JENA-XING GROUP TAPS CORNELL’S INTELLECTUAL POWER TO PUSH LIMITS OF MATERIALS

PAGE 10
Dear Alumni and Friends of the Department

Last year we launched the Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials (PARADIM), an NSF-supported five-year, $25 million initiative in which users from throughout the nation can design and synthesize new interface materials using facilities and expertise located at Cornell and our partners. It’s been exciting to watch PARADIM blossom since that time, with many of our own faculty and students making discoveries using the platform. For example, assistant professor Jin Suntivich is growing single-crystal transition-metal oxides to gain a better understanding of what makes for the perfect fuel cell catalyst.

I invite you to read about Jin’s work and other research projects on Pages 4-9, the variety of which demonstrates the wide impact we as materials scientists and engineers have on the world. Whether it’s gaining a deeper understanding of how breast cancer metastasizes or developing an oleophobic coating for stain-resistant clothing, we pride ourselves on being problem solvers in all realms.

On Pages 10-11, we take you inside the laboratory of Grace Xing and Debdeep Jena—two faculty members who joined us in 2015 and have since been making waves, literally. Among their breakthroughs has been the fabrication of gallium-nitride-based LEDs that emit the shortest ultraviolet wavelengths ever recorded. A group from the lab is now commercializing the technology for use in medical and food sterilization.

Through PARADIM we’ve also launched an on-campus, full-year materials engineering program for local high school students, which you can read about on Page 13. The New Visions program has become a great opportunity for our own students to engage with the high school students and provide mentoring, promoting the leadership skills we seek to instill in our young scholars.

This year we welcomed several new faculty and staff to our MSE family, including Andrej Singer, a tenure-track faculty member who uses X-ray characterization to better understand nanoscale structure and its dynamics in complex materials. On Page 3 he notes the exceptional strengths of MSE’s students, some of whom are featured on Pages 16-19. Andrej also notes Cornell’s exceptional research infrastructure, such as the Cornell High Energy Synchrotron Source (CHESS). I’d also like to acknowledge the prominence of the Cornell Nanoscale Science and Technology Facility, which is now directed by former MSE director Chris Ober and recently celebrated its 40-year anniversary (Page 5).

There are many other accolades to give—too many to list them all here. But I can’t avoid using this opportunity to congratulate former MSE director Darrell Schlom on his induction into the National Academy of Engineering—an extraordinary honor which you can read about on Page 20. And speaking of friends in high places, former MSE director Emmanuel Giannelis has been named Cornell’s senior vice provost for research and vice president for technology transfer, intellectual property and research policy (Page 22). Congratulations Emmanuel!

Please enjoy this newsletter and find us online to keep up on even more MSE news. If you’d like to be more directly involved with our faculty, students and facilities, I encourage you to review the giving opportunities listed on Page 25.

Sincerely,

R. Bruce van Dover
MSE Department Chair

GREETINGS FROM PROFESSOR R. BRUCE VAN DOVER, MSE CHAIR
MSE WELCOMES THREE NEW FACULTY

LISA THOMPSON
ADJUNCT PROFESSOR

Thompson teaches a laboratory course that spans both the fall and spring semesters. Thompson’s focus is to help MSE undergraduates build skills in careful experimentation, formal data analysis, publication quality plotting and technical communication that will prepare students for senior research, internships, graduate school and employment in materials science and engineering. Thompson received a B.S. in materials science and engineering from Northwestern University in 1987 while working as a co-op engineer for a year and a half at National Steel in Portage, Indiana. She received an M.S. and Ph.D. from Cornell University in 1993 doing research in the area of microstructural scale design of metal-ceramic composites. She was a lecturer at MSE from 1995-2000, teaching courses on the structure and processing of materials. During a professional hiatus to raise her two children, Thompson spent 10 years as director of a summer camp for 150 students, developed STEM curriculum for students participating in several local summer camp organizations, and has worked as the director of music and an organist for a church in Ithaca.

PETER BOCKO
ADJUNCT PROFESSOR

After a 35-year career in research and development at Corning, Inc., Bocko, Ph.D. ’79, has returned to Cornell to teach a graduate course in glass technology and theory. At the time of his retirement as chief technology officer of Corning Glass Technologies in 2014, Bocko was considered one of the foremost leaders in glass innovation for consumer electronics. He joined Corning in 1979 as a glass chemist and was a principal in Corning’s participation in the flat-panel display revolution. He focused most of his career on technology applications for engineered glass in the information age, including optical amplifiers, LCD substrates and glass for semiconductor packaging. Bocko was the technical advisor for Corning’s acclaimed “A Day Made of Glass” internet video series, was featured in a NOVA episode, frequently spoke at industry conferences and still guest lectures in business schools on leadership and innovation. Bocko holds 11 patents in diverse areas of materials science and is credited with over $20 billion of revenue. In 2012, he was presented with a Special Recognition Award from the Society for Information Display for his contributions to that field.

ANDREJ SINGER
ASSISTANT PROFESSOR

Singer has joined MSE as an assistant professor after completing a postdoctoral position at the University of California, San Diego (UCSD). Singer uses X-ray characterization to better understand nanoscale structure and its dynamics in complex materials. He then aims to use what he learns about mesoscale phenomena to improve material functionality. Singer, who earned his undergraduate degrees in physics and math at the University of Muenster in Germany, found himself drawn to mathematics before he even started secondary school. “I was always good at math,” says Singer. “By the time I was in high school I started to see the beauty of mathematical theorems and proofs.” Singer received his master’s degree in physics from Muenster and then moved to the University of Hamburg for his doctoral studies in physics. Singer gives partial credit for his decision to pursue physics rather than mathematics to a particular officer in the German army. “When I did my mandatory military service I had lots of time to read,” says Singer. “I read multiple books by Stephen Hawking and it gave me a big push toward physics. One of my commanding officers gave me support and encouragement. He said ‘just mention me when you discover something important.’” At Hamburg, Singer studied in the lab of professors Edgar Weckert and Ivan Vartanyants. He specialized in the properties of new X-ray sources and was especially interested in their ability to generate interference patterns, similar to lasers in optics. In 2012, Singer took a postdoctoral research position in the lab of professor Oleg Shpyrko at UCSD. While there, he applied coherent X-ray scattering techniques to study materials. Now that he is at Cornell, Singer is excited to expand his work applying X-rays to a wide range of materials. “Cornell is one of the top engineering schools in the world. The students here are exceptional and the research infrastructure on campus is unique worldwide. Access to the CHESS facility is a big selling point.”

MSE WELCOMES THREE NEW STAFF

ALEXANDER DEYHIM
ASSOCIATE DIRECTOR, M.ENG. PROGRAM

After working in manufacturing of a Ford Motor Company, Deyhim earned his MBA from Cornell’s Johnson School in 1998 and founded Advanced Design Consulting, Inc., based in Lansing, New York. For over 20, Deyhim managed contracts and designed complex instruments for government laboratories, international organizations and academic institutions. Clients included NASA, Argonne National Laboratory, ITER and similar organizations in more than 26 countries around the world. During his tenure at Advanced Design Consulting, the company developed over 14 patents and had 16 patents pending. Deyhim has a passion for teaching and taught MAE 4300: Professional Practice in Aerospace Engineering at Cornell for a number of years, taking the course from the lowest ranked in the department to above-average student ratings. He loves challenging himself and being back at Cornell as the associate director of the MSE M.Eng. Program. He intends to grow the program and work with students to help them become leaders in their respective fields.

BRENDA FISHER
LAB MANAGER, CENTER FOR NANOMATERIALS ENGINEERING AND TECHNOLOGY

Fisher joined Cornell in the spring of 2011, supporting the research in KAUST-CU Center for Energy and Sustainability. Her experience prior to joining Cornell includes time at a large pharmaceutical company and a small start-up, where she served as a bench scientist, laboratory and project manager.

CORINNE RUSSELL
ACCOUNTS REPRESENTATIVE

Russell started working at Cornell in 2004 and before joining MSE, was an account representative in the Financial Transaction Center where she supported multiple departments for six years. She graduated from Tompkins Cortland Community College with an associate degree. Russell and her husband Jason have a 13-year-old son who is very active in soccer and lacrosse and an 11-year-old daughter who is very active in soccer, basketball and softball. In her spare time she enjoys playing softball.

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METASTATIC BREAST CANCER AFFECTS BONE MINERAL BEFORE SPREADING

When breast cancer metastasizes, or spreads, one of its most likely destinations is bone. In fact, four in five metastatic breast cancer patients will develop bone lesions, according to research published by the National Institutes of Health.

Most research studies have focused on the cellular and molecular mechanisms involved in cancer metastasis, but little is known about how the physical properties of bone are altered by cancer.

An international collaboration led by Claudia Fischbach-Tschel, associate professor of biomedical engineering, and included Lara Estroff, MSE associate professor, reports that not only does the cancer favor a certain state of bone mineral, but that breast cancer tumors actually remotely enhance that favorable state—“talk,” in effect, with the region of choice—before metastasizing there.

The group’s paper, “Multiscale Characterization of the Mineral Phase at Skeletal Sites of Breast Cancer Metastasis,” published online Sept. 18 in Proceedings of the National Academy of Sciences USA.

Even before breast cancer cells spread to the skeleton, they interact with bone cells to facilitate later tumor growth at those sites. This region of interest for disseminated cancer cells is known as the pre-metastatic niche. At the same time this remote cellular interaction is taking place, the cancer cells are disrupting the bone’s natural remodeling, a constant process in which old tissue is shed and new tissue forms.

Metastasis in the bone triggers a vicious cycle: Cancer cells migrate to a region that’s suited for their growth, and their presence degrades the region, making it even more suited to tumor growth.

Analysis of the metaphyseal bone after breast cancer cell injection into the bloodstream, a procedure that will produce tumors in bone, confirmed that metastatic breast tumors degrade bone. Additionally, this analysis showed that the HA crystals in the remaining bone were even less mature than before the cancer arrived.

The surprising result came after breast cancer cells were injected directly into mammary tissue. Not only did the cells produce a localized tumor, but they affected the metaphysis—even before the formation of metastasis.

NANOSCALE FACILITY CELEBRATES 40 YEARS OF NANOTECH, FOCUSES ON FUTURE

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he Cornell Nanoscale Science and Technology Facility (CNF) celebrated its 40-year anniversary on Sept. 14 with a full day of presentations and panel discussions that reflected on its contributions to nanotechnology and focused on its future.

When it opened in 1977 as the National Research and Resource Facility for Submicron Structures, it was the only facility of its kind, welcoming scientists and engineers across the country to conduct research on a scale approximately 75 times smaller than the width of a human hair. It operated out of Phillips Hall and contained about $4 million in research equipment.

Today, CNF is part of a larger national network of facilities and conducts research on the nanometer scale—about 50,000 times smaller than the width of a human hair. With about $75 million in equipment, the Duffield Hall facility operates 24/7, serving about 600 users a year who conduct research in the fields of biology, electronics, materials science, optics and physics.

One aspect of the facility that hasn’t changed in 40 years is its expert staff and service-oriented culture, according to Christopher Ober, CNF director and MSE professor.

“About a lot of other places bring you in and say, ‘These are the instructions, don’t break the equipment,’” Ober said. “Our staff invests the time in teaching people how to design processes.”

CNF has facilitated breakthroughs in micro- and molecular electronics. It has also helped lead the fields of magnetic storage and nanobiotechnology, and studies in energy-related systems like batteries and carbon nanotubes.

To understand the facility’s impact on science, one need look no further than its research output. About 100 patents and patent applications are rooted in CNF research each year, as well as about 500 publications, many in top-tier academic journals.

Also, look at research that has been translated into real companies,” said Ober. “Just in recent times: microelectromechanical company Kionix, laser-technology company Binoptics—which was sold to MACOM—and Pacific Biosciences, which is a half-billion-dollar biotech company.”

But CNF’s 40th anniversary wasn’t just about looking back. People from academia, industry and government were asked to participate in workshops to help predict the future of nanotechnology research. The information is being compiled into a document that will help guide future CNF decisions.

“You would think after 40 years we’d have it all down pat,” Ober said, “but in fact there’s just tremendous opportunities to try new things, and there’s constantly new challenges.”
Jin Suntivich, Department of Energy’s 2017 Early Career scientists, is studying catalysts in a new way, and he believes that the foundational knowledge will be valuable beyond fuel cells, as transition-metal oxides are used as coatings and micelles.

“Growing a single crystal is really, really hard. It’s one of the reasons why our work has not been carried out anywhere else,” said Suntivich, who plans to work with engineers who specialize in the heart of every fuel cell is a catalyst that controls how the cell converts fuel into energy. The better the catalyst, the more efficient, powerful and cost-effective the fuel cell.

Transition-metal oxides are a class of high-performance catalysts with great potential, but the way in which they govern electrochemical reactions that turn fuel into energy remains poorly understood. Jin Suntivich, MSE assistant professor, hopes to change that by studying catalysts in a new way, and he has been awarded $750,000 by the U.S. Department of Energy’s 2017 Early Career Research Program.

“What are the many things going on when a transition-metal oxide is working as a catalyst, and that makes it difficult to study how a reaction fundamentally happens,” said Suntivich. His solution is to use a single-crystalline form of transition-metal oxides to gain an unprecedented look at the role defects, strain and subsurface layering of atoms play in how the catalyst performs. The simple structure allows Suntivich to test each variable and record the performance to understand mechanisms and scientific principles that make for the best catalyst.

“Growing a single crystal is really, really hard. It’s one of the reasons why our work has not been carried out anywhere else,” said Suntivich, who plans to work with engineers who specialize in growing them at Cornell’s Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials.

Once the catalysts are created, Suntivich will use a suite of characterizations to evaluate their performance and reaction mechanisms, focusing on finding the best atomic arrangements for converting carbon monoxide and oxygen into energy.

“To convert natural gas to electricity, one possibility is put it in a reformer that cracks the natural gas molecules and converts them to carbon monoxide and hydrogen,” said Suntivich, describing carbon monoxide as a gateway molecule to how a reaction fundamentally works with computer simulations, conducted by Kao. This imaging, done by Sun and Ma, gave the team a sort of time-lapse look at the quasicrystal growth process, which they could control in a couple of different ways.

One way was to vary the concentration of the chemical compound mesitylene, also known as TMB, a pore expander. The imaging, including cryo-TEM performed by Spoth, showed that as TMB concentration increased, micelles became bigger and more heterogeneous. Adding TMB induced four mesoporous nanoparticle structure changes, starting as a hexagonal and winding up as a dodecagonal (12-sided) quasicrystal.

“The more TMB we add, the broader the pore size distribution,” Wiesner said, “and that perturbs the crystal formation and leads to the quasicrystals.”

The other way to make these structures evolve is mechanical. Starting with a hexagonal crystal structure, the team found that by simply stirring the solution more and more vigorously, they introduced a disturbance that also changed the micelle size distribution and triggered the same structural changes “all the way to the quasicrystal,” Wiesner said.

A lot of the discovery in this work was “serendipity,” Wiesner said, the result of “hundreds and hundreds” of growth experiments conducted by the students. The more insight gained into the early formation of these unique particles, the better his understanding of silica nanoparticles, which are at the heart of his group’s work with Cornell dots.

Wiesner added TMB induced four mesoporous nanoparticle structure changes, starting as a hexagonal and winding up as a dodecagonal (12-sided) quasicrystal.
**MECHANISMS FOUND TO EXPLAIN ATYPICAL FEMORAL FRACTURES**

Radiograph imaging showing morphology of a typical fragility fracture of the hip (A), compared with an atypical femoral fracture (B). The nature of the AFF indicates a brittle fracture process, possibly due to excess mineralization of the bone.

There is no disputing that the use of bisphosphonates—with brand names such as Fosamax, Boniva and Reclast—is proven to combat bone loss and fragility fractures in millions of osteoporosis patients for whom a fracture could be debilitating, even life-threatening.

But there is a caveat: Prolonged use of these drugs can alter the composition of bone, making it more brittle and more susceptible to a rare but serious form of fracture. And a group led by Eve Donnelly, MSE assistant professor, has put forth a couple of possible explanations for this phenomenon.

Her group—in collaboration with researchers from Weill Cornell Medicine and the Hospital for Special Surgery in New York, among others—detail their findings in “Atypical Fracture with Long-Term Bisphosphonate Therapy is Associated with Altered Cortical Composition and Reduced Fracture Resistance,” published July 31 in Nature Communications. Ashley Lloyd, doctoral student in MSE, was lead author.

It’s been known for some time that prolonged use of bisphosphonates can put people at risk for atypical femoral fracture (AFF), a break in the shaft of the femur that can occur as a result of little or no trauma. The Donnelly group set out to understand the link between the drugs and AFF.

For this study, the team examined biopsies of cortical bone—the outer layer—from the shaft of the femur obtained from postmenopausal women during fracture repair surgery. The participants were placed in five groups, based on fracture type and bisphosphonate use. Some of the women in the study had used bisphosphonates for more than eight years.

The testing pointed to a couple of contributing factors: Bisphosphonate-treated women with AFF had bone that was harder and more mineralized than bisphosphonate-treated women with typical osteoporotic fractures. Donnelly said this is due to bisphosphonates’ main functions: slowing the resorption (shedding) of old bone, which is typically followed by remodeling, the growth of new bone. In healthy adults, cortical bone is constantly being resurfaced, such that the entire adult skeleton is overhauled every 10 years or so.

But that resurfacing process begins with resorption, and if resorption is slowed by bisphosphonates, the remodeling process is also affected. The result: The existing bone ages and gets brittle over time.

“It’s kind of a double-edged sword,” Donnelly said. “It’s extremely good to prevent bone loss, but the drugs will also slow this natural process, which allows turnover.”

The other unforeseen side effect to long-term bisphosphonate use involves crack-deflection—the resurfaced bone’s ability to stop a microscopic crack from propagating, which can lead to a break. New layers of bone can act as a “firewall” of sorts, stopping a crack from spreading, but mineralized, older bone loses that function.

The Food and Drug Administration is now recommending patients use bisphosphonates for three to five years, followed by reassessment of their risk. Donnelly makes it clear that her study is not proposing doing away with bisphosphonate treatment. Studies have estimated the risk of AFF among bisphosphonate users at between one and 10 in 10,000, and have shown the benefit of bisphosphonates continues to far outweigh the risk of AFFs.

“That’s one of the cautions I’d like to impart,” Donnelly said. “What we have observed is really the result of long-term treatment, well beyond what the FDA is recommending for these drugs now. Our work explains some of the underlying mechanisms of AFFs and can inform the refinement of dosing schedules for patients at risk of fragility fractures.”

**COLLABORATION YIELDS PROMISING INNOVATION IN STAIN RESISTANCE**

When you spill pasta sauce on your favorite shirt but there is no trace of it after being washed, you can thank oleophobicity, a resistance to oil commonly applied to textiles.

That resistance, however, comes at a price. The coating that makes textiles oil resistant is fluoro-based and breaks down into chlorofluorocarbon gas, a greenhouse gas harmful to the environment.

But that may change, as a result of a Cornell cross-campus collaboration involving Emmanuel Giannelis, MSE professor and Cornell’s vice provost for research, and Jintu Fan, professor and chair of the Department of Fiber Science and Apparel Design. Work from their labs has yielded a promising new material that could help change the way oleophobicity is developed.

They worked with an apparel maker on creating a polymer that could make fabric more breathable while retaining wrinkle resistance—always a challenge—and Giannelis said they made good progress along that line.

“The company came back and said, ‘That is good and great—but can you do something similar with oleophobic coatings?’” he said. “It’s a very different kind of chemistry, and something we had not worked on previously, but one of the great things about being at Cornell is that we have great students and postdocs who can take this kind of challenge and do great things.”

Postdoctoral researcher Gengqiang Qi developed a polymer that combines well-known chemistry with a rough surface texture that creates little air pockets. Fluids with a high enough surface tension will ball up on this fiber and not stick, making for easy cleaning.

This roughness uses the same principle as the water-resistant quality of the lotus leaf, which has a rough nanostructure and naturally repels water.

Fan is excited by early results of this material, noting that they’ve just done testing using mineral oil, which has a low surface tension.

“We’ve found that even after 30 washings it’s still durable, which is great,” he said. “Even if we can achieve [oleophobicity] that’s even close to fluorine-based [polymers], that would be a huge breakthrough.”

Giannelis is cautiously optimistic about the work.

“I don’t want to declare complete victory,” he said with a smile, “but we believe we are the first group to show that non-fluorine-based chemistry opens up the possibility to create oleophobic coatings that are probably good enough to resist stains from vegetable oils, olive oil, and other oils.”
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ilex semiconductors are at the heart of just about every electronic device, but as the demand for smaller, more powerful and more efficient electronics grows, the technical limitations of silicon and other traditional semiconductors are being realized.

The Jena-Xing Group at Cornell is challenging conventional thought in search of the semiconductors, superconductors and topological insulators of tomorrow. Based jointly in the Department of Materials Science and Engineering and the School of Electrical and Computer Engineering, the group is focused on understanding the fundamental limits of materials—how electron, light and heat waves move through materials, and how they can be controlled—as well as finding new potential uses for gallium nitride—a semiconductor with a wider energy bandgap than silicon. They continued the work when they arrived at Cornell in 2015 and created a gallium nitride power diode capable of supporting over 1,400 volts of electricity despite only being about one-tenth the width of a human hair.

While faculty members at the University of Notre Dame, Debdeep Jena and Huili Grace Xing began examining potential uses for gallium nitride—a semiconductor with a wider energy bandgap than silicon. They discovered a way to seamlessly combine the superconductor niobium nitride with semiconductor gallium nitride. The result is a promising new class of materials that combine the best characteristics of each conductor family.

One of Jena’s first major successes in superconductivity came earlier this year when, working in conjunction with other materials science faculty and students, he discovered a way to seamlessly combine the superconductor niobium nitride with semiconductor gallium nitride. The result is a promising new class of materials that combine the best characteristics of each conductor family.

“WE ENCOURAGE STUDENTS NOT TO BE DEFINED BY THE KNOWLEDGE OF THEIR ADVISORS, NOT TO BE CONFINED BY WHAT WE’VE DONE BEFORE. WHEN THEY GRADUATE, THEY SHOULD BE BETTER THAN US.”

– Huili Grace Xing

With the team’s combined knowledge, it hopes to capitalize on recent advances in the physics of magnetic switching to make a memory device that is essentially a computing element itself, as opposed to being a storage element that relies on processing from another unit. This reimagining of computational memory could provide an entirely new paradigm for the semiconductor industry.

Another attraction to Cornell, says Jena, was the ability to expand his scope of research. “I wanted to explore certain classes of materials which exhibit properties that I always wished I had a chance to work with, such as superconductivity and topological insulators,” says Jena. “Having colleagues, and motivated and extremely talented students to work on these areas is necessary to do that, and I knew Cornell would have those kind of students.”

With their feet firmly planted at Cornell, Jena and Xing now see a greater potential for materials discovery by introducing their work to researchers outside of the materials science realm. “We came to Cornell because we were attracted to the intellectual power at this place,” says Xing. “We also wanted to create more collaborative projects in synergy with the activities on campus.”

That collaborative mindset is what will create the research breakthroughs the semiconductor industry needs, according to the National Science Foundation. The foundation established the Energy-Efficient Computing: From Devices to Architectures program to fund what it calls “revolutionary solutions” to computational performance. The funding is aimed specifically at interdisciplinary groups of researchers.

Xing is leading one of the program’s latest grants, which aims to change the way computers and other devices process memory. The project has nine co-principal investigators, all at Cornell, spanning expertise in materials science, devices, circuits and computer architectures.

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“It fills this gap of these two families which is holding them back from being a real technology for quantum computation in the future,” says Xing, noting the Jena-Xing Group hosts about 35 students, postdoctorates and research associates. “We tell them, ‘go to physics, go to computational science.’ For example, one student took a computer science class in machine learning and he immediately applied it to develop device modeling, leading to an elegant and general solution.”

This philosophy is leading the Jena-Xing Group to not only produce new materials, but to produce the next generation of scientists and engineers who understand that sometimes you have to break the rules to make great discoveries.

“The group has an intimate mix of students from Materials Science, Electrical and Computer Engineering, and Applied and Engineering Physics by design, because breaking rules starts with breaking the artificial walls between disciplines,” says Jena.

“We encourage students not to be defined by the knowledge of their advisors, not to be confined by what we’ve done before. When they graduate, they should be better than us,” Xing says with a smile.
MSE TEAMS UP WITH PBS AFFILATE FOR SCIENCE COMMUNICATIONS COURSE

I f you can’t communicate your ideas, then their potential can’t be realized. Julie Nucci, MSE adjunct professor, is teaming up with Ithaca’s PBS affiliate to teach students this lesson through a new course on science communications.

Nucci is the principal investigator of an Engaged Cornell grant that is funding the new curriculum. Co-principal investigators include Jim Overhiser, director of K-12 education at PARADIM; Darrell Schlon, MSE professor; and Bruce van Dover, MSE chair.

The course will launch in spring 2018, and will tackle the challenge of 21st century science communication by providing instruction and practice creating innovative presentations and videos. The course will also focus on the responsible use of social media platforms.

WSKG, a PBS television station, is a community partner on the grant and Nancy Coddington, WSKG’s director of science content, services and programming, will co-teach the course to provide combined technical and communication expertise.

The content created will become part of PBS LearningMedia—a nationally distributed and widely used educational resource—if approved by the WSKG Scientific Advisory Board. WSKG will also curate a YouTube channel dedicated to content that is created.

Graduate students interested in effectively and innovatively sharing their research will especially benefit from taking ENGRG 3360. It is expected that the videos and taped presentations created will enhance faculty and engineering project team websites, in addition to being featured as educational tools via PBS’s various media outlets.

A hallmark of community-engaged learning is reciprocity between the community partners. The ENGRG 3360 participants will directly engage the community by mentoring the New Visions Engineering (see Page 13) students as they choose colleges and by sharing their research and engineering activities with them. Later in the semester they will team up to visit the New Visions students’ former middle school physical science classrooms to talk about spending their senior year exploring engineering on the Cornell campus, getting an engineering degree and careers in engineering.

Reaching out to middle schools is critical. While all students take middle level physical science, only a fraction of these middle school students ever find their way into upper level high school science and math classes. It is clear what the Cornell students bring to the K-12 community. In return, this K-12 audience is an ideal one to help the Cornell students develop an engaging, honed message for the general public.

A second effort funded by the Engaged Cornell grant involves infusing MSE into the highly lauded, nationally distributed Engineer Your World curriculum created by University of Texas at Austin for high school students. A key feature of Engineer Your World’s curriculum is its low financial barrier to implementation. This sets it apart from other nationally distributed K-12 engineering programs and makes it accessible to all schools. As word of this curriculum spreads, it is being taught to more students in more states.

We are teaming with UT Austin to create MSE focused content with the lead role coming from graduate students Alica Cintron (Ober Group), Lindsey Noskin (Schlon Group), and Ben MacMurray (Shepherd Group). Engineer Your World students analyze the earthquake resistance of a wooden tower. Our activity first adds a mechanical isolation to the tower for earthquake protection. Next, students will explore different materials to discover which are most effective at further reducing the tower’s acceleration and displacement beyond the mechanical solution. The New Visions Engineering students will be empowered by beta testing the base isolation activity and sharing their insights with the Cornell students, who will benefit from having this ideal population critique the activity they created.

We anticipate that UT Austin will welcome a new high school program to the Cornell campus: New Visions Engineering. New Visions programs are offered across New York State to high-achieving seniors in fields ranging from audio engineering to zoo wildlife. These one-year programs are designed to give students a concrete way to experience a potential career before making a college or career choice. Thurston Hall Room 204 is now a high school classroom where a cohort of high-achieving high school seniors from across the TST BOCES region are sampling the wide variety of engineering careers and endeavors as well as learning the broader impact of engineering on society.

Central to the New Visions program is the Engineer Your World curriculum created by the University of Texas at Austin. Engineer Your World is taught to over 10,000 students in 216 schools in 24 states across the U.S. It introduces students to engineering design, processes and practices through a series of well-crafted hands-on challenges. Students will receive credit for ES 301: Engineering Design and Problem Solving from UT Austin upon successful completion of this course. The balance of the New Visions curriculum includes concurrent TC3 enrollment and college credit for honors physics as well as high school credit for English, participation in government and in economics. The latter three credits are earned through interactions with local and state legislators, readings around engineering and its impacts on society, and a variety of other interdisciplinary activities.

New Visions Engineering offers students the opportunity to explore the many facets of the engineering field through an “experiential Friday” program that leverages the Cornell campus and local industry. Students have already been inspired and enthused about engineering in September by touring labs, exploring...
the engineering project teams, interacting with professors and students at Cornell Engineering, and touring Incodema3D. A selection of upcoming events includes visiting Advanced Design Consulting, Inc., learning about entrepreneurship at Rev, and touring the Cayuga power plant and Lake Source Cooling/Central Heating Plant at Cornell. This spring, students will work with graduate students and postdocs for several weeks in PARADIM’s thin film facility, giving them access to world-class, cutting-edge research to complement their engineering experiences.

Julie Nucci, MSE adjunct professor and PARADIM education and outreach director, spearheaded the program’s creation and she manages it alongside James Overhiser, PARADIM’s K-12 education director. The New Visions Engineering teacher, who is a TST BOCES employee, is David Syracuse. The program is very fortunate to have David, as he is an inspiring and engaging teacher who has New Visions off to a fantastic start.

The program is graciously funded by NYSTAR as a part of a NYS match to the NSF-funded materials innovation platform, PARADIM.

ALUMNI PROFILE: RACHEL DORIN, PH.D. ’13

Rachel Dorin, Ph.D. ’13, says “I have always been a bit of a risk-taker and trouble-maker. So I am lucky to have found a place where these traits are valued and even rewarded.”

The place Dorin found is the CEO’s chair at Terapore Technologies, Inc., in the San Francisco Bay Area. And she didn’t find that place so much as she created it. Terapore is a nanomaterials company that serves the biopharmaceutical industry by making highly-specialized membrane filters used in pharmaceutical manufacturing and other types of separation processes. The company is four years old and was started by Dorin just one month after she received her Ph.D. from Cornell’s Department of Materials Science and Engineering (MSE).

“Both of my parents were professors of medicine at University of New Mexico (UNM) as I was growing up,” says Dorin. “They wore lab coats and did research, but they also saw patients.” Dorin wanted to follow in their path and become a medical doctor, so she decided to major in biology as an undergraduate. Then Dorin found materials science and it changed her life.

“While I was at UNM working on my B.S. in biology I found a job at Sandia National Laboratories in the Advanced Materials Lab,” says Dorin. “It paid better than the hotel desk clerk job I was working at the time and it seemed much more interesting.” Based on her experiences at Sandia, Dorin added a B.S. in chemistry to her undergraduate studies and found a valuable mentor in Dr. Yujiang Song, a member of the technical staff at Sandia.

Dorin applied to Cornell for graduate studies and was impressed by the camaraderie in the MSE department and inter-disciplinary nature of Cornell Engineering evident during her visit. She came to Cornell hoping to work on the creation of platinum nanostructures using block copolymers. That changed when professor Uli Wiesner proposed a project using block copolymers to create new types of filters. “With Yujiang Song’s help, I was able to see it as an exciting chance to be in on something new and to advance knowledge and technology,” says Dorin.

“At first I didn’t know anything about polymers—the other grad students taught me and it really felt like a family.” While Dorin was learning all about polymers, she was also earning a minor in business from Cornell’s Johnson Graduate School of Management. At the same time, her husband started his own business in Rochester. All these threads came together one day when Dorin had a conversation with David BenDaniel, the Don and Margi Berens Professor of Entrepreneurship at the SC Johnson College of Business.

“I told David that I was going to go into management consulting,” says Dorin. “He casually mentioned that he was a bit disappointed—he thought I was going to start a company and be an entrepreneur. It was probably a nothing conversation to be in on something new and to advance knowledge and technology,” says Dorin.

“So I had all of the glassware packed up very carefully in a U-Haul.” It has been two years since the move and Terapore Technologies has expanded from two employees to 10. “Our filters are very well structured—they are fast, fine and have high resolution,” says Dorin. “The biopharmaceutical industry is driven by science and performance, and our filters are earning a great reputation for reliability. I am excited to be a part of this. This technology has the potential to revolutionize healthcare.”

When asked how her years at Cornell prepared her for life as a nanomaterials entrepreneur, Dorin does not hesitate: “The group I was part of in the Wiesner Lab felt like a family—a family that was committed to collaborate to solve big problems that no one has been able to solve before,” says Dorin. “In fact, some of those people have moved to California and now work at Terapore. Also, I had a lot of freedom in Uli’s lab to try new things; he was very supportive. Cornell was an excellent place for me to explore hard problems without being afraid.”

“The biopharmaceutical industry is driven by science and performance, and our filters are earning a great reputation for reliability. I am excited to be a part of this. This technology has the potential to revolutionize healthcare.”

— Rachel Dorin
The 2017 Materials Science and Engineering Awards Dinner was held on Saturday, May 6, at the Statler Hotel Terrace Restaurant.

The annual event honors one or more distinguished alumni of the department and recognizes over a dozen students who have earned various awards throughout the year. Students also presented research posters and had the opportunity to network with corporate collaborators.

Linda Schadler received the 2017 MSE Distinguished Alumni Award in recognition of her contributions to the science and engineering of polymer composites, as well as her achievements as an educator. She is currently the vice provost and dean of undergraduate education and the Russell Sage Professor in Materials Science and Engineering at Rensselaer Polytechnic Institute. After receiving her B.S. in materials science and engineering from Cornell, Schadler received a Ph.D. in materials science and engineering from the University of Pennsylvania. After two years of postdoctoral work at IBM Yorktown Heights, she served as a faculty member at Drexel University before coming to Rensselaer.

Active in materials research for over 25 years, Schadler is an experimentalist and her research has focused on the behavior of two-phase systems, primarily polymer composites. Schadler has co-authored more than 140 journal publications, several book chapters, and one book. She is a fellow of the Materials Research Society and ASM International, and is an associate editor for the Journal of Materials Research. In 2011, Schadler was named one of the ’Top 100 Materials Scientists’ worldwide in the last decade by Times Higher Education.
JAMES L. GREGG PRIZE
Matti Thurston ’18
Awarded to outstanding juniors based on GPA.

ADVANCED MATERIALS FELLOWSHIP
Divya Srinivasan ’18 (right) Lauren Kilcullen ’18 (not pictured)

MSE NANOTECHNOLOGY ACHIEVEMENT AWARDS
Lauren Morehouse ’18 Emily Greenstein ’18
(No photo provided)

SENIOR THESIS POSTER AWARDS
Lindsey Noskin ’17
Awarded for the poster “Growth of NbO2 by Molecular-Beam Epitaxy and Characterization of its Metal-Insulator Transition”

Christian Waibel ’17
Awarded for the poster “Examining The Phase Space of Triblock-Terpolymer and Additive Systems”

Soham Agarwal ’17
Awarded for the poster “Methanol Oxidation Catalysis on IrO2(110) and RuO2(110) Single Crystals”

SENIOR LAB AWARD
Addie Nolan ’17 (right) Wes Forster ’17 (not pictured) Eli Alman ’17 (left)
Awarded to a senior lab team for effectively conducting and communicating a rigorous research project.

OUTSTANDING M.ENG. PROJECT AWARD
Zhiq Wang, M.Eng. ’17
Awarded for the project “Synthesis and Characterization of Copper Tin Sulfide”

TEACHING ASSISTANT EXCELLENCE PRIZES
Abby Goldman, doctoral student (left) Ethan Susca, doctoral student (right)
Awarded to graduate students for exemplary performance as teaching assistants based on faculty nominations and student evaluations.

OUTSTANDING M.S. RESEARCH PAPER AWARD
Yuanmeng Zhang ’17
Awarded for the poster “Synthesis and Mechanical Properties of Na0.7CoO2”

EXCELLENCE IN M.S. RESEARCH AWARD
Liheng Zhang ’17
Awarded for the paper “Materials Processing of Gallium Oxide”

OUTSTANDING PH.D. RESEARCH PAPER AWARD
Zhengyuan Tu, doctoral student
Awarded for the paper “Stabilizing Reactive Metal Electrodeposition Through Nano-Structured Electrolyte and Interphase Protection.”

EXCELLENCE IN PH.D. RESEARCH AWARD
Zhengyuan Tu, doctoral student
Awarded to a Ph.D. student for an innovative contribution to materials science or engineering research.
SCHLOM ELECTED TO NATIONAL ACADEMY OF ENGINEERING

Darrell Schlom, the Herbert Fisk Johnson Professor of Industrial Chemistry in MSE, has been elected a member of the National Academy of Engineering (NAE). Election to the NAE is among the highest professional distinctions accorded to an engineer. Membership honors those who have made outstanding contributions to “engineering research, practice or education, including, where appropriate, significant contributions to the engineering literature,” as well as to “the pioneering of new and developing fields of technology,” according to the academy.

Schlom has dedicated much of his career to discovering new materials that possess properties of great value to the electronics industry. In the mid-1990s he and his senior thesis student were the first in the world to suggest the idea of extending cell phone technology from today’s approximately 1 GHz frequency range into the tens of GHz frequency range desired for fifth-generation cell phones.

The NAE praises Schlom’s “materials-by-design” approach in which he works closely with experts in theory, synthesis and characterization to discover materials with properties superior to those in existence. Schlom and his Cornell collaborators create these new materials with atomic-layer precision by a technique known as molecular-beam epitaxy, which Schlom likens to “atomic spray painting.” They also scrutinize the atomic structure of what they have created using powerful microscopes and techniques that can measure the band structure of the materials for direct comparison with theoretical predictions. This powerful, targeted approach to materials discovery has enabled Schlom and collaborators to invent multiple materials with unparalleled performance.

“This recognition by the NAE is really a testament to the talented students, postdocs and collaborators with whom I have had the pleasure of interacting,” said Schlom. “Our progress comes from jamming together daily to better understand the intricate inner workings of materials at the atomic level. A critical element of our successful team approach to accelerating materials discovery is direct, honest interactions that cross scientific disciplines, within an atmosphere of respect and trust. The combination of scientific excellence and collegiality makes Cornell ideal for the discovery of atomically engineered materials that will revolutionize electronics.”

Today, Schlom is empowering others from around the country to discover new materials through a new national user facility called PARADIM—the Platform for the Accelerated Realization, Analysis and Discovery of Interface Materials. He founded and leads the platform, which is using a $25 million grant from the National Science Foundation to make facilities and expertise from Cornell and its partner institutions available to materials innovators from industry, academia and national labs across the country.

“I couldn’t be more pleased to hear the news about Darrell,” said Lance Collins, the Joseph Silbert Dean of Engineering. “It was his leadership that led to PARADIM, which will enable the discovery of new materials discovery because of its complexity and potential payoff,” said Schlom, the Herbert Fisk Johnson Professor of Industrial Chemistry.

The team’s project is titled “A Materials-by-Design Approach to an Odd-Parity Topological Superconductor” and its goal is to discover a material that will lay the foundation for a stable and scalable quantum computing technology.

U.S. NEWS RANKS CORNELL NO. 14; ENGINEERING NO. 10; MATERIALS NO. 8

Cornell University advanced one spot to No. 14 in the 2018 edition of U.S. News & World Report’s Best National Universities among 311 schools ranked. Brown, Rice and Vanderbilt join Cornell—which had been No. 15 for three years—at No. 14. The annual assessment is based on academic reputation, faculty resources, graduation and retention rates, selectivity, financial resources and alumni giving.

The College of Engineering is ranked No. 10 for undergraduate engineering programs in Ph.D.-granting institutions. Among the engineering specialties, Cornell placed in the top 10 in seven of 12 categories. The university ranked No. 4 in biological/agricultural; No. 8 in materials; No. 9 in computer, electrical/electronic/communications, and mechanical; and No. 10 in civil and in industrial/manufacturing. The university ranked No. 11 in environmental/environmental health.

U.S. News includes eight lists in a section called “A Focus on Student Success,” which looks at programming factors thought to help undergraduate students thrive. Cornell was recognized for internships/co-ops, service learning and writing in the disciplines.
EMMANUEL GIANNELIS NAMED VICE PROVOST FOR RESEARCH

Giannelis succeeds Robert Buhrman, Ph.D. ’73, who held the vice provost position for 10 years. Buhrman, the John Edison Sweert Professor of Engineering in the School of Applied and Engineering Physics, added vice president for technology transfer, intellectual property and research policy to his title when the position was created in 2011.

Kotlikoff thanked Buhrman for his steady leadership over the past decade. “Bob has worked tirelessly on several fronts during a transformative time at the university, all the while maintaining his research and teaching responsibilities,” Kotlikoff said.

“I am deeply honored by the opportunity to represent and be the advocate for all researchers at Cornell,” said Giannelis, who served as director of MSE from 2004 to 2012. “I look forward to working with the staff of the Office of the Vice Provost for Research, the university leadership and stakeholders across all campuses to build on the successes of my predecessors and advance Cornell research to even higher levels.”

The mission of the Office of the Vice Provost for Research is to advance and support Cornell research. It advocates for the division within the university and with external agencies, sponsors and governmental representatives; facilitates and provides specialized research facilities and services; provides campuswide research administration support services; furthers major interdisciplinary research initiatives; and promotes entrepreneurship and technology commercialization.

A key focus for Giannelis will be identifying and promoting innovative research, including that which fosters collaboration across Cornell’s Ithaca and New York City campuses. As vice president for technology transfer, intellectual property and research policy, Giannelis will report to President Martha E. Pollack.

Giannelis leads a research group that is one of the world leaders in nanohybrids and nanocomposites. He is author or co-author of more than 270 papers, has been granted 19 patents, and is a fellow of the American Chemical Society and a member of the European Academy of Sciences. Giannelis has championed several initiatives that foster a culture of innovation and entrepreneurship, with a focus on graduate students and postdoctoral researchers. He is looking forward to extending that effort across the university.

“Part of my role as associate dean has been to develop new ways to use research as a vehicle to offer a new educational paradigm for our Ph.D. students and postdocs,” he said. “I see this new role as an opportunity to take some of those opportunities and make them universitywide rather than engineering-centric.”

In more than eight years as director of MSE, Giannelis recruited and hired seven new faculty members, including three women. He nearly doubled the department’s research expenditures, from $5.6 million in fiscal year 2005 to $10.5 million in fiscal year 2012. He also co-founded, with chemical and biomolecular engineering professor Lynden Archer, the King Abdullah University of Science and Technology-Cornell University Center for Energy and Sustainability, which operated from 2008 to 2015. Giannelis is a 1980 graduate of the University of Athens, Greece, with a Ph.D. in inorganic chemistry from Michigan State University (1985).

VAN DOVER AWARDED $7.5M TO STUDY AUTONOMOUS SYSTEMS

Their goal is to develop a multi-agent system that accelerates the science of materials-discovery and development by integrating quantum physics principles, experimental materials synthesis, processing, characterization and AI-based algorithms. The system will be augmented by human insights so that artificial intelligence leverages that of expert scientists. This, the group said in its summary, will create an unprecedented platform for human-machine collaboration.

The group claims that SARA will realize the vision of the Materials Genome Initiative, a multi-agency initiative launched in 2011 to create a new era of policy, resources and infrastructure by discovering, manufacturing and deploying advanced materials.

Van Dover will work with Michael Thompson, MSE associate professor and associate dean for undergraduate programs, and computer science faculty. Researchers from Colorado University, Northeastern University and California Institute of Technology are also on the team. Staff scientist Jacob Ruff from the Cornell High Energy Synchrotron Source will work with the group as an unfunded collaborator.

A group led by Robert Bruce van Dover, MSE chair, has received up to $7.5 million funding from the Department of Defense under its Multidisciplinary University Research Initiative (MURI) for the project “Scientific Autonomous Reasoning Agent (SARA): Integrating Materials Theory, Experiment and Computation.”
The Department of Materials Science and Engineering held a reception for Reunion Weekend on Friday, June 9, 2017 in the Bard Hall Lobby. The event was attended by alumni, faculty and guests.

We are grateful to the many alumni and friends of the department for their generous support of its programs over the last 50 years. Your generosity allows us to sustain and enhance our programs’ reputation as a top-tier materials science and engineering department. Please consider a gift that will help the department accomplish its goals.

ENHANCE THE GRADUATE EXPERIENCE

Graduate Fellowships
Attracting talented graduate students to the department is a key goal in our pursuit of excellence in research. Your gift will allow MSE to meet its goal of providing competitive graduate fellowships to every first-year graduate student enrolled in the Materials Science and Engineering program.

Awards for Students
Junior Class Awards to recognize highest achieving students.
Teaching Assistant Awards in recognition of the top graduate teaching assistants each academic year.
Research Excellence Awards, awarded to MSE Ph.D. students and post-docs in recognition of their research contributions.

MODERNIZE & UPGRADE THE INSTRUCTIONAL LABORATORIES

Modernizing the instructional laboratories is a high priority for sustaining the department’s reputation for excellence in educating students. The Instructional labs are used by undergraduates from across the College of Engineering, in addition to the MSE Junior and Senior lab teams.

Gifts in support of the MSE Instructional Labs can be earmarked to either of the following two funds: A current-use fund which will support immediate needs and upgrades; and endowment, which will support continuous improvement of the laboratory infrastructure.

ATTRACT TALENTED FACULTY

Gifts in support of faculty can be earmarked to either of the following funds: A current-use fund to support salary and research startup costs for hiring a new faculty member in materials science and engineering; or to establish a named faculty endowment.

FOR MORE INFORMATION ON THESE OR ANY OTHER GIVING OPPORTUNITIES, CONTACT

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