhere. And we have a pretty good track record of doing so. Since I have been with NC State, our group has published four papers in the *Nature* family of journals (in addition to about 200 others); we have 13 patents, and three of the patents have been licensed to external companies. We are by no means the most successful at NC State, there are lots of talented overachievers on this campus, but I am proud of our trajectory.

MSE: What are the potential applications this work could lead to?

MARIA: I'd like to highlight our work on Dy-doped cadmium oxide (CdO). In the simplest terms, this new material and process that we developed fills an electronic performance gap. The performance that is possible with CdO enables infrared detection and imaging mechanisms that were currently not possible. Our group believes that the materials unique to our lab will enable a new set of IR technologies (primarily low cost nightvision in the mid-infrared) that will be of extreme value to U.S. armed forces, police forces, first responders, medical diagnostics and manufacturing. Make no mistake, there are many obstacles to overcome before accomplishing such dreams, but we have to think big.

MSE: How have MSE and NC State facilitated your work in that field/those fields?

MARIA: Number one is collaboration. All of the programs that I described are collaborative. To some extent, each requires input from our partners. For example, within our department, theory developed by Doug Irving's group was instrumental in our CdO research; Don Brenner's group is a key partner in our energetic materials development; and oxide/nitride research incorporates experiments, instruments and know-how from Zlatko Sitar and Ramon Collazo's groups. Outside of our department, our plasmonics work would not have been possible without leadership from Stefan Franzen's group in NC State's Department of Chemistry.

Second, facilities. Much of the work we do requires some of the most sophisticated characterization tools available anywhere. Our university benefits from access to the NC State Analytical Instrumentation Facility (AIF), where an amazing palette of state-of-the-art capabilities are available to propel our research goals. In our group, we make a lot of stuff, and the stuff we make can only be as good as our ability to measure it.

Third, leadership. Our group benefits from the efforts of dedicated leaders within our department. These include: Justin Schwartz, who ensures that our faculty members have the infrastructure needed to succeed, and that we create a faculty cohort whose collective expertise is complementary and promotes collaboration; Elizabeth Dickey, who manages our graduate program leading the recruitment and education of the graduate students that are the engine of research; and Jacob Jones, who manages AIF and shapes its capabilities to promote materials research campus wide. It is easy to take all of these things for granted, but when I talk to my colleagues at different universities and laboratories, it becomes clear that we are very well supported. ▪

THE DOMINO EFFECT

MSE alumnus John Freeman and his wife, Dolores, didn't know it, but their gift to MSE in 2014 set in motion a chain of events that helped MSE secure a significant role in a statewide research initiative – and helped secure support for five new positions at the university focused on carbon electronics.

"We wouldn't have had the resources to bring Franky So to NC State without John and Dolores's gift – So is now the Walter and Ida Freeman Distinguished Professor in MSE," says MSE Department Head Justin Schwartz [see related story]. "And So's hiring was a factor in convincing the university to make carbon electronics research a 'cluster hire' priority – which will bring new research expertise to NC State." The Walter and Ida Freeman Distinguished Professorship is a tribute to John Freeman's parents and their promotion of higher education.

"I had three siblings, and each of us went to college," said John Freeman, a 1957 ceramic engineering graduate. "Throughout our time, we weren't pressured to support ourselves. This was very exemplary of my parents."

"John and Dolores's gift not only honors John's parents, but put MSE in a position to make meaningful discoveries in an exciting and important research area," Schwartz says. "That's good for our field, good for NC State, and great for all of the students who will get an opportunity to break new ground and be ready to take advantage of the new jobs those discoveries will create."

Freeman's legacy commitment to education was handed down to his daughter, Karen Freeman Bisi, who is also a graduate of the MSE Department and serves on the department's External Advisory Board.

MSE, carbon electronics and the future of technology

Over the past year, NC State has positioned itself to take the lead in the emerging field of carbon electronics, thanks in large part to MSE's research expertise and facilities.

Carbon-based electronic materials are expected to be the basis of many next-generation technologies in coming decades, largely because traditional silicon-based materials are approaching their fundamental limits in terms of miniaturization and capacity.

In other words, it's a competitive field – and those who are slow to embrace it may find themselves at a significant competitive disadvantage.

The University of North Carolina system recognizes that, and in February 2015 made NC State the lead institution in a three-year, $2.8 million Research Opportunities Initiative (ROI) project called the NC Carbon Materials Initiative: Materials Design, Processing, and Manufacturing for Defense and Energy Needs. That funding is earmarked primarily for equipment and infrastructure, which the UNC system hopes "will open the door to revolutionary computing approaches, truly renewable energy sources, and self-sustaining systems."

But that equipment and infrastructure is useless without the talent to take advantage of it. The initiative is headed by NC State physics professor Harald Ade, but MSE is playing a major role.

"Our objective is to advance our fundamental understanding of the properties of carbon-based electronic materials, develop those materials, and use them to create new devices," says MSE Department Head Justin Schwartz. "MSE sits right in the middle of that science-to-technology continuum."

To that end, some of the NC Carbon Materials Initiative funding helped MSE bring carbon electronics researcher Franky So to NC State [see sidebar].

"One of the reasons we're so excited to have Franky So on board is that he is an international leader in the fields of synthesizing and characterizing carbon electronic materials, as well as exploring relevant applications ranging from sensors to extreme light sources," Schwartz says.

But MSE won't be relying on So's expertise alone. The department will be capitalizing on its longstanding expertise in computational and optoelectronics materials research to make headway on the ROI goals.

"We're laying the groundwork to be one of the global leaders in carbon electronics, because we think these materials will be the basis of new technologies for 20-30 years," Schwartz says.

And NC State agrees.

The university has made carbon electronics the focus of a "cluster hire," meaning that it will be hiring at least five faculty members who have demonstrated interdisciplinary expertise in the field. The hires will likely be spread across multiple colleges and departments – but are all expected to collaborate in advancing our understanding of carbon electronics and its potential applications.

At its heart, organic electronics research will focus in large part on understanding the structure, properties and performance of these materials – and how processing techniques influence them. And while the technology may change, those research challenges have always been at the core of materials science and engineering. ▪

To learn more about the ROI, and see a video on the NC Carbon Materials Initiative, visit **http://roi.northcarolina.edu/index.html**

Q&A with Professor Linyou Cao

Professor Linyou Cao

MSE: What is your research focus?

LINYOU CAO: My research focuses on developing ideal photocatalysts for solar water splitting and integrated optoelectronic circuits for high-speed data communications. Our strategy is to explore the unique properties of two-dimensional materials, which are atomically thin and may show properties that cannot be obtained with conventional materials.

MSE: What is it about those fields that is exciting to you, and what are the potential applications of the work?

CAO: I am very excited by the potential of my team's research to make society better off. Photocatalytic water splitting by solar energy is widely considered to be the ultimate solution to our current energy challenge. However, the biggest challenge for the implementation of photocatalytic water splitting lies in the lack of ideal photocatalysts that would enable cost-effective and efficient solar water splitting to produce hydrogen for fuel. Part of our effort is to develop ideal photocatalysts based on two-dimensional materials. If successful, the result of our work has the potential to transform the landscape of energy utilization.

Our goal in regard to the development of integrated optoelectronic circuits is to address the challenge of computing speed. The continuous improvement in speed that electronic computers have enjoyed in recent decades has essentially come to an end. One promising solution to further improve computing speed is to use optical communications instead of the conventional electrical wires for chip-scale data communications. To make those optical paths a reality, we need to develop functional integrated optoelectronic circuits.

Similar to the photocatalytic water splitting, the development of integrated optoelectronic circuits has been delayed by materials challenges. We envision that two-dimensional materials would provide a very promising platform for integrated optoelectronic circuits because of their excellent electronic and optical properties. Our work may eventually lead to the development of optical computers to replace electronic computers.

MSE: How have MSE and NC State facilitated your work in that field/those fields?

CAO: My research has greatly benefited from the infrastructure and collaborative environment in the MSE department and at NC State. We have also benefited from being close to our colleagues at Duke and UNC Chapel Hill. Most of our fabrication work has been performed in the clean room at Duke.

MSE: What does the horizon look like for this work? What research challenges lie ahead?

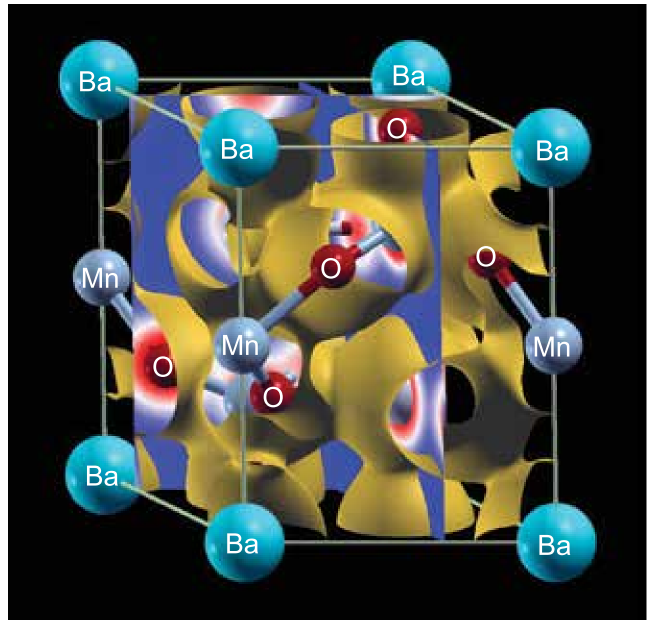
CAO: Resources! We are very clear about the goal of our research and also clear that the strategy we have used is promising, as evidenced by the significant progress we have achieved. However, the biggest challenge may be the lack of necessary resources for us to address the important technical problems that have to be solved to reach our final destination. The government funding situation is very tight at the moment. ▪

Researchers aim to develop new techniques for creating high-temperature alloys

NC State is taking the lead in a new initiative aimed at addressing fundamental scientific questions that could lead to the development of so-called "entropy-stabilized alloys" that can withstand extremely high temperatures. The initiative includes Duke University, the University of Virginia and the University of California, San Diego, and is funded by a five-year, $8.4 million grant from the Office of Naval Research (ONR).

"The Defense Department has a need for materials that are mechanically and chemically stable at ultra-high temperatures – meaning temperatures of 2,000 degrees Celsius or more," says Don Brenner, Kobe Steel Distinguished Professor of MSE at NC State and principal investigator of the ONR grant. "These materials can have significant aerospace applications, but the number of usable materials is currently small, and those materials rely on strong chemical bonding to remain stable. At high temperatures, most materials are simply no longer stable."

To address the shortage of ultra-high temperature materials, ONR has tasked Brenner and the rest of the research team with investigating the viability of creating entropy-stabilized alloys that withstand these temperatures. Entropy-stabilized alloys are materials that consist of four or more elements in approximately equal amounts, and they have garnered significant attention in recent years because they can have remarkable properties. These alloys are of interest for use in ultra-high temperature applications because of their unique ability to "absorb" disorder in a material's crystalline structure that otherwise would lead to the breakdown of a material.



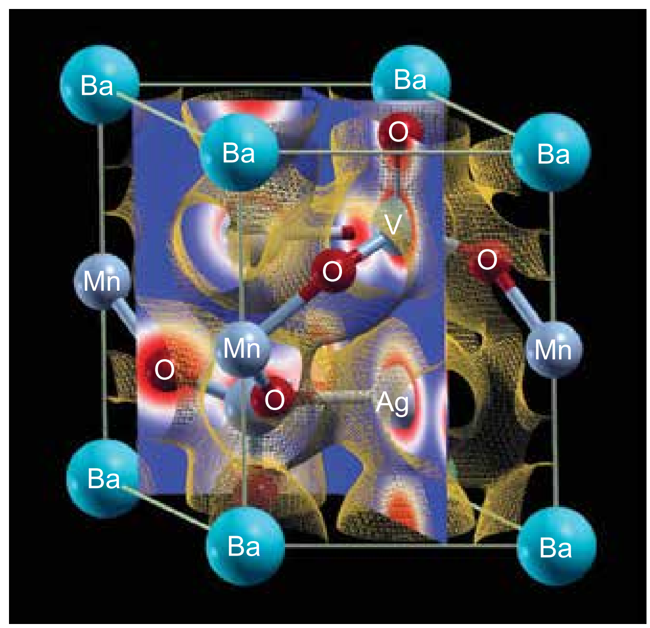


Illustration of the atomic structure and calculated electron density of a $Ag_2BaMnO_8V_2$ random alloy.

WHY DISORDER IS IMPORTANT

Crystals are composed of a repeating arrangement of atoms, which can be different from crystal to crystal. That arrangement is called the crystal's "lattice type." For example, think of one crystal as having its atoms arranged as a series of cubes, while another crystal may have its atoms arranged as a series of three-dimensional hexagons.

As the temperature of a crystal is increased, it begins to lose its ordering. That means that individual atoms may move around. And when those atoms get rearranged, it can affect the structure – one of the cubes might start changing into a different shape. This can occur in different ways, such as distortions of the lattice or atoms missing from their lattice sites. At high enough temperatures, this disordering can lead to melting, or otherwise cause a material to lose strength.

But in entropy-stabilized alloys, the mix of elements can be arranged in many different ways on a single lattice type.

In other words, the structure can continue to be a series of cubes, even if the elements that make up the structure are shuffled around. Researchers think this ability to retain its structural integrity even when the atoms become disordered has the potential to increase melting points and make materials useful at ultra-high temperatures.

RESEARCH QUESTIONS

The ONR grant is tasking the research team to develop the scientific concepts needed to determine whether it's possible to create ultra-high temperature high-entropy alloys – and, if it is possible, how.

"We'll be developing new experimental approaches for evaluating high-entropy alloys at ultra-high temperatures," Brenner says. "For example, how do you test an alloy if the equipment containing the alloy melts before the alloy does? And how can we evaluate whether a material will oxidize at extreme temperatures, thus altering the material's properties?"

The researchers will also be developing and modifying computational techniques for identifying the most promising possible high-entropy alloys, which can then be targeted for additional experimental testing.

"After good candidate materials are established, we will work to synthesize, process and test bulk samples," Brenner says. "However, our work is not aimed at necessarily creating new materials, but rather introducing new theoretical, computational and experimental tools into the larger ultra-high temperature materials community.

"It's also important to stress that all of this work is truly interinstitutional, drawing on expertise from all of the parties involved," Brenner says.

And the researchers won't be working in a vacuum. There will be significant input from a variety of third parties to help guide the work.

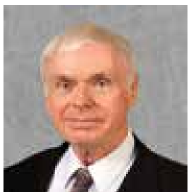
"Researchers from Lockheed-Martin, the Naval Air Weapons Station at China Lake, the Air Force Research Laboratory and the Naval Research Laboratory, together with other DoD-related laboratories will help to advise our work, especially in terms of DoD and civilian needs," Brenner says. ▪

AWARDS & HONORS

Faculty Awards

Jones

PROFESSOR JACOB JONES was named a Fellow of the American Ceramic Society.

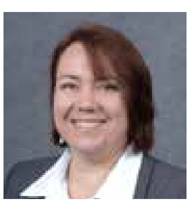


Koch

PROFESSOR CARL KOCH won the TMS Bruce Chalmers Award in March 2015.

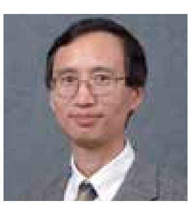
Spontak

PROFESSOR RICHARD SPONTAK won the 2015 Society of Plastics Engineers International Award. Spontak, recipient of a 2015 NC State Alumni Distinguished Graduate Professorship, was elected a member of the Norwegian Academy of Technological Sciences in 2015, was elected as a Fellow of the Royal Society of Chemistry for 2014 and won a 2014 Fulbright Senior Specialist Award from the IIE Council for International Exchange of Scholars.



Yingling

PROFESSOR YAROSLAVA YINGLING was named an NC State University Faculty Scholar for 2014 to 2019.



Zhu

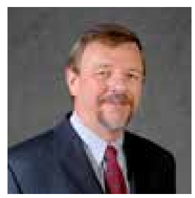
PROFESSOR YUNTIAN ZHU was named one of the Highly Cited Researchers of 2014, among 147 in materials science, by ThomsonReuters (ISI). He also won a Leadership Award from TMS for 2015 and a Somiya Award for 2015. He also received the ASM International Albert Sauveur Achievement Award.

Loboa

PROFESSOR ELIZABETH G. LOBOA, an associate chair and professor of the Joint NC State/UNC Department of Biomedical Engineering and a professor in MSE, has been named dean of the University of Missouri College of Engineering, effective October 15, 2015. Loboa is the 11th full-time dean in the MU College of Engineering's history and its first female dean.

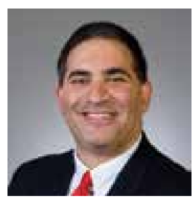
Brenner

PROFESSOR DONALD BRENNER participated on a National Science Foundation-supported WTEC study group on Nanomodular Materials and Systems by Design.



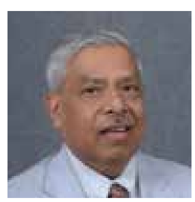
Sitar

PROFESSOR ZLATKO SITAR won a gold medal from the Japanese Physics Society.



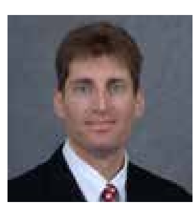
Schwartz

PROFESSOR JUSTIN SCHWARTZ was named a Fellow of ASM International and the American Association for the Advancement of Science.



Narayan

PROFESSOR JAGDISH NARAYAN won the 2014 North Carolina Science Award (the highest civilian honor in the state of North Carolina) bestowed by the governor of North Carolina. He was the first materials scientist and the sole winner at the Golden Jubilee Celebrations of North Carolina Awards. Past winners included four Nobel Laureates in science and Maya Angelou, Charlie Rose, Andy Griffith, Charles Kuralt and John Hope Franklin. He was also inducted into the National Academy of Inventors.



Maria

PROFESSOR JON-PAUL MARIA won an American Ceramic Society Fulrath Award and a best presentation award at the 2014 Workshop on Oxide Electronics. •

Student Awards

■ **Ali Moballegh**, a postdoctoral research associate working with Professor Elizabeth Dickey, won the 2014 Microscopy and Microanalysis Presidential Student Award 2014.

■ **Boopathy Kombaiah**, a recent Ph.D. recipient under Professor Korukonda Murty and current postdoctoral researcher at Carnegie Mellon University, won the 2015 American Nuclear Society Mark Mills Award.

■ **Richard Floyd**, a graduate student studying under Professor Elizabeth Dickey, was named a GAANN 2014-2015 Research Fellow and 2015-18 National Science Foundation Graduate Research Fellow.

■ **Bryan Anderson**, a graduate student studying under Professor Joseph Tracy, won third place in the 2014 MRS/ASM/AVS Joint Symposium Student Poster Competition and took an honorable mention (2nd place) at the 2014 Research Triangle MRSEC Technology Innovation Forum at the Triangle Student Research Competition.

■ **Yang Liu**, a member of the department's research staff, won a Presidential Post-doctoral Award at the Microscopy and Microanalysis 2014 Conference.

■ **William Crumpler**, a graduate student studying under Professor Joseph Tracy, won a 2015 Barry Goldwater Scholarship and a DAAD RISE Scholarship.

■ **Ed Mily**, a graduate student studying under Professor Jon-Paul Maria, won the Best Student Presenter Award at the fall 2014 Energetic Materials Symposium.

■ **Tasha Tucker**, an undergraduate student studying under Professor Yaroslava Yingling, won an NC State 2014 undergraduate research award.

■ **William Fuss**, an undergraduate studying under Professor Yaroslava Yingling, won 1st Place in the Undergraduate Poster Competition at the 128th NC-ACS Local Section Conference at Duke University in 2014, a Best Oral Presentation Award at UNC MIRT and RT-MRSEC Summer Research Experience for Undergraduates Research Symposium in July 2014, an NC Creativity Award for 2014, a 1st place Best Poster Award from the MSE Advisory Board in 2014, an ACCIAC Undergraduate Fellowship in Creativity and Innovation and an NC State undergraduate research award for 2014 and 2015.

■ **Sabrina Huang**, an undergraduate student studying under Professor Yaroslava Yingling, won a 2014 NC State undergraduate research award.

■ **Professor Edward Sachet**, a postdoctoral research associate working with Professor Jon-Paul Maria, took the Runner-up Best Student Presenter Award (2nd place) at the 2015 American Ceramic Society EMA Conference and a spring 2015 MRS Graduate Student Award gold medal.

■ **Giovanni Esteves**, a graduate student studying under Professor Jacob Jones, received an international research fellowship from the International Center for Materials Research at UC Santa Barbara.

■ **Sumeet Mishra**, a graduate student, won a second place poster award at the 2014 Nano Manufacturing Conference.

■ **Hoshin Kim**, a graduate student studying under Professor Yaroslova Yingling, won a second place poster award at the Korean-American Scientists and Engineers Association regional conference in Durham, NC, in November 2014.

■ **Matthew Burch**, a graduate student studying under Professor Elizabeth Dickey, won a Microscopy and Microanalysis 2014 Presidential Student Award and a first place poster award in the physical sciences category from Microscopy and Microanalysis for 2014.

■ **Wei-Chen (Ivy) Wu**, a graduate student studying under Professor Joseph Tracy, received the fall 2014 MRS Silver Graduate Student Award, 1st place at the 2014 MRS/ASM/AVS Joint Symposium Student Poster Competition and 2nd place at the 2014 Research Triangle MRSEC Technology Innovation Forum at Triangle Student Research Competition.

■ **Zachary Bryan**, a graduate student studying under Professor Ramon Collazo, won a silver medal from MRS in fall 2014.

■ **Nan Li**, a graduate student studying under Professor Yaroslava Yingling, won the American Chemical Society, Division of Computers in Chemistry, The Chemical Computing Group Excellence Award for Graduate Students in March 2015; an MRS, Silver or Gold Graduate Student Award in December 2014; was an AIChE, Biomaterials Graduate Student Award finalist in November 2014; and won a Best Poster Presentation Award (3rd place) at the 2014 Triangle Student Research competition.

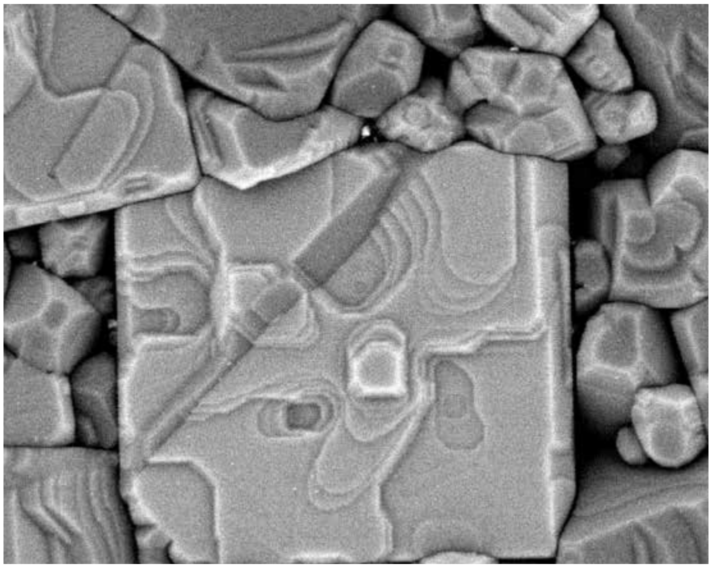
■ **Xiahan Sang**, a postdoctoral researcher, won a Presidential Post-doctoral Award at the Microscopy and Microanalysis 2014 Conference.

■ **Jessica Nash**, a graduate student studying under Professor Thom LaBean and Professor Yaroslava Yingling, won a National Science Foundation graduate research fellowship, a first place Best Poster Presentation Award at the 2014 Triangle Student Research competition and a Best Poster Award from Triangle Soft Matter in May 2014.

■ **Tina Roast**, a graduate student studying under Professor Jon-Paul Maria, won the Best Student Presenter Award (1st place) at the 2015 American Ceramic Society EMA Conference.

■ **Milena Bobea**, a graduate student studying under Professor Ramon Collazo, won a Best Poster Award from Materials Research Society for fall 2014. ▪

Researchers create first entropy-stabilized complex oxide alloys



Field emission scanning electron microscope (FESEM) image of a polycrystalline $BaTiO_3$ thin film prepared by pulsed laser deposition. This image was acquired with the NC State Verios microscope which provides unique access to very fine topographic features that decorate these ceramic grains. This is made possible by very low electron landing energies, very sensitive detectors, and very short working distances.

Researchers from MSE and colleagues at Duke University have created the first entropy-stabilized alloy that incorporates oxides – and demonstrated conclusively that the crystalline structure of the material can be determined by disorder at the atomic scale rather than chemical bonding.

"High entropy materials research has been a hot field since 2007, but no one reported that the unique structure of these materials was indeed stabilized by configurational disorder alone – and no one had created an entropy-stabilized material using anything other than metals," said MSE's Jon-Paul Maria, corresponding author of a paper on the new findings.

"While the influence of entropy is present in the natural world – for example, the arrangement of metal ions in feldspar, one of the most common minerals in the Earth's crust – crystalline solids that are stabilized by entropy alone do not exist naturally," Maria says. "We wanted to know if it was possible to stabilize an oxide using entropy and whether we could prove it. The answer was yes to both. Oxides were chosen for this study because they enabled us to directly test this entropy question."

High entropy alloys are materials that consist of four or more elements in approximately equal amounts. More importantly, these elements are distributed randomly at the atomic scale. They have garnered significant attention in recent years because they can have remarkable properties. But to understand entropy-stabilized alloys, you have to understand the crystalline structure of materials.

A material's crystalline structure consists of a repeating arrangement of atoms, which can be different from material to material. That arrangement is called the crystal's "lattice type." For example, think of one crystal as having its atoms arranged as a series of cubes. In a conventional material that contains multiple atom types, the arrangement is regular and ordered. Along one of those cube edges, the atoms would follow a regular repeat pattern. In an entropy-stabilized material, the relative arrangement is completely random.

By adding more and more different atom types to a crystal, you can generate more and more disorder if the arrangement of atoms on that lattice remains random. Finding the right mix of atoms that will retain this randomly mixed state is the key to entropy stabilization and testing the entropy question.

In this case, researchers created an entropy-stabilized material made up of five different oxides in roughly equal amounts: magnesium oxide, cobalt oxide, nickel oxide, copper oxide and zinc oxide. The individual materials were mixed in powder form, pressed into a small pellet, then heat treated at 1000 degrees Celsius for several days to promote reaction and mixing.

The researchers then used the Advanced Photon Source at Argonne National Laboratory and X-ray fluorescence spectroscopy to determine that the constituent atoms in the entropy-stabilized oxide were evenly distributed and that their placement in the crystalline lattice structure was random.

"The spectroscopy told us that each unit cell in the entropy-stabilized oxide's structure had the appropriate distribution of atoms, but that where each atom was located in a unit cell was random," Maria says. "Making this determination is very difficult, and requires the most sophisticated characterization tools available at the Advanced Photon Source.

"This is fascinating – we've proved that you can create entirely new crystalline phases of matter – but it's fundamental research," Maria says. "A lot of additional work needs to be done to characterize the properties of these materials and what the potential applications may be.

"However, the work does tell us that we'll be able to engineer new materials in unusual ways – and that is very promising for developing materials with desirable properties."

The paper, "Entropy-Stabilized Oxides," was published in *Nature Communications*. ▪

Professor William Nix

Nix delivers the 2015 Davis Lecture

From left, Professors Ronald Scattergood, Carl Koch, Jagdish Narayan, William Nix and Justin Schwartz.

The 2015 Robert F. Davis Distinguished Lecture was given on April 15 by Professor William Nix, Lee Otterson Professor in the School of Engineering Emeritus at Stanford University. The Davis lecture, named for a former NC State faculty member, is one of the premiere lecture series in materials science and engineering in the United States.

A leading researcher on the mechanical properties of materials for more than five decades, Nix gave the lecture "Electrochemical Lithium Insertion: The Future of Lithium-Ion Battery Applications," in which he discussed his recent results on the mechanical properties of lithiated nanostructures.

2016 LECTURE PLANNED

The 2016 Robert F. Davis Distinguished Lecture will be given by William A. Goddard, the Charles and Mary Ferkel Professor of Chemistry, Materials Science and Applied Physics at the California Institute of Technology, and the director of its Materials and Process Simulation Center.

With more than 1,100 publications that have been cited 70,000 times in the scientific literature, Goddard is a pioneer in developing methods for quantum mechanics (QM), force fields (FF), reactive dynamics (ReaxFF RD), electron dynamics (eFF), molecular dynamics (MD) and Monte Carlo (MC) predictions on materials systems and is actively involved in applying these methods to ceramics, semiconductors, superconductors, thermo-electrics, metal alloys, polymers, proteins, nuclei acids, Pharma ligands, nanotechnology and energetic materials.

A member of the National Academy of Sciences since 1984, he is also co-founder of Molecular Simulations Inc. (now Accelrys), Schrodinger Inc., Systine (which he co-founded with Davis), Allozyne, AquaNano and QioMed. ▪

Professor William A. Goddard

From left, Ankesh Madan, Stephen Gray, Tasso Von Windheim and Tyler Confrey-Maloney

More than a nail polish

A powerful tool for preventing sexual assault begins with a senior design project

Four engineering students started with a problem: how could they help prevent the use of date rape drugs to commit sexual assault, a crime that has impacted several of their closest friends.

After thinking about ways to ensure that perpetrators are caught and prosecuted, one had an idea: why not try to prevent the crime in the first place by giving women a discreet and fast-acting way to test their drink at a bar or college party before taking that first sip?

Their idea is to develop a clear fingernail polish that changes color when put in contact with a date rape drug. A woman at a party could simply stir her drink with her finger to check that it hasn't been altered.

Started from an MSE senior design project, Undercover Colors is now a company with seven full-time employees, investor backing and worldwide attention. It's a company that offers survivors hope that others won't have to go through the same trauma. As one sexual assault survivor told the team, "I know it won't make my daughter invincible to the risk of sexual assault, but it will at least provide a little peace of mind to every woman in the entire world."

The story of Undercover Colors' growth from idea to company offers a glimpse at how NC State, and specifically the College of Engineering, teaches entrepreneurship and then supports its students' and faculty members' efforts to build companies that create jobs and change lives.

"We wouldn't be here," said Tyler Confrey-Maloney, CEO of the company and one of those four MSE senior design students. "Our company simply wouldn't exist if it wasn't for NC State."

AN ENTREPRENEURIAL ECOSYSTEM

MSE students hadn't been allowed to participate in the Engineering Entrepreneurs Program (EEP) before. But Confrey-Maloney and partners Stephen Gray, Tasso Von Windheim and Ankesh Madan pushed to complete their senior design project as part of the program, established at NC State in 1993 by Professor Tom Miller to provide an immersive entrepreneurial education experience for engineering students.

Once they settled on an idea, the group began spending 40 hours a week working in the library during the middle of the night. That was on top of their busy senior year class loads.

A breakthrough came at the 2014 LuLu eGames, an annual business start-up competition that's part of the Entrepreneurship Initiative (EI), a university-wide entrepreneurship program that grew out of the EEP.

Undercover Colors won eGames, along with $13,000 to put toward a product. They were also introduced to their first investor, an NC State alumnus and entrepreneur who was one of the judges. That investor would later introduce the students to a community of investors tied to NC State.

Invigorated by their eGames victory, the team kept working. Miller served as an advisor. So did Professor Nathaniel Finney, a former chemistry professor at the university who is now a member of the company's Technical Advisory Council.

After graduation, all four had job offers or chances to attend graduate school. Was it worth it to continue pursuing this dream?

Miller created a bridge program that provided a small stipend to keep the company going as it sought further funding. The EI had taught them how to craft a business plan and pitch to potential investors. Those skills paid off and they continued to improve. They learned about patent law and received help in securing the exclusive rights to create and manufacture the product.

"It was clear that they had the smarts to do this, that they had the motivation and drive to do it, that they had enough of the basic science figured out to have a plausible chance of getting there," Miller said.

That's when a story about the company posted on a Triangle business website went viral. Undercover Colors and the idea behind it were on every major news website and all over social media. Just a few months after winning eGames, their company was being discussed on ABC's "Good Morning America." This fall, their product was mentioned on the ABC sitcom "Modern Family."

Confrey-Maloney said it was as "exciting as it was frightening. One moment we were students with an idea and some promising research, and the next we had the attention of the entire world."

The company was still in its infancy and not looking for attention, but the exposure led to survivors of sexual assault and others reaching out with messages of encouragement. They knew they were on the right track.

Today, Undercover Colors is located in the university's Technology Incubator on Centennial Campus. Confrey-Maloney is the company's CEO. Gray is its COO. Madan and Von Windheim, both engineering Ph.D. candidates at Duke University, are working part-time.

They have developed several color-changing compounds and are now testing them first in a tube and then on a nail surface. Confrey-Maloney said the company will likely partner with an established cosmetics manufacturer to get the product into users' hands as quickly as possible.

Undercover Colors employees in the lab

The company has been approached by most major cosmetics players, who have expressed interest in manufacturing and selling the product. Undercover Colors is backed by individual angel investors (rather than venture-capital firms) and the vast majority of those investors have been NC State alumni or have some connection to the university.

ONE PART OF A LARGER EFFORT

Statistics show that 18 percent of women will fall victim to sexual assault during their lifetime. So, along with their business duties, Confrey-Maloney and Gray spend several hours every week volunteering with InterAct of Wake County, a Raleigh nonprofit that provides services to survivors of domestic violence and sexual assault. Confrey-Maloney is a sexual assault emergency responder trained to assist survivors as they talk to police and are treated by a nurse. Gray volunteers on the agency's 24-hour telephone crisis line.

Confrey-Maloney says Undercover Colors is but "one small part of a larger effort to combat sexual violence." That effort includes outreach, prevention, victim services and culture-shifting. He hopes the company's product will serve as a deterrent to those who use date rape drugs, shifting a sense of fear potential victims might feel and putting it on the perpetrators.

"As a community, we need to come together and put an end to this epidemic. That change has to start by talking about the issue and providing survivors with the services they need to heal."

Von Windheim is the son of an entrepreneur. It wasn't until he grew older and saw the impact his father's work could have that he began to see starting a new company as more than a path to wealth.

"You can make money a thousand different ways. But, having the opportunity to make such a huge difference in people's lives – to prevent such extreme pain – that's a rare opportunity. It's something I'm very proud to be a part of."

When he's not volunteering, working in the lab or speaking three or four times a week on sexual assault prevention, Confrey-Maloney serves as a mentor to other NC State student entrepreneurs working their way through business plans and seeking investment. They work, learn and hang out together. On Sunday nights, they gather to watch "Silicon Valley," a television comedy about life in a technology startup.

His friends are working on ways to help smokers quit, use infrared light to detect food pathogens and bring bee hives to urban areas.

"Those are the kind of people I want to spend my time around," he said. "Entrepreneurs with bright ideas and the ability to execute can have a tremendous impact on the future of society, and NC State's really at the forefront of developing and supporting these kinds of people." ▪

MORE COMPANIES WITH MSE TIES

HEXATECH

Morrisville, NC-based HexaTech is creating next-generation wide bandgap semiconductor devices based on aluminum nitride for use in power conversion devices and ultraviolet LEDs. Professor Zlatko Sitar, Kobe Steel Distinguished Professor in MSE, and Professor Raoul Schlesser, a former research assistant professor in the department, are co-founders. MSE alumni Gregory Mills, Professor Baxter Moody and Professor Rafael Dalmau also hold senior positions in the company.

CREE

Engineering alumni Calvin Carter Jr., John Palmour, Neal Hunter, John Edmond and Eric Hunter took their idea from an MSE lab and turned it into a Durham, NC-based company with thousands of employees that creates lighting-class LEDs, LED lighting and semiconductors for use in wireless and power applications.

TRIBOFILM RESEARCH, INC.

Based in Raleigh, TriboFilm Research is an independent research and development center bringing together material scientists, chemists and engineers focused on novel medical devices and pharmaceutical packaging. TriboFilm holds multiple worldwide patents licensed to several pharmaceutical companies and medical device manufacturers. Vice-Presidents Vinay Sakhrani and Robert A. Mineo have NC State degrees in materials science and engineering and aerospace engineering, respectively, and Professor Jerry Cuomo, Distinguished Research Professor in MSE, is chairman of the company's board of directors.

ATMOSPHERIC PLASMA SOLUTIONS

Founded in 2005 by MSE graduate Peter Yancey, Atmospheric Plasma Solutions, Inc. develops advanced plasma technologies and solutions for environmentally friendly paint removal, surface modification and cleaning and plasma-enhanced deposition for the advanced materials, defense and medical markets. The APS PlasmaFlux technology brings the benefits of plasma processing to industrial processes without the need for expensive vacuum chambers and pumps.

ITST-LLC

Professor Jerry Cuomo is a Distinguished Research Professor in MSE. ITST-LLC is a research and consulting company he founded that has negotiated the exclusive rights to a patent filed by NC State and ITST-LLC on a method and process for the low temperature capture and transformation of CO_2, NH_3, SO_2, H_2S, CS_2 and Thiophenes as well as the alkylation of hydrocarbons that will improve the octane in fuels. All of these processes are at low temperatures with the renewal of the activating medium.

WARPSPEC DIAGNOSTICS

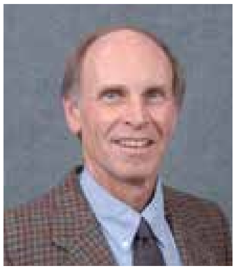
MSE Ph.D. candidate Jordan Moering and Jenkins MBA student Rafael Estevez are using a plasma energy field and advanced optics developed by the US Navy to scan processed food to ensure pathogens such as salmonella and e. coli. will not make it to grocery store shelves. The team won first place in the New Venture Challenge at the 2015 Lulu eGames and is a semifinalist for the 43North business plan competition. ▪

Ivanisevic, Reynolds promoted

The department proudly announced two faculty promotions this year. Professor Albena Ivanisevic was promoted from associate professor to professor and Professor Lew Reynolds was promoted from associate teaching professor to teaching professor.

Professor Albena Ivanisevic

Ivanisevic joined the department in July 2011 after teaching at Purdue University. Her group is working on: fabrication and characterization of semiconductor surfaces composed of biomolecular structures; parallel manufacturing of nanoscale structures with semiconducting, magnetic and metallic properties; high-resolution and -throughput surface characterization; and lithographic tools for tissue engineering applications. All projects in the group involve the fabrication of new platforms for placement and evaluation of materials and permit one to do basic research that enables the tuning of materials properties. Many aspects of the projects are also interfaced with finding solutions for biomedical problems. A University Faculty Scholar, she received a B.S. in chemistry from Drake University and a Ph.D. in chemistry from the University of Wisconsin-Madison.



Professor Lew Reynolds

Reynolds was a distinguished member of the technical staff at Bell Laboratories for 23 years prior to coming to NC State in 2003. He has 30 years experience in the growth, characterization and device development of III-V compound semiconductors. He has investigated extensively the influence of doping profiles on laser characteristics, developed MOVPE growth techniques for growth on gratings and along mesa sidewalls to minimize defects and collaborated on the design of high speed photonic devices. More recent efforts have focused on mobility modulation in AlGaN HFET structures, strain relaxation in InGaAs solar cell structures, characterization of GaAsSb nanowires for mid-IR applications and the pulse width dependence of optical gain in conjugated polymers.

He received a B.S. in physics from the Virginia Military Institute, and M.S. and Ph.D. degrees in materials science from the University of Virginia. ▪

MSE Graduate Students' Council

The Materials Science Graduate Students' Council (GSC) seeks to enhance the overall graduate experience in the MSE department by promoting a sense of community and facilitating communication between the department and graduate students. The council consists of volunteers pursuing either a masters or Ph.D. in MSE.

During the 2014-2015 year, the Materials Science GSC planned professional development and social events for graduate students and the department, including a recruitment visit from Cree, Inc; the annual MSE holiday party; and the MSE chili cook-off in the spring. New this year, the GSC held a Science as Art competition along with the chili cook-off. The winners are shown on page 28. ▪

2015-2016
Graduate Student Council Leadership

President — Houston Dycus
Vice President — James Peerless
Treasurer — Brian Lynch
Social Chair — Peter Feldtmann

2014-2015
Graduate Student Council Leadership

President — Christer Akouala
Vice President — Jessica Nash
Treasurer — Nathaniel Rohrbaugh
Social Chair — Tad Deaton

Above: Tad Deaton prepares the MSE GSC House Chili for the annual chili cook off.

Former department head's impact leads to endowed fellowship

When most people think of a university department head, they imagine someone sitting behind a desk of paperwork, but not Gerald ('60 B.S. MSE) and nephew David ('73 B.S. & '80 M.S. MSE) White.

The Whites, whose time at NC State was separated by more than a decade, recall Professor William Austin, former materials engineering department head, driving an old, broken black bus – which was later upgraded to a minivan – on field trips. "He was that kind of guy," said Gerald.

Austin joined NC State's Metallurgical Engineering Department as an associate professor after leaving the Southern Research Institute in Birmingham, Ala. in 1952.

During his time at NC State, he taught students to build upon metallurgical research, became a full professor, and was head of the Department of Materials Engineering. Austin helped in the restoration of the Cape Hatteras Lighthouse and received the Outstanding Teacher's Award from the School of Engineering in 1981. He passed away in 2004.

As a way to honor Austin and cement his legacy at NC State, Gerald White and wife, Nancy, established the Dr. William W. Austin Graduate Student Endowment with a $200,000 donation. This endowment is for graduate students studying materials science and engineering. Inspired by his Uncle's philanthropy and tribute to Dr. Austin, David White also made a generous contribution to support this fund, which led to a matching gift by his employer, General Electric. This double impact gift will be combined with Gerald's initial donation and enable the department to recruit the best and brightest graduate students in the field of materials science and engineering.

"This fellowship is an honor well deserved and past due," said Gerald White. "Not only will it help improve the status of the department and honor Professor Austin, but it also falls in line with the Chancellor's view to build endowments."

Professor William Austin in the 1950s

PROFESSOR AUSTIN'S IMPACT

Thinking back to his time in the metallurgy department, Gerald White recalls Austin encouraging all of his students to pursue a minor outside their degree focus to broaden their skills as they entered the workforce.

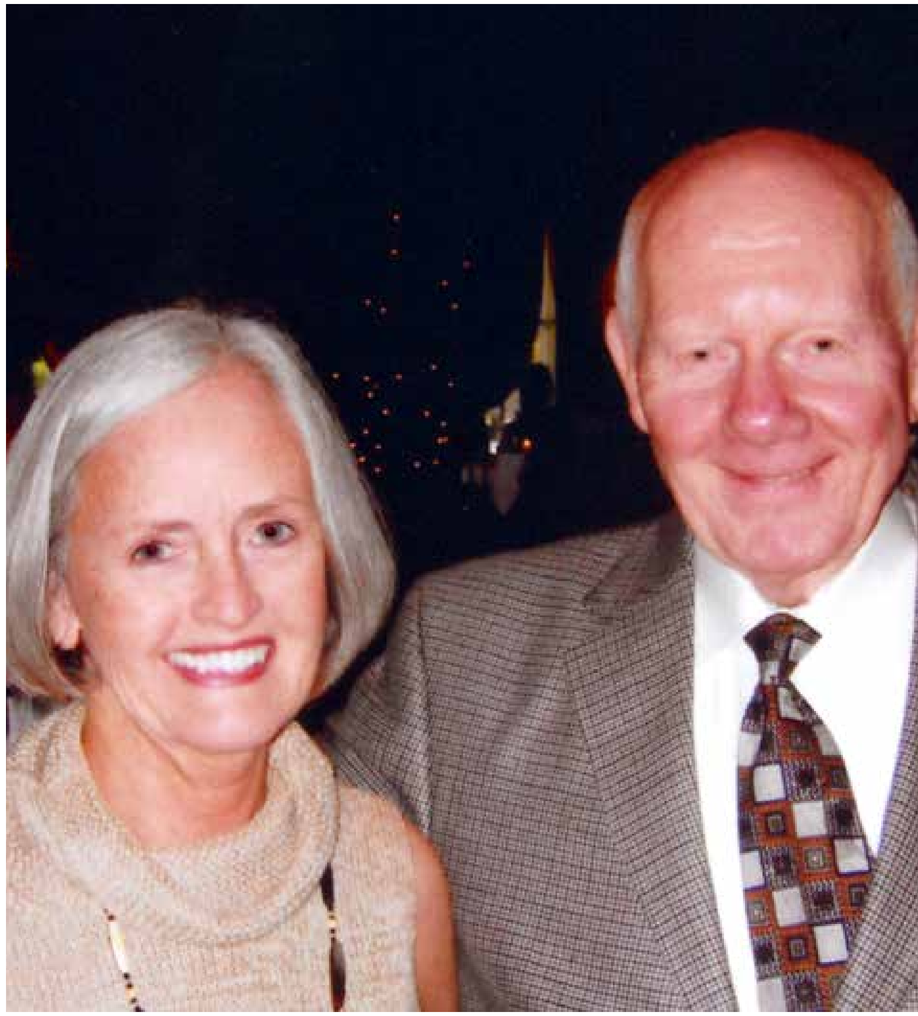
"During a time when you were pushed into lab situations and working in a major that required so much work that the only Christmas break you got was Christmas day off because you had to be disciplined and work on projects, Austin was there to offer advice and help," said Gerald White.

Although Austin was not teaching during David White's time on campus, he remembers him being a fatherly figure for the students in the department.

"He was a very stabilizing figure who did a great job of coordinating, looking after students and integrating field trips he personally coordinated," David White said.

The field trips he planned took students from Charlotte, to Greensboro and Wilmington. "All the seniors in the department, at the time, could fit on the bus and Professor Austin always drove," David White said. "He would take us anywhere he could to give us a first-hand look at industry, promote education and job interest." Both Gerald and David White attribute their successful careers to NC State and to Austin's support and encouragement.

After graduating with his bachelor's degree, Gerald White returned to work at Douglas Aircraft in Charlotte in the metallurgical lab. He then went on to work at Industrial Piping Inc. as a fabrication engineer. In 1984, his friend John Ward offered him a partnership in Ward Tank & Heat Exchanger Company – a business that designs and fabricates custom shell and tube heat exchangers and pressure vessels. Gerald White retired in 2007 but remains a partner in the company and sits on its board of directors. He and Nancy have remained active supporters of Wolfpack athletics and have also created the Gerald and Nancy White Scholarship within the College.



Gerald and Nancy White

David White

David White earned both his bachelor's and master's degrees from NC State and has worked for General Electric in Wilmington since graduation. His current role as senior materials science engineer/technologist involves nuclear energy, fuel bundles for reactors, evolving alloys and dealing with the processing issues, corrosion resistance and performance factors.

"The school is growing and this fellowship is a great way to attract the best of the best," said David. ▪

Anyone interested in donating to the Dr. William W. Austin Graduate Student Endowment is asked to contact Director of Development Ketura Parker at 919.513.1338 or knparker@ncsu.edu.

Family history in metallurgy led alum to materials science at NC State

Charlotte, NC native Laurens Willard always felt his ties to metallurgy and engineering stemmed from his father, Clarence, and his uncle Charles Willard.

Charles Willard started Willard Industries, a secondary lead refinery and manufacturing facility in Charlotte, NC, soon after WWII. In 1958, with Clarence Willard's help, the Willard brothers purchased a small galvanizing facility in Harrisburg, NC that grew into Galvan Industries. Galvan is the company Laurens Willard now owns and operates.

"I was drawn to the metals processing business from an early age," Laurens Willard said. "Metallurgy is in my roots. I worked summers in both plants learning the business from the bottom up."

After high school, Willard knew he wanted to attend a top engineering school and after being accepted to NC State, Georgia Tech and Clemson, he felt NC State was the best fit for him. "Growing up in North Carolina I have always had a connection to State, so it was a natural fit."

After graduating from NC State in 1973 with a bachelor's degree in materials science, Willard went on to work at the L.D. Caulk Company, a consulting client of former materials science professor Professor Charles Manning, as a research metallurgist in the dental alloys laboratory in Milford, Del. The company developed silver, copper and tin dental amalgam alloys.

Willard left L.D. Caulk Company in 1975 and went to work for his father at Galvan Industries, where he has been for 40 years.

The company has expanded from the original plant Charles and Clarence Willard began that was equipped with a 10' x 3' x 4' kettle suitable for small parts to becoming the largest-capacity-job galvanizing plants in the Southeast, processing more than 30,000 tons of fabricated steel products a year. In its electrical products business, Galvan Electrical is the second largest manufacturer of copper coated and galvanized ground rods in the United States.

With 120 employees, Galvan Industries and Galvan Electrical manufactures and ships products all over the United States, Canada and Mexico, with exports to the Middle and Far East.

And what does Willard attribute to helping with his career and company success? His MSE degree from NC State.

"Materials science is a continuous learning process that goes beyond school and well into the job field," said Willard. "NC State helped lay the foundation of my knowledge and skills, giving me the basis for the technological growth of our company."

Under Laurens Willard's leadership, Galvan Industries has received numerous accolades and awards for both companies, including the 2006 American Galvanizers Association (AGA) Galvanizing Excellence Award for an airport parking deck designed to mirror the curvature of a modern airplane wing and built with 300 tons of hot-dipped galvanized steel, the 2005 AGA National Award For Excellence for a one-of-a-kind pedestrian bridge using hot-dip galvanized steel reinforcements and the 2003 Excellence In Hot-Dip Galvanizing Bridge And Highway Award from AGA for its work on the Goshen Bridge in Virginia.

"My engineering degree has helped provide me with a technical background that has helped in running a company. Although I have never been a lead engineer, my background and degree has enabled me to hire engineers and have the ability to evaluate their work from a technical point of view," said Willard. "I may not have all the answers, but I know where to find them thanks to my education from State." ▪

Laurens Willard

Ketura Parker

Ketura Parker joins department as director of development

KETURA PARKER joined the NC State Engineering Foundation in 2014 as director of development and works to develop major gifts for the Department of Materials Science and Engineering and the Department of Electrical and Computer Engineering. Parker comes to NC State from the College of Arts and Sciences at UNC-Chapel Hill, where she was an associate director of development. With seven years of fundraising experience in higher education, she is dedicated to building meaningful relationships with alumni and friends and helping secure private support that would meet the highest priorities of the departments and College of Engineering.

Parker graduated from UNC-Greensboro with a master's degree in consumer apparel and retail studies and received a bachelor's degree from UNC-Chapel Hill in political science. ▪

MSE Launches Alumni Hall of Fame

The MSE Department is proud to honor the accomplishments of our outstanding graduates through the newly formed MSE Alumni Hall of Fame.

This extraordinary recognition celebrates MSE alumni who have used their education to excel in a profession, career, and/or service. Our alumni are at the core of the Department, representing the agents and ambassadors that have made groundbreaking contributions in the translating and practice of materials science and engineering and beyond. With more than 1,800 MSE alumni, only 16 graduates were selected for the inaugural class, making this a truly noteworthy distinction. Additionally, we hope this meaningful accolade will inspire current and future students.

We offer a special thank you to the MSE Alumni Hall of Fame Committee. Their diligent efforts in the review and selection process are indeed appreciated. The Department is the fortunate recipient of their commitment to alumni engagement. Our sincerest gratitude is bestowed to the following members for their time, dedication and invaluable service: **MRS. KAREN F. BISI** (B.S. MSE '90), **PROFESSOR DOUGLAS IRVING**, **PROFESSOR. C. LEWIS REYNOLDS, JR.**), and **MR. CHRISTOPHER STORY** (B.S. MSE '81).

Congratulations to the following 2015 inductees of the inaugural MSE Alumni Hall of Fame!

MR. REUBEN B. ARTHUR, JR., B.S. Ceramic '59, Greensboro, NC
DR. CALVIN H. CARTER, JR., B.S. MSE '77, M.S. MSE '80 and Ph.D. MSE '83, Durham, NC
MR. THOMAS G. CUNNINGHAM, B.S. MSE '71 and M.S. MSE '74, Wilmington, NC
DR. ROBERT F. DAVIS, B.S. Ceramic '64, Pittsburgh, PA
DR. JOHN A. EDMOND, Ph.D. MSE '87, Durham, NC
DR. ANNA C. FRAKER, M.S. Ceramic '61 and Ph.D. Ceramic '67, Gaithersburg, MD
MR. JOHN L. FREEMAN, B.S. Ceramic '57, Charlotte, NC
DR. ROBERT C. GLASS, Ph.D. MSE '91, Chapel Hill, NC
MR. JACOB T. HOOKS, B.S. MSE '78, Wilmington, NC
BRIGADIER GENERAL LEODIS T. JENNINGS, B.S. MSE '83, Stafford, VA
DR. NASSER H. KARAM, Ph.D. MSE '85, La Canada, CA
DR. CHARLES R. MANNING, JR., Ph.D. Ceramic '67, Raleigh, NC
DR. HAYNE PALMOUR, III, Ph.D. Mineral Industries '61, Raleigh, NC
DR. JOHN W. PALMOUR, B.S. MSE '82 and Ph.D. MSE '88, Cary, NC
MR. GERALD M. WHITE, B.S. Metallurgy '60, Charlotte, NC
MR. LAURENS G.Y. WILLARD, B.S. MSE '73, Charlotte, NC

For complete biographical information on these outstanding inductees, please visit www.mse.ncsu.edu/alumni/hall-of-fame.

To learn more about the MSE Alumni Hall of Fame or to nominate alumni in the future, please contact Director of Development Ketura Parker at knparker@ncsu.edu or 919.513.1338. ▪

MSE external advisory board

The External Advisory Board (EAB) is a group of outstanding thought leaders dedicated to providing experience and expertise for the department's continued success. These MSE advocates play a major role in setting the direction for research, education and industry partnerships. Their collective insight empowers the department to sustain its excellence and relevance in the field of materials science and engineering. We are grateful for their commitment, support, and friendship.

PROFESSOR REZA ABBASCHIAN (Chair), Dean of Engineering, University of California, Riverside
DR. TERRY ASELAGE, Senior Manager of the Materials Synthesis and Processing Technology Group, Sandia National Laboratories
DR. PAUL BESSER, Senior Technology Director, Lam Research Corporation
MS. KAREN F. BISI, Branch Manager, Cer-Met, Inc.
DR. RICH COLTON, Superintendent Chemistry Division (retired), Naval Research Laboratory
DR. JOHN EDMOND, Co-founder, Cree, Inc.
DR. JOHN C.C. FAN, Chief Executive Officer, Kopin Corporation, Inc.
DR. JULIE P. MARTIN, Assistant Professor in the Department of Engineering & Science Education, Clemson University
MR. JOHN FREEMAN, President, Cer-Met, Inc.
DR. BRENT NEAL, R&D Manager, Milliken
DR. DON GUBSER, Superintendent of the Materials Science and Technology Division (retired), Naval Research Laboratory
DR. SUNG HAN, Director of Technology, Eastman Chemical Company
DR. BRIAN LAUGHLIN, Technical and R&D Supervisor for the MCM Advanced Materials, DuPont
PROFESSOR ENRIQUE LAVERNIA (Vice-Chair), Provost and Executive Vice Chancellor, University of California, Irvine
PROFESSOR JENNIFER LEWIS, Hansjorg Wyss Professor of Biologically Inspired Engineering, Harvard University
MR. JIM LEWIS, Manager Rolling and Finishing, Nucor Steel
DR. HENRY LIPPARD, Manager, Nickel and Iron Process Metallurgy, ATI Allvac
MR. CHRISTOPHER STORY, Senior Vice President of Global Operations, CommScope
DR. STEPHEN STREIFFER, Deputy Associate Laboratory Director, Argonne National Laboratory
DR. STEVE ZINKLE, Governor's Chair for Nuclear Materials, University of Tennessee, Knoxville
DR. BARRY FARMER, Chief Scientist, Materials and Manufacturing Directorate (retired), Air Force Research Laboratory ▪

CDP starts second year strong

The Center for Dielectrics and Piezoelectrics, a National Science Foundation Industry/University Cooperative Research Center, began its second year of operation in 2015. Research thrusts within the CDP include: capacitors for extreme environments, high energy-density electrochemical capacitors, polymer nanocomposite dielectrics, piezoelectrics, dielectrics for low-temperature substrates and nonlinear/high-frequency dielectrics. The center, jointly organized with Penn State University, currently has 25 member companies and supports 12 research programs across the two universities.

The Ph.D. students involved in the CDP have unique opportunities to interact with high-level scientists and technical managers from this international array of companies. A number of CDP faculty members and graduate students will be participating in the coming US-Japan Conference on Dielectrics and Piezoelectrics in Mastumoto, Japan this November. CDP Director and Principal Investigator Professor Elizabeth Dickey serves as the U.S. General Chair for the conference.

"I enjoy interacting with MSE graduate students that are conducting research related to CDP topics of interest – for me, it is one of the highlights of our meetings. The students that make formal presentations do a great job, and the poster sessions provide an ideal opportunity to learn more about the students' research and career interests. Students seem to appreciate and benefit from the input from industry, and it's a wonderful networking opportunity for everyone." – said Larry Mann, vice president of sales and marketing for Shoei Electronic Materials, Inc. ▪

INDUSTRY MEMBERS

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AVX
Boston Scientific
Eaton Cooper
Fenghua Advanced Tech.
Ferro
Kemet Electronics Corp.
Kyocera
Mitsubishi Materials Co.
Morgan Advanced Materials
MRA Laboratories
Murata Mfg. Co., Ltd.
NGK Spark Plug Co., Ltd.
PI Ceramic GmBH
Protochips
Radiant Technologies
Sabic Innovative Plastics
Samsung Electro-Mechanics
Sandia National Laboratory
Shoei Chemical
Taiyo Yuden Co., Ltd.
U.S. Army Research Lab
Yageo Corp.
Xaar PLC

NC State students William Hoffmann and Gibson Scisco exploring Sydney's coasts in some downtime from the laboratory

An international perspective for NC State students

From front to rear: Five UNSW undergraduate students visiting NC State, Prof. John Daniels (UNSW), and Prof. Jacob Jones (NC State).

One of Jacob Jones' favorite places in the world is Sydney, Australia. And he has been sharing it with students for nearly a decade. Before moving there in 2004 for a postdoc at the University of New South Wales (UNSW), he had never lived outside of Indiana. His move across the globe and his time at UNSW was eye-opening – he was exposed to materials research in a different culture and this gave him a fresh international perspective to bring home. Now he is giving a similar experience to NC State students.

Since becoming a faculty member, he has persistently shared his passion for international research with his students. Since 2007, he's received three large grants from NSF to send groups of students to Europe and Australia for extended periods of time. The most recent one focuses on NC State students. In collaboration with Professors Elizabeth Dickey, Jon-Paul Maria and Cheryl Cass, the NSF award supported four NC State undergraduate students to pursue a research and training experience at UNSW this past summer for 10 weeks.

The goal of the NSF-supported program is to engage U.S. students in an international research setting early in their career. Jones says, "International cooperation is becoming ever more necessary to address a growing number of global challenges. At minimum, international cooperation allows for access to unique resources and the intellectual collaboration of leading scientists and educators. Beyond this, the most effective collaborations involve the sharing of different ideas and problem solutions that originate from individuals of different backgrounds and experiences."

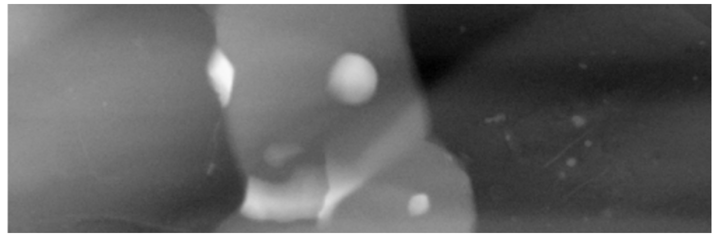
A previous NC State student participant, John Mangum, said, "This program provided an influential environment both in and out of the lab that stimulated my passion for materials research as well as international travel. The experiences and people I encountered this summer will never be forgotten." John is now a Ph.D. student at Colorado School of Mines.

In the past year, Jones has also worked with an Australian counterpart, Professor John Daniels, senior lecturer at UNSW, to enable a reciprocal program for UNSW students to undertake research and training at NC State. The first five students arrived at NC State this past winter and spent two months working in MSE research labs. A new group of five students will arrive in November for the second year.

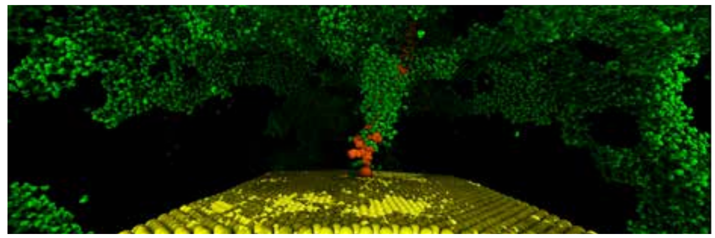
NC State is "leading the pack" in internationalism, giving students amazing opportunities and a clear career advantage. ▪

Science as Art competition

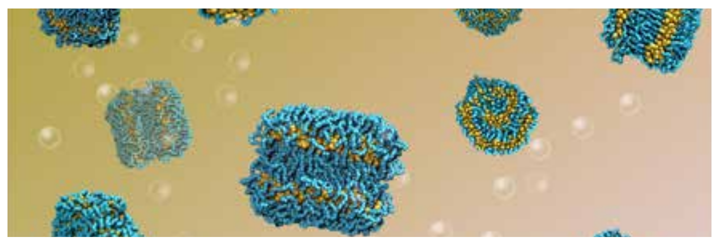
The MSE Graduate Student Council recently held the department's first Science as Art competition. The competition gave researchers the opportunity to be creative with images they have collected. Entries and captions were judged by outside panelists, and the top three images and honorable mention were awarded.



Houston Dycus and James LeBeau



Hoshin Kim and Yaroslava Yingling



Nan K. Li, Hayden Fuss and Yaroslava Yingling

Nicole Estrich

TEM Haunted Tales—The Story of Sir Polter Geist
HOUSTON DYCUS and JAMES LEBEAU
First Place

Many structural and chemical observations have been made using transmission electron microscopy (TEM). Understanding of supernatural occurrences has however remained elusive...until now. Sir Polter Geist was cursed to live amongst the shadows in the nano-world of bismuth telluride grains. One day, his world was investigated in NC State's FEI Titan microscope and imaged with an electron beam. This beam empowered Sir Polter Geist, allowing him to escape his accursed life and bring peace to his former world. (Image acquired with an FEI Titan using a sample of bismuth telluride, a material used for converting heat into electrical power. The bright spots simulating the impression of facial features are consequences of voids within the material.)

A DNA Tree | HOSHIN KIM and YAROSLAVA YINGLING
Second Place

A DNA tree on gold surface. This snapshot represents a moment when vacuum bubbles come into DNA (brown), gold surface (yellow) solvated into water (green).

Burger Solution
NAN K. LI, HAYDEN FUSS, YAROSLAVA YINGLING
Third Place

The "burger" shape aggregates are obtained through the self-assembly of amphiphilic poly- electrolyte triblock copolymers in coarse-grained modeling and simulation. These "burgers" are smart materials which are responsive to the changes in salt concentration, pH, or temperature.

One Woman's Trash | NICOLE ESTRICH
Honorable Mention

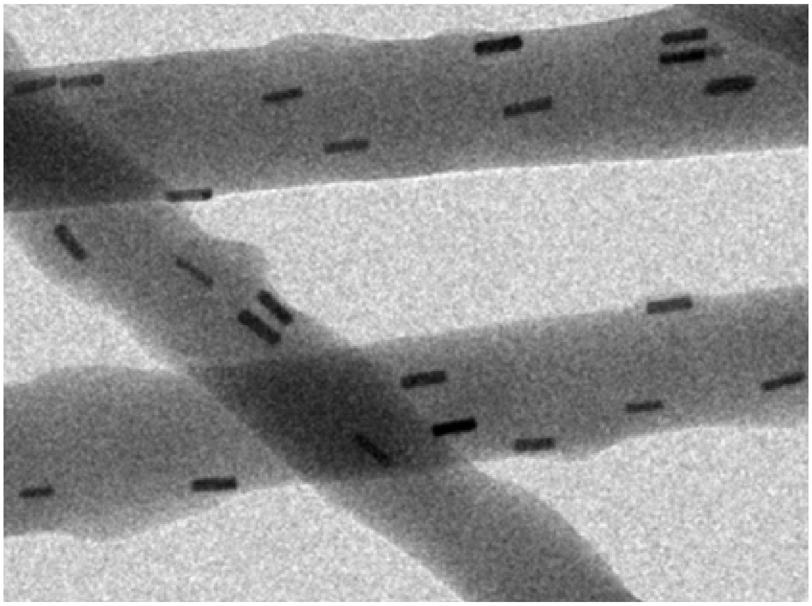
Research often requires us to vary parameters to find the best fit for our application. In the process, we create suboptimal samples. I've turned mine into art.

Solar Tree: Ceramic pellet "soil" nurtures a solar cell "tree." The pellets are ZnO with varying dopant concentration. Pellets were laser ablated to create antireflective coatings on thin-film solar cells. Silicon "leaves" were patterned to measure contact resistivity, or how incoming electrons travel through the solar cell. (P.I. Jon-Paul Maria)

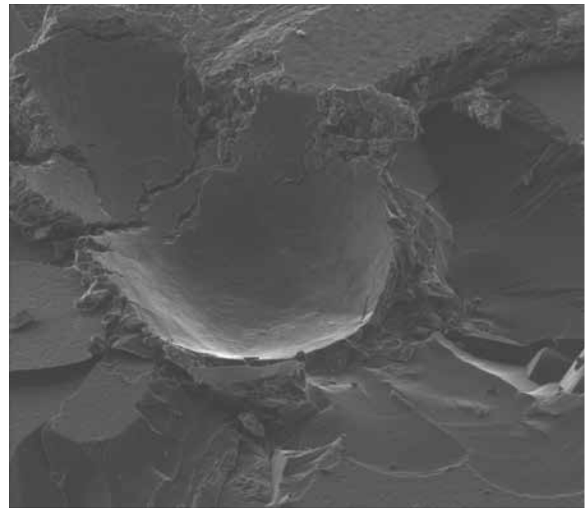
Nano Rocket: Materials science is often concerned with the nano, but without a scale bar, it can be difficult to tell if an image is a star, light-years away, or a tiny molecule. This "rocket" is comprised of a tube with gold nanorods and a surfactant. The "planet" is a polystyrene bead with gold nanorods on it. (P.I. Thom LaBean; SEM Image by Jon-Paul Maria. ▪

MSE image contest

The department solicited art entries for this newsletter. The winning image appears on the cover. Other entries are presented here.

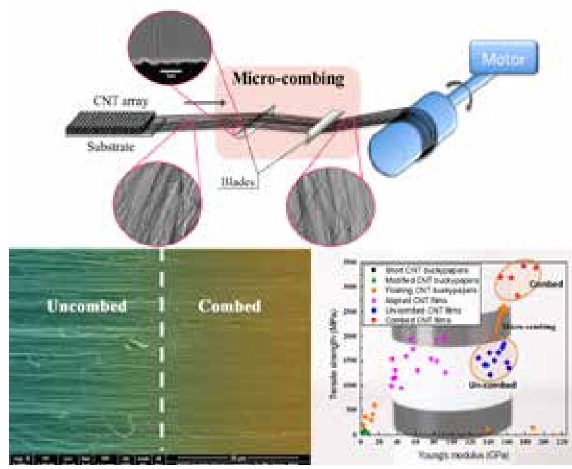


Sumeet Mishra

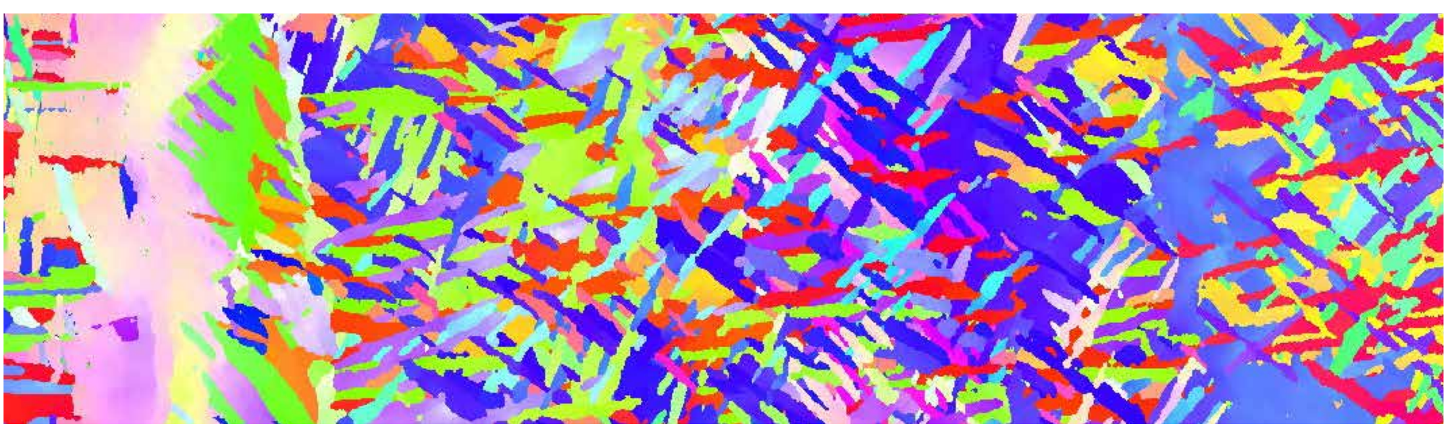


Gibson Scisco

Balaji Lenin



Liwen Zhang



Zaynab Mahbooba

NC STATE Engineering

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

SUPPORT THE MSE DEPARTMENT

Give Today. Impact Tomorrow.

The Department of Materials Science and Engineering (MSE) provides the highest quality 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 MSE's ability to extend educational opportunities to bright, deserving students and recruit and retain an outstanding faculty to teach these future scholars. Give Today. Impact Tomorrow.

MSE ENHANCEMENT FUND

Annual gifts to the MSE Enhancement Fund give current engineering students the same life-changing opportunities you enjoyed. These critical funds enable the department to address top priorities with the greatest flexibility. Resources from the MSE Enhancement Fund support an outstanding faculty, excellent students and significant teaching infrastructure. With your help and generosity, we can continue to respond immediately to emerging needs and exciting challenges and provide world-class educational experiences for all of our students. Make your gift today by visiting: **www.engr.ncsu.edu/giving.**

ENDOWMENT OPPORTUNITIES

Endowment gifts are long term investments from alumni and friends to the MSE Department. The stability and growth potential represented by an endowment gift amplifies its impact in perpetuity. Endowments can support the categories below and much more!

- Undergraduate Scholarships - Endowed scholarships provide donors with perhaps the greatest opportunity to make an impact on the greatest number of lives.
- Graduate Fellowships - Endowed graduate fellowships provide essential support in the intense competition for graduate students, agents of innovation in the department.
- Distinguished Professorships - Endowed professorships are the most important vehicle for recruiting and retaining exceptional research faculty members, whose work in MSE solves significant challenges and improves the educational experience for all students. We also utilize the state of North Carolina's generous matching program, which underscores the importance of research faculty by providing 1/3 of the cost of an endowed professorship.

For more information on ways to support the MSE Department, please contact Ketura Parker, director of development, at 919.513.1338 or knparker@ncsu.edu.

http://www.mse.ncsu.edu/giving

3,000 copies of this document were printed at a cost of $4,687.