The Department of

Materials Science & Engineering

2013 NEWS

MaterialsMatters

Materials Science & Engineering
Celebrating 15 years

INSIDE: Detecting environmental pollutants at the single-molecule level (*pg. 17*)

Dare to be first.

UNIVERSITY OF DELAWARE

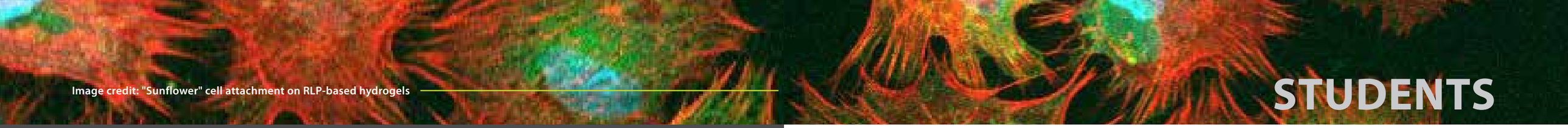

Image credit: "Sunflower" cell attachment on RLP-based hydrogels

Message from the Chair

Colleagues, Alumni and Friends:

It is an exciting time for the University of Delaware's Department of Materials Science and Engineering (MSEG). After four years of planning and construction, we are beginning to move into the newly completed Interdisciplinary Science and Engineering Laboratory (ISE Lab). The ISE Lab provides the campus with state-of-the-art space for materials synthesis, physical and chemical characterization, and electron and optical microscopy. There is also a 10,000 square foot clean room and nanoprocessing facility that will give UD faculty and students the opportunity to design, build and test novel electronic and photonic devices.

Our MSEG faculty and students continue to be recognized for their excellence and expertise. Specific faculty awards from this past year include the promotions of MATT DOTY and JOSH ZIDE to associate professor with tenure; the Materials Research Society Innovation in Materials Characterization Award to JOHN RABOLT and BRUCE CHASE; the Sheth International Alumni Award for the University of Illinois to ISMAT SHAH; a Fulbright Fellowship to study in Turkey and Australia to BOB OPILA; the Academic Research Award from Delaware Bio to KRISTI KIICK; the American Society of Composites Fellow to JACK GILLESPIE, JR.; and the University of Delaware Faculty Senate award to J.J. HU for Excellence in Teaching. More details about our recent activities are given in this newsletter.

Our search for new faculty, research scientists and students that wish to join the Delaware Materials community continues. We anticipate new faculty searches in the areas of soft materials synthesis and simulation, and in nanofabrication. These areas of activity build off of our current expertise and will allow us to take full advantage of the ISE Lab facilities. There are also new hires in UD's Biomedical Engineering program (BMEG) that have strong materials science and engineering interests. This year's BMEG cohort includes three junior faculty members: EMILY DAY, CHRIS PRICE and JOHN SLATER.

This year marks the ***15th anniversary*** of the formal establishment of MSEG as a UD department, and we are having a gala celebration at the Winterthur Estate to mark the event September 20th. I hope you are able to join us, but even if you can't make the celebration, please drop us a line to keep us up to date with your own activities.

As always, please don't hesitate to contact us if you have questions, concerns or suggestions. We particularly appreciate those of you who have shown your generosity to MSEG through gifts and donations, and would like to encourage the rest of you to demonstrate your support in this substantive manner.

Prof. David C. Martin
Karl W. and Renate Böer Professor and
Chair of Materials Science and Engineering

What's inside?

MaterialsMatters

Credits:

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David Martin

Contributing Writers
Laura Crozier, Juan Guerrero, Gregory Holt, Diane Kukich, Megan Marschall, Sarah Meadows, Karen Roberts, Ismat Shah, Neil Thomas

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RESEARCH RECOGNITION

UD doctoral student's drug delivery dissertation earns AACR honors

University of Delaware doctoral student **VINU KRISHNAN** is studying nanotechnology-based drug delivery to help reduce chemotherapy-induced side effects in children fighting acute lymphoblastic leukemia (ALL), the most common form of childhood cancer.

His research is supervised by **A.K. RAJASEKARAN**, adjunct professor of materials science and engineering at UD and director of basic cancer research program at the Nemours/A.I. duPont Hospital for Children in Wilmington, Del., and by **XINQIAO JIA**, UD associate professor of materials science and engineering and biomedical engineering. Together, the team has shown that the most commonly used leukemia-fighting drug, Dexamethasone, can be successfully encapsulated in nanoparticles and used to treat leukemia. The study revealed that this approach improved survival and reduced disease symptoms in preclinical models.

"Our next step is to validate this approach for future clinical trials and bring this to the bedside to treat children with cancer," says Rajasekaran.

Krishnan's dissertation—a continuation of Rajasekaran and Jia's promising nanotechnology work—earned him the *Gerald B. Grindey Memorial Scholar-in-Training Award from the American Association for Cancer Research* (AACR). The annual award recognizes a scholar with the most "meritorious pre-clinical cancer research paper in the field."

Krishnan presented his paper, "*Nanotechnology Based Drug Delivery in Childhood Leukemia Therapy: A Novel Approach to Reduce Side Effects*," at the AACR poster presentation in Washington, D.C., last April.

The work is supported by the National Institutes of Health (RO1 DK56216, P20RR016458, P20 RR017716), Delaware Health Sciences Alliance, Andrew McDonough B+ Foundation, Caitlin Robb Foundation, Kids Runway for Research, Sones Brothers, Nemours Foundation and the University of Delaware.

Adapted from article by Gregory Holt | Photo by Kathy F. Atkinson

Doctoral student Jiahua Zhu presented his novel polymer research at the American Chemical Society national meeting.

TRAINING LEADERS

Doctoral student presents polymer research at American Chemical Society meeting

University of Delaware alumnus **JIAHUA ZHU** (MSEG Ph.D. 2012) is developing advanced assembly strategies for nanoscale polymers using molecular design and kinetics. Following the rules in nature, he blends various polymer molecules to create nano-scale objects seldom observed in nature.

By integrating multiple components and geometries, Zhu hopes to create multifunctional hybrid nanostructures that work together, but also retain their personal characteristics.

Ultimately, he hopes these new materials will be applied to address major societal concerns in energy and medicine.

DARRIN POCHAN, professor of material science and engineering, who was Zhu's faculty adviser during his doctoral work at UD, applauded Zhu's synergistic collaboration with researchers at UD and at Texas A&M University to create what he calls "new and fascinating nanomaterials."

"This well-deserved honor is the result of Jiahua's hard work and creativity in the laboratory," praised Pochan, adding, "This work would not be possible without UD's strong core facilities, such as the Keck electron microscopy lab in the College of Engineering, the support of which provides opportunity [for faculty and students alike] to create and understand future technology."

Zhu presented his doctoral work, entitled "Multigeometry Nanoparticle and Multicompartment Superstructure Construction from Block Copolymers – Molecular Design, Assembly Hierarchy, and Kinetics," at the Excellence in Graduate Polymer Research Symposium of the American Chemical Society Polymer Chemistry Division (POLY) in New Orleans last April.

Article by Karen B. Roberts | Photo by Kathy F. Atkinson

STUDENTS

AN, QI, Winner of the SAMPE Technical Conference Student Poster Competition. SAMPE International Student Symposium (*read more on pg. 14*) and CCM Student Achievement Day Achievement Award

ATTIA, PETER (UG), MSEG & ASM Poster, General Honors Awards - Chemical Engineering, DE Space Grant Undergraduate Fellowship, a Barry M. Goldwater Scholarship and Excellence in Education Foundation and winner of the MSEG609 Proposal Writing Contest

BAH, MOHAMED, UD Graduate Scholar Award

BHAGWAT, NANDITA, Graduate Office Professional Development Award

BOYLE, JONATHAN, MSEG & ASM Poster - Hard Materials Award and the Bill N. Baron Fellowship Award

CHANG, KEVIN (UG), General Honors Awards - Biomedical Engineering

DONGMO, PERNELL, DE Space Grant Graduate Fellowship

FARRELL, BRENDAN (UG), MSEG & ASM Poster

GONG, LIANG, MSEG Outstanding Graduate Student Teaching Award

LI, LINQING, MSEG Outstanding Graduate Student Service Award

LIANG, YINGKAI, MSEG & ASM Poster - Soft Materials

MCGANN, CHRISTOPHER, University Graduate Fellow Award

MUELLER, JENNIFER, MSEG & ASM Poster - Composite Materials Award and winner of the SAMPE International Student Symposium (*read more on pg14*)

MURRAY, ROY, NSF Scholar Award - Global School for Advanced Studies on Organic Solar Cells National Taiwan University

RUJISAMPHAN, NOPPORN, NSF Scholar Award - Global School for Advanced Studies on Organic Solar Cells National Taiwan University

RUZYBAYEV, INCI, Dean's Doctoral Student Summer Scholar Program and recipient of the Society of Vacuum Coaters Student Award

SIMCHI, HAMED, MSEG & ASM Poster - Hard Materials Award

SOCKALINGAM, SUBRAMANI, Center for Composite Materials Director's Award

SOLTANMOHAMAD, SINA, MSEG & ASM Poster - Hard Materials Award

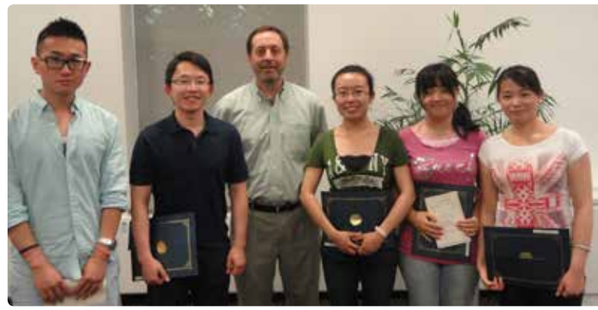
STEWART, BRANDON (UG), General Honors Awards - Chemical Engineering

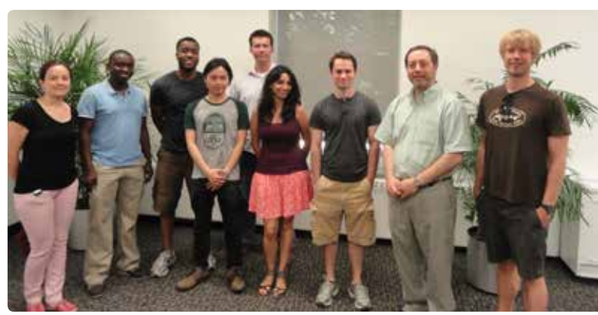
XIN, PEIPEI, MSEG & ASM Poster - Hard Materials Award

XU, XIAN, MSEG Oustanding Graduate Student Research Award

ZHANG, DANNING, MSEG Chairperson's Oustanding Graduate Student Award

ZHOU, XINRAN, MSEG Outstanding Graduate Student Research Award





IEC HIGHLIGHT

CATCHING SOME RAYS

SEIGERT students develop hands-on solar module labs to gain practical experience in harnessing sunlight

Students enrolled in **STEVEN HEGEDUS'** ELEG 628 not only get hands-on experience working with real solar modules, but also take the show on the road, presenting the capabilities of the Mobile Solar Demonstration System through outreach activities at local school and community events.

Three UD graduate students, supported under the Purdue University Solar Economy Integrative Graduate Education and Research Training (SEIGERT) program, conceived, developed and tested the hands-on solar module labs that supplement the graduate course taught by Hegedus, a scientist with UD's Institute of Energy Conversion (IEC). The current labs use the Mobile Solar Demonstration System designed and built by a previous group of SEIGERT students.

The labs allow students to measure the output under varying sunlight orientation, learn about series and parallel connections and resistance losses, and perform an energy efficiency analysis of a complete, self-contained power station consisting of photovoltaic modules, batteries, charge controller and DC/AC inverter.

Established in 1972 by Prof. Karl Böer, and currently directed by **ROBERT W. BIRKMIRE**, the IEC seeks to improve photovoltaic device performance and processing technologies and then effectively transfer laboratory results to large-scale manufacturing. ❖

Ismat Shah, (pictured here with Robert Easter, President of the University of Illinois at Urbana-Champaign), received the Sheth International Alumni Award for Exceptional Achievement for his humanitarian efforts in Pakistan and Afghanistan. Shah is also a regular contributor to UD's K-12 Engineering outreach camps (pictured below).

GLOBAL CITIZENSHIP

UD's Shah honored for humanitarian efforts in Pakistan, Afghanistan

ISMAT SHAH, professor in the departments of materials science and engineering and physics and astronomy, was awarded the Madhuri and Jagdish N. Sheth International Alumni Award for Exceptional Achievement by the University of Illinois at Urbana-Champaign for his dedicated humanitarian efforts, particularly those to raise funds and resources for Pakistani and Afghan refugees affected by natural disaster and war.

The award pays tribute to Shah's "international civic engagement, global citizenship and leadership, which are not bound by national or social borders."

Shah, who joined the University of Delaware faculty in 2004, has long worked to encourage social understanding between Muslim communities and other religious and cultural groups.

While at the University of Illinois, he fostered cross-cultural relationships with international students, work he continued in Delaware, especially after the events of September 11, 2001, delivering more than 50 lectures at local churches, police academies and local schools on "Understanding Islam."

He has also promoted advanced education in Pakistan by building schools, supplying equipment and delivering lectures and workshops about alternative energy sources in developing nations.

Shah says one of his greatest accomplishments was building a school in the Jalozaii refugee camp in Pakistan following 9/11. For six years, the school catered to girls in grades 1-5, teaching about 300 students per year.

Known as a leader and mentor at UD, Shah organized the first Engineering Study Abroad program in 2001 to further his students' understanding of diverse cultural values. Under his leadership, students have visited Germany, Italy, Greece, Spain, France and Turkey.

Last fall, while a Fulbright Scholar, he worked with the U.S. Embassy in Azerbaijan to coordinate community speaking engagements with local high school and college students. ❖

Article by Megan Marschall | Photo by Kathy F. Atkinson

John Rabolt (left) and Bruce Chase have received the 2013 Innovation in Materials Characterization award from the Materials Research Society.

SPECTROSCOPIC INNOVATION

JOHN RABOLT, who is the Karl W. and Renate Böer Professor of Materials Science and Engineering, and **BRUCE CHASE**, a research professor in the department, were honored with the Innovation in Materials Characterization Award at the 2013 Materials Research Society meeting in San Francisco last April.

Rabolt and Chase were selected for co-developing Fourier Transform Raman (FT-Raman) spectroscopy, a technique that, for the first time, allowed the acquisition of Raman spectra of polymers in the presence of fluorescence. Developed in 1986, this type of spectroscopy allows researchers to examine "the chemical structure and properties of organic molecules and polymers in solids, thin films and solutions."

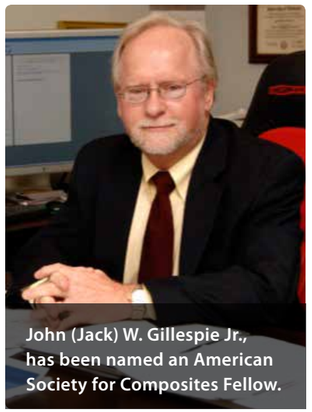
According to Rabolt, FT-Raman instruments are found in more than 2,500 laboratories worldwide and have been used to conduct research that has produced thousands of papers published in peer-reviewed literature journals over the last 25 years.

Leaders in the field of spectroscopic techniques, Chase and Rabolt founded PAIR Technologies, LLC in 2005, a Newark, Del. company that sells Planar Array infrared (PA-IR) spectrographs, which are considered the next generation in fast, infrared spectroscopy.

Rabolt, who joined UD in 1996, led the materials science program to departmental status as chairperson of the program. His current research focuses on polymer deformation, organic thin films, PA-IR, FT-Raman and FT-IR spectroscopy of polymers and biomolecular materials for tissue engineering scaffolds.

Chase served 34 years with DuPont in the spectroscopy division of the Central Research Department before retiring in 2009 as an elite DuPont Fellow. A member of the materials science faculty, his research interests include spectroscopic techniques, vibrational analysis of polymeric fibers and thin films and materials characterization. ❖

Adapted from article by Sarah Meadows



John (Jack) W. Gillespie Jr., has been named an American Society for Composites Fellow.

COMPOSITES FELLOW

JOHN (JACK) W. GILLESPIE JR., director of the Center for Composite Materials since 1996, has been named an American Society for Composites (ASC) Fellow, making him one of only 43 such internationally recognized experts.

ASC Fellows are distinguished members who have made "genuinely outstanding contributions to the composites community through research, practice, education, and/or service."

Gillespie is the Donald C. Phillips Professor of Civil and Environmental Engineering with a joint appointment in materials science and engineering. He has actively supported ASC since the Society's founding in 1986, including co-authoring 91 conference papers with members of his research group.

From 1990 to 1997, he served as a member of the ASC executive committee. In 2009, he was co-chair of the 24th Technical Conference and the First Joint U.S.-Canadian Conference, which was held at UD.

He received ASC's Outstanding Research Award in 2009 and the society's best paper award at the 25th Technical Conference in 2010. Gillespie was elected to the Society of Manufacturing Engineers College of Fellows and was a co-recipient of the 2013 American Society for Civil Engineers Charles Pankow Award for Innovation.

He is the principal investigator of two Army Research Laboratory (ARL) centers of excellence at UD, one in multifunctional composite materials and the other in mechanics and performance of composites. He is also the UD principal investigator and a member of the consortium management committee of an ARL Collaborative Research Alliance focused on materials in extreme dynamic environments, which was awarded to a team comprising Johns Hopkins University, Rutgers University and California Institute of Technology. He is co-principal investigator of a fourth center of excellence focused on advanced materials and intelligent processing funded by the Office of Naval Research.

Article by Diane Kukich | Photo by Kathy F. Atkinson

Merhaba and cheers

MSEG professor **ROBERT OPILA** spent his sabbatical year in two rewarding pursuits—as a Fulbright Fellow at Bilkent University in Ankara, Turkey and as a "visiting professor" at the University of New South Wales in Sydney, Australia. In Ankara, Opila conducted and published an experiment that he and his host, **PROF. SEFIK SUZER**, had been contemplating for 10 years, while teaching Kimya (Chemistry) 552, The Solid State and Renewable Energy. Sightseeing with his wife Marlene included touring the Hittite city in Hattusha, the Byzantine chapels in Cappadocia, the Ottoman mosques, Hagia Sophia and the Blue Mosque in Istanbul, and the tomb of Ataturk, the founder of the Republic of Turkey, in Ankara. He also visited MSEG alums **OZGENC EBIL**, **MUSTAFA GUDEN**, **METIN TANOGLU** and **AYBEN TOP** at the Izmir Institute of Technology, where he is working to establish a partnership with UD's College of Engineering. "The people, history, science and food made this a memorable semester," Opila said. Opila's collaborations with former UD professor **ALLEN BARNETT** and others at University of New South Wales, acclaimed for its photovoltaics work, has led to several pending PV research proposals. He called Sydney "a remarkable city, full of light shows (Vivid Sydney), parades (Mardi Gras), film festivals, and great food and beaches."

PIONEERING POLYMER RESEARCH

Delaware Bio selects UD's Kiick to receive Academic Research Award

Kristi Kiick receives the 2013 Academic Research Award at the Delaware Bio annual awards gala.

University of Delaware professor and deputy dean of the College of Engineering **KRISTI KIICK** is developing a range of novel hydrogels to improve the treatment of cardiovascular conditions, as well as the delivery of antibodies to protect against toxins. The polymers that comprise the hydrogels are engineered to regulate the rate of drug delivery and to protect the therapeutic molecules from degrading before reaching their destination.

For the work, Kiick was honored the 2013 Academic Research Award from the Delaware BioScience Association.

"Kristi is a pioneer in biopolymeric hydrogels and she is collaborating with numerous partners across Delaware and beyond to develop these materials—which are based on polymers and resilin—for cardiovascular and protein delivery applications," wrote **KARL STEINER**, former UD senior associate provost for research development in his nomination letter to Delaware Bio.

Says Kiick, "I am honored by this recognition, and thankful for the opportunities I have had to collaborate with talented scientists in the region. The activities of Delaware Bio help keep such collaborations vibrant, bringing together professionals from academia and industry and across many disciplines. A collaborative environment is key to improving our chances for solving difficult medical and biotechnology challenges."

Kiick also collaborates with UD colleagues to develop novel nanomaterials from biomolecules for potential use in energy applications, and to explore the potential for an engineered resilin-like protein, similar to that found in the joints of insects, to treat vocal fold disorders in humans.

She was recently one of 19 women engineers selected nationwide for the Executive Leadership in Academic Technology and Engineering (ELATE) program at Drexel University College of Medicine, where she will participate with other engineering leaders on organizational development activities.

Adapted from article by Sarah E. Meadows

FACULTY BRIEFS

Rabolt explores vibrational spectroscopy near Shanghai, China

JOHN F. RABOLT, the Karl W. and Renate Böer Professor of Materials Science and Engineering, presented a course on "Characterization of Materials Using Vibrational Spectroscopy" this spring at Donghua University in the Songjiang district outside Shanghai, China. The course explored the conceptual and theoretical background of vibrational spectroscopy in correlation with experimental techniques available for spectroscopic characterization.

Structure-processing-property relationships in materials underpin the basis by which materials are chosen for specific applications. The course is sponsored in part by the National Science Foundation's EPSCoR program at the University of Delaware, along with Donghua University and the International Materials Institute for Solar Energy and Environment at Northwestern University.

Two associate professors earn tenure

MATTHEW DOTY and **JOSHUA ZIDE** of materials science and engineering were each promoted to associate professor with tenure in May 2013.

Kloxins earn UDRF funding

APRIL KLOXIN, assistant professor of chemical and biomolecular engineering and materials science and engineering, and **CHRISTOPHER KLOXIN**, assistant research professor of materials science and engineering, are among 11 researchers selected for funding by the University of Delaware Research Foundation.

The grants seed original, high-priority, "proof of concept" studies that are designed to lay the groundwork for future proposals to external agencies such as the National Institutes of Health and the National Science Foundation.

April Kloxin will use her funding to develop hydrogels for controlled release of therapeutic drugs to treat skin cancers. The hydrogels will be designed to degrade in response to cell-secreted enzymes and light from periodic irradiation, resulting in reduced toxicity and improved outcomes. Currently, nonsurgical treatment of basal cell carcinoma, a prevalent skin cancer, requires daily topical chemotherapeutic application or weeks of photodynamic therapy, with only a 33 percent nodular cure rate.

CHRISTOPHER KLOXIN will devise synthetic DNA arrays to detect single nucleotide polymorphisms (SNPs), subtle changes in the DNA that are believed to be responsible for many genetic diseases. The work exploits highly efficient and easily implemented chemical reactions, known as "click" reactions, to rapidly fabricate these arrays. This synthetic DNA platform combines enhanced sensitivity to detect SNPs and orders-of-magnitude fabrication cost savings to create a new diagnostic tool for the human health industry.

Hu wins Excellence in Teaching Award

JUEJUN (J.J.) HU, assistant professor of materials science, is one of eight UD faculty members to receive the University's 2013 Excellence in Teaching award presented by the Faculty Senate for outstanding work in teaching and advising.

"Teaching is a fun inventive process. I draw inspiration from research of my own and others, from everyday life, from conferences I attended, from the news I read, from the movies I watched, and from conversations with people – and these resources may well become examples in my class lectures in the forms of projects, examples, in-class demos and little jokes," he forewarns.

Thostenson receives prestigious National Science Foundation Career Award

ERIK THOSTENSON, assistant mechanical engineering professor who holds an affiliated appointment in materials science and engineering, received a prestigious five-year $400,000 Faculty Early Career Development Award from the National Science Foundation. With it, he'll investigate a new processing approach for novel multi-scale hybrid composites with functionally graded material properties.

Thostenson, who is also an affiliated faculty member in UD's Center for Composite Materials, plans to study an environmentally friendly water-based processing technique as an alternative to current energy-intensive approaches for integrating carbon nanotubes within fibrous structures.

"Our preliminary research has established an efficient technique for producing very stable aqueous suspensions of highly dispersed carbon nanotubes in a single processing step," he says. "The technique enables the nanotubes to fully penetrate fiber bundles and form chemical bonds with the fiber surface.

"This is important for the future use of these hybrid materials, which offer remarkable improvements in shear strength, fracture toughness and electrical conductivity over traditional fiber-reinforced composites," Thostenson continues. "Our work is paving the way for integrating adaptive, sensory and energy storage capabilities into structural composite materials."

Adapted from an article by Diane Kukich | Photo by Kathy F. Atkinson

SAMPE HONORS

Two University of Delaware doctoral students won grand prizes for their presentations at the recent Society for Materials and Process Engineering (SAMPE) international symposium and exhibition in Long Beach, Calif.

As a result, **QI AN** and **JENNIFER MUELLER**, both doctoral candidates in materials science and engineering and affiliated with the Center for Composite Materials (CCM), will present their work at international SAMPE conferences in Europe and Japan, respectively.

An, who is advised by assistant professor **ERIK THOSTENSON**, placed second and will present *"Carbon Nanotube Reinforced Fiber/Epoxy Multi-scale Hybrid Composites via Electrophoretic Deposition: Multifunctional Properties, Processing, Characterization and Modeling"* in Paris in 2014.

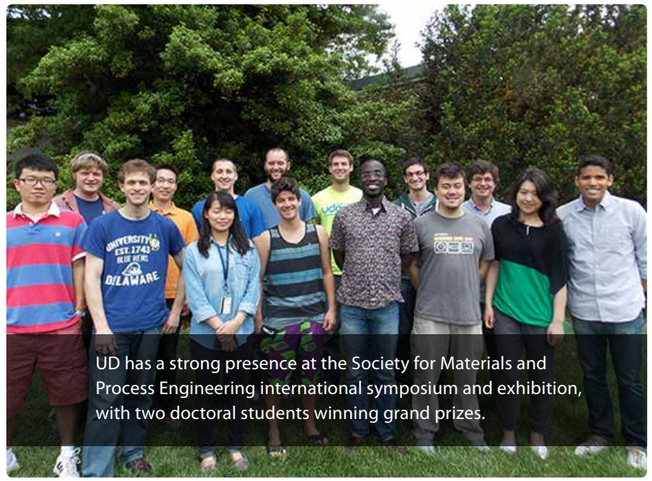
Mueller is co-advised by **JACK GILLESPIE**, CCM director, and **SURESH ADVANI**, chair of mechanical engineering, took first place and will present her talk, *"Diffusion as a Bonding Mechanism for Ultrasonically Consolidated Metal Matrix Composites,"* in Nagoya this November.

In addition to the doctoral winners, **CHRISTINE GREGG** (ME13), a senior at the time of competition, tied for first place in the undergraduate category, and a team from CCM placed second out of 17 teams in the bridge competition.

The team, which included 13 UD students, collaborated to submit five entries to the bridge competition. In addition to their second-place overall finish, they received the following top division awards:

- 1st place: Natural Fiber Square Beam
- 1st place: Natural Fiber I-Beam
- 2nd place: Glass Fiber I-Beam
- 3rd place: Glass Fiber Box Beam

Adapted from article by Diane Kukich



UD has a strong presence at the Society for Materials and Process Engineering international symposium and exhibition, with two doctoral students winning grand prizes.

EXTREME ENGINEERING

Research to provide better protection for soldiers and vehicles

Researchers at the University of Delaware's Center for Composite Materials (CCM) are part of the Materials in Extreme Dynamic Environments (MEDE) Collaborative Research Alliance consortium helping the U.S. Army develop new lightweight materials to better protect soldiers and vehicles.

CCM joins engineers from national laboratories, private industry and three other universities — Caltech, Johns Hopkins and Rutgers.

The researchers will investigate what happens to a broad array of material systems—including polymers, composites, metals, ceramics and alloys—at the moment of intense impact, when a large amount of energy enters a small space in a short period of time.

CCM's contributions will be in the areas of polymers and polymer composites. Polyethylene and S-glass/epoxy are the selected model polymer and model composite systems, respectively.

The research involves both multiscale modeling and experimental work ranging from molecular dynamics to the continuum length scales. The goal is to develop a materials-by-design approach to improve material performance in extreme dynamic environments.

Professor **JACK GILLESPIE**, CCM director, principal investigator and member of the MEDE leadership team, explains that for the polymer system, specific mechanical properties and new energy absorbing mechanisms can be achieved by manipulating the molecular structure. "We plan to model and characterize the polymer structure over length scales ranging from single crystals to fibers," he says.

The composite system brings in the added complexity of three components — the S-glass fibers, the epoxy matrix, and the region where they meet, known as the *interphase*, which has properties different from those of both the fiber and the matrix. The research focuses on molecular dynamic modeling of the interaction between the glass surface, fiber sizing and the epoxy matrix to help researchers understand interphase formation and to predict the mechanical properties such as strength and energy absorption. These MD-based traction laws will be used to bridge length scales for use in composite microstructure and novel experimental methods testing the interphase at high strain rates.

"An important outcome of our materials-by-design approach is that the fundamental multiscale modeling tools we develop will be transitioned to ARL and can be used to create materials to meet future Army needs," Gillespie says.

Center Makes Significant Equipment Upgrades

CCM faculty, staff and students have access to a broad spectrum of composites characterization, manufacturing processing and computational equipment in the Center's 52,000-sq-ft, state-of-the-art facility.

CCM's equipment is continuously upgraded and augmented to support basic research, as well as applied programs carried out in collaboration with industrial and government sponsors.

Last year, the facilities underwent a significant expansion and upgrade in three areas: high-performance computing, materials processing and materials characterization.

"We are very excited about our new equipment and capabilities that will enhance the quality, breadth and depth of our educational mission; the research conducted by our faculty, staff and students; and the value we provide to our government and industrial sponsors." ❖
--Professor Jack Gillespie, Director,
Center for Composite Materials

Equipment added to CCM's labs:

High-Performance Computing

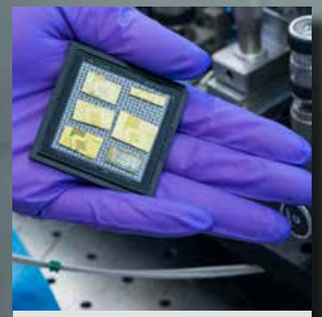
- SGI Shared Memory Supercomputer (Veyron)

Materials Characterization

- Micro CT scanner
- Instron Mechanical Test Machine (50 kip)
- T A Instruments Discovery Hybrid Rheometer
- Digital Image Correlation System
- Keyence Confocal Microscope
- Bruker X-Ray system
- Bruker Atomic Force Microscopy

SENSOR ON A CHIP

University of Delaware professors Juejun Hu and Chaoying Ni in the lab with their sensor device.



In their sensor-on-a-chip research, professors **Juejun Hu** and **Chaoying Ni** are creating small, highly sensitive devices for detecting environmental pollutants at the single-molecule level. The technology also may have applications in biomedicine—for example, for analyzing a patient's breath to detect disease.

NEW TECHNOLOGY HOLDS POTENTIAL FOR MONITORING ECOSYSTEM

University of Delaware materials science researchers **JUEJUN HU** and **CHAOYING NI** are developing sensors that they hope will allow real-time, in situ detection of water and air pollutants in an inexpensive and environmentally friendly manner.

Hu, assistant professor and Ni, associate professor, are creating small, highly sensitive devices that will detect organic, inorganic and biological molecular species at low levels in the environment. The team is funded by a seed grant from the National Science Foundation's Delaware Experimental Program to Stimulate Competitive Research (EPSCoR).

"We're making nanostructures to detect chemical molecules in a very sensitive manner," says Hu, lead researcher on the project.

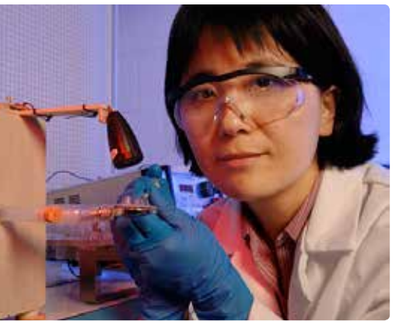
With further research and development, the devices could be integrated into portable, battery-powered sensor packages, replacing more traditional molecular detectors, which require bulky and expensive equipment.

Deployed in a network in the field, an array of the small sensors could detect contamination in air, water and soil in real time and relay that information wirelessly to a computer.

Although still in the early stages, and with testing only started last fall, Hu is already looking ahead to the practical benefits the devices could have for the environment.

"We'll be able to continuously monitor environmental pollutants, so we'll know if water in a stream is getting polluted or if a chemical plant is leaking. We can also use it to detect toxic leaks in industrial plants," he says. ❖

Article by Juan Guerrero | Photos by Evan Krape



HELP FOR CANCER PATIENTS

UD partners in $2.5 million NIH grant to produce artificial salivary glands

XINQIAO JIA is part of a research team breaking new ground in the creation of artificial salivary glands.

Funded through a $2.5 million grant from the National Institutes of Health (NIH), the research team hopes the work will lead to new solutions for xerostomia, or dry mouth, an inevitable consequence of radiation treatment for head and neck cancers.

The four-year project is a collaborative effort between researchers at Rice University, the University of Delaware and Christiana Care Health System in Wilmington, Del. Principal investigators named to the project include:

- **CINDY FARACH-CARSON**, vice provost for translational bioscience and professor of biochemistry and cell biology at Rice University
- **XINQIAO JIA**, associate professor of materials science and engineering and biomedical engineering at UD
- **ROBERT WITT**, M.D., chief of the multidisciplinary head and neck oncology clinic at Christiana Care's Helen F. Graham Cancer Center.

Patients with head and neck cancer often undergo radiation as an early course of treatment, which can destroy the saliva-producing cells in the mouth. This side effect causes dry mouth which can lead to severe dental issues, as well as difficulty swallowing, speaking and eating, and overall discomfort.

Current therapies in this area have proven ineffective over the long term.

"Few in the research community have applied tissue engineering strategies to the problem," notes Jia, a tissue engineering expert. "Our hope is that by assembling a strategic team with engineering, biological and clinical expertise, we can make headway and offer new hope to patients suffering from this condition."

In previous work the research team developed methods for isolating and growing salivary cells—responsible for water and enzyme production—in the lab prior to radiation. These cells form 3D secretory structures when cultured in biologically relevant hydrogels.

Jia's group will develop hydrogels that will be used as instructive matrices to guide the salivary cells through morphogenesis processes and potentially organize them into functional salivary glands. Jia explains that the hydrogels can be "tuned" to match the structure and properties of the native tissues in salivary glands, increasing the potential for success.

Working with collaborators at the Helen F. Graham Center's Center for Translational Cancer Research, the team hopes the work will translate into reliable methods to produce artificial salivary glands.

Doctors will culture a patient's cells prior to radiation treatment and then re-implant the salivary glands grown from the patient's own cells back into the mouth following treatment.

Jia says, "The goal is to help cancer survivors overcome dry mouth problems and improve their quality of life."

"Interdisciplinary teams permit research groups to more effectively solve complex problems, and this project highlights the synergy between basic, applied and clinical aspects of bioengineering research," adds **KRISTI KIICK**, deputy dean of UD's College of Engineering. "As more faculty engage in these types of interdisciplinary programs and partnerships, the impact and visibility of the University's research will continue to grow."

Article by Karen B. Roberts | Photos by Kathy F. Atkinson and Christiana Care Health System

Research reported in this article was supported by the National Institute of Dental and Craniofacial Research of the National Institutes of Health under award number RO1DE022969.

BIO FOR NANO

Engineers work to create new biomaterials with energy technology applications

When automotive engineers want to create a new car, they don't build thousands of prototypes. They create computer models and run simulations for performance, efficiency and desirability before a model is selected for fabrication.

Materials science professors **DARRIN POCHAN** and **KRISTI KIICK**, also deputy dean of the College of Engineering, are taking a similar approach to building new nanomaterials from biomolecules—namely peptides and proteins—that could increase the efficiency of photovoltaics, also known as solar cells, and other electronic devices.

Collaborating with **JEFFREY SAVEN**, professor of physical and biological chemistry at the University of Pennsylvania, Pochan and Kiick are working to develop useful protein-like molecules that can easily be scaled up into complicated nanomaterials for industrial applications.

"There is a lot of power in protein molecules," explains Pochan, who holds secondary appointments in chemistry and biochemistry and biomedical engineering, and is principal investigator on the grant. "Proteins are what make humans function. We want to harness that functionality for nonbiological materials applications."

The work is funded through a four-year, $1 million grant from the National Science Foundation's Division of Materials Research. It parallels efforts by the Materials Genome Initiative to accelerate how transformative materials technology moves from research to production.

Kristi Kiick and Darrin Pochan are working to create new biomaterials with potential energy technology applications.

HARNESSING NATURE

According to Pochan, many engineers have attempted to harness the functionality of biomolecules to make materials, mostly by using "bio-inspired" ideas. The key difference in this project is the opportunity to capitalize on the inherent chemistry and shape of proteins to organize new, designed molecules into desired, arbitrary structures.

A large part of the research is defining how the molecules come together, or assemble, in solution to form a desired material.

Once the molecular details are determined, the team will synthesize the protein molecules in the laboratory and then identify the best conditions for assembling the molecules into the desired nanostructures in water. The work also includes characterizing the constructed materials and comparing them with the original design.

"Peptides and polypeptides offer unlimited potential in designing new materials that can uniquely address limitations in current electronic devices," notes Kiick.

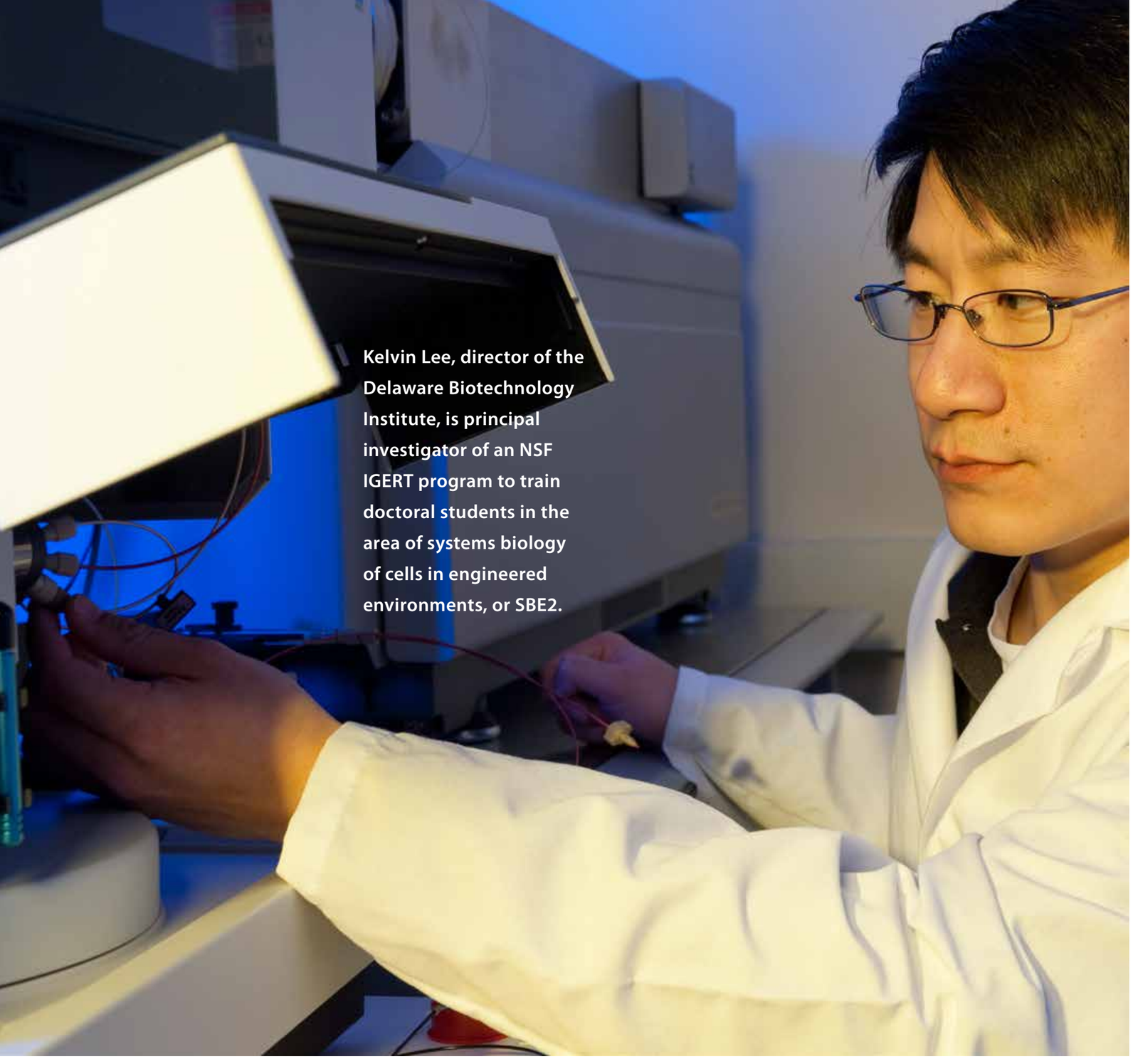
If successful, Pochan says the project could offer manufacturers a "dirt simple" processing and materials technique for creating a structured, protein-based backing that could be applied to photovoltaic devices to improve their efficiency.

It may also create new opportunities to work with colleagues in energy disciplines—particularly those at UD—to test and refine the materials process.

"Normal semiconductor manufacturing processes are extremely difficult and expensive at this small of a length scale, making this research area very important," Pochan says. Undergraduate and graduate students, as well as post-doctoral researchers involved in the project, will gain multidisciplinary expertise in the design, modeling, fabrication and characterization of peptide-based biomaterials.

Says Kiick, "This type of project requires a seamless integration of theory, synthesis and characterization, with an interdisciplinary team capable of moving basic research into the practical realm."

Article by Gregory Holt and Karen Roberts | Photo by Kathy F. Atkinson



Kelvin Lee, director of the Delaware Biotechnology Institute, is principal investigator of an NSF IGERT program to train doctoral students in the area of systems biology of cells in engineered environments, or SBE2.

IGERT FUNDING

NSF grant supports work in systems biology of cells in engineered environments

With the responsibility of great research also comes the requirement of educators to transcend traditional boundaries by integrating multidisciplinary knowledge into their work. To do this, they must build a team of experts in other fields to integrate programs that will broaden the capabilities of future leaders.

A group of University of Delaware faculty has been awarded a National Science Foundation (NSF) grant under the Integrative Graduate Education and Research Traineeship (IGERT) program to train doctoral students in the area of systems biology of cells in engineered environments (SBE2).

IGERT is the NSF's flagship interdisciplinary training program, educating U.S. doctoral scientists and engineers by building on the foundations of their disciplinary knowledge with interdisciplinary training.

Led by principal investigator **KELVIN LEE**, Gore Professor of Chemical Engineering and director of the Delaware Biotechnology Institute, the grant brings together experts across the University—drawn from the colleges of Engineering; Agriculture and Natural Resources; Earth, Ocean, and Environment; Arts and Sciences; and Business and Economics—for a comprehensive, intense work/study program designed to create the science leaders of tomorrow.

Co-principal investigators include **CATHY WU**, Edward G. Jefferson Chair of Bioinformatics and Computational Biology; **KRISTI KIICK**, deputy dean and professor in materials science and engineering and of biomedical engineering; **THOMAS HANSON**, associate professor of marine biosciences and biological sciences; and **JIA SONG**, assistant professor of biological sciences.

The five-year, $3 million grant will engage the IGERT scholars in an important paradigm shift, teaching them critical skills related to science and engineering, as well as bioethics, research ethics, business innovation, communications and outreach to train them to be world leaders in industry, government or academia.

"This proposal represents a novel and comprehensive approach to graduate education in science and engineering," says **Thomas Powers**, director of UD's Center for Science, Ethics and Public Policy and faculty participant in the IGERT. "We intend to prepare students to do good science and to be responsible scientists."

IGERT Scholars will have the opportunity to rotate in faculty laboratories, do internships at partner companies and laboratories in Delaware and around the country, and design and implement solutions to important industry problems through an "innovation rotation."

The most innovative proposals will receive additional funding for implementation during IGERT Scholar internships with industrial partners. Another unique feature of the IGERT SBE2 program is that faculty will also spend time in their colleagues' laboratories to foster interdisciplinary communication.

The plan to create this IGERT program also included the launching of a new doctoral program in bioinformatics and systems biology last fall, which now offers an exciting new interdisciplinary home for IGERT scholars.

The program immerses graduate students in a training program connecting biological systems and cells in engineered environments, while coupling novel computational approaches with cutting-edge experimental systems biology techniques.

"The interdisciplinary research and innovation experiences will indeed leave the scholars of this program well-poised for futures in multiple areas," says Kiick. "The program will also have long-term benefits for the more than 19 UD faculty participants and range of industry partners. The opportunity for the faculty to work closely on projects, classes and industry rotations that merge our strengths in systems biology and engineered environments will allow us to solve a broader range of complex biological problems."

Article by Laura Crozier | Photo by Evan Krape

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"Mind the Gap: Quantum Effects and Optical Magnetism in Plasmonic Partical Junctions "

Researchers (from left) Kristi Kiick of UD and Jessica Chichester and Mark Jones of Fraunhofer explain their work during a session in Dover.

EDUCATING LEGISLATORS

UD, Fraunhofer researchers share their work with Delaware lawmakers

Three research teams from the University of Delaware and the Fraunhofer Center for Molecular Biotechnology (CMB) shared highlights of their work with Delaware legislators and their staff members in Legislative Hall.

"Our goal was to inform the legislators about the progress of this important partnership and how the field of life sciences is growing in Delaware," explains **KARL STEINER**, UD's former senior associate provost for research development. "The event was also an opportunity to thank those who supported the partnership."

Two of the highlighted projects are being funded through a six-year partnership agreement that includes UD, Fraunhofer CMB and the State of Delaware.

- **KRISTI KIICK**, professor of materials science and engineering and biomedical engineering and deputy dean of the College of Engineering, is collaborating with Fraunhofer's Jessica Chichester and Mark Jones on a project to develop and demonstrate the ability of engineered polymer gels to increase the stability, immunogenicity and/or therapeutic efficacy of proteins.
- **JUNG-YOUN LEE**, associate professor of plant and soil sciences, is partnering with CMB's Alex Prokhnevsky to improve the efficiency of "molecular farming" of such pharmaceutically valuable materials as vaccines.

The third project showcased at the open house is supported by the Delaware Bioscience Center for Advanced Technology (CAT), which synergizes efforts among the various life science communities in Delaware and is also funded by the State of Delaware. Led by **CATHY WU**, Edward G. Jefferson Chair of Bioinformatics and Computational Biology, the work focuses on bioinformatics, an emerging field where biological and computational disciplines converge.

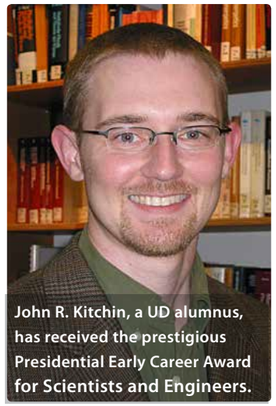
Some 50 legislators and their staffers turned out for the opportunity to chat with the researchers.

"State support facilitates collaborative work that will lead to future projects," said **ALAN LEVIN**, who directs the Delaware Economic Development Office and invited the researchers to Legislative Hall.

"Events like this allow our legislators to see what state dollars have enabled in Delaware," noted Levin. "This partnership is one small part of biotechnology in the state, and we plan to continue to support it."

Article by Diane Kukich | Photos by Evan Krape

PRESIDENTIAL HONOR



John R. Kitchin, a UD alumnus, has received the prestigious Presidential Early Career Award for Scientists and Engineers.

UD engineering alum Kitchin selected for prestigious PECASE

JOHN R. KITCHIN (MSEG '02; PhD '04), associate professor of chemical engineering with a courtesy appointment in materials science and engineering at Carnegie Mellon University, was honored by President Barack Obama last summer with the prestigious Presidential Early Career Award for Scientists and Engineers (PECASE).

PECASE is the highest honor bestowed by the U.S. government on scientists and engineers in the early stages of their independent research careers.

"The PECASE award is a testament to the breadth and depth of education I got at UD."

– John R. Kitchin

Kitchin was nominated by the Department of Energy's Office of Fossil Energy for his research efforts in collaboration with the National Energy Technology Lab's Regional University Alliance (NETL-RUA), an alliance of five universities that conduct fully integrated basic and applied energy and environmental research.

In this work, Kitchin and his team developed an electrochemical separation method for separating oxygen from air at ambient pressure and temperature.

"Our approach uses electrochemistry to reversibly convert oxygen in air to ions, transport the ions across a membrane, and convert the ions back to pure oxygen on the other side of the membrane," explains Kitchin. "All this can be done at room temperature and ambient pressure. We continue to develop catalysts to make this process more efficient and economical."

KITCHIN'S CAREER

Kitchin received a bachelor's degree in chemistry from North Carolina State University in 1996, then worked as a chemist for Lord Corp., developing new magnetorheological fluids and applications.

He returned to academics at the University of Delaware, where he received a master's degree in materials science and engineering in 2002 and a doctorate in chemical engineering in 2004.

Kitchin was selected as an Alexander von Humboldt postdoctoral fellow at the Fritz Haber Institut der Max Planck Gesellschaft in Berlin from 2004-05, and joined Carnegie Mellon University as an assistant professor in 2006. He was a Resident Institute Fellow at the National Energy Technology Laboratory in 2007 and the following year became the leader of the carbon management thrust area for NETL.

An innovative researcher and educator, he received the Kun Li Award for Excellence in Education in 2010 and won a five-year, $750,000 grant from the U.S. Department of Energy in 2010 to develop new materials for producing hydrogen and oxygen from water using electrochemistry.

In March 2011, he returned to UD to present the Department of Chemical Engineering's Allan P. Colburn Memorial Lecture, on *"Oxygen Evolution on Multicomponent Oxide Electrocatalysts."*

"My time at UD uniquely prepared me for the work we currently do," Kitchin acknowledges. "My undergraduate degree is in chemistry. After graduating, I wanted to change fields to engineering, and UD made that possible. I transitioned from chemistry to materials science to chemical engineering, and UD was the only school that would let me do that."

"It has been the breadth of this education that enables our research, which uses quantum chemistry calculations to predict the reactivity of electrocatalysts, as well as electrocatalyst synthesis and oxygen separation device construction," he continues. "We span basic science to engineering analysis of the applications we study. The PECASE award is a testament to the breadth and depth of education I got at UD."

Kitchin was advised at UD by **MARK BARTEAU**, former senior vice provost for research and strategic initiatives and Robert L. Pigford Chair of Chemical Engineering; and by **JINGGUANG CHEN**, former Claire D. LeClaire Professor of Chemical Engineering.

Adapted from an article by Neil Thomas

GOING BIG

UD alumna among materials science researchers featured in scientific journals for carbon nanotube-based continuous fibers development

From left, Tsu-Wei Chou, Amanda Wu and Weibang Lu in Spencer Laboratory

The Chou research group's progress on advances in carbon nanotube-based continuous fibers was recently published in two high-impact scientific journals—*Advanced Materials and Materials Today*.

According to **TSU-WEI CHOU**, Pierre S. du Pont Chair of Engineering, who co-authored the articles with colleagues **WEIBANG LU** and **AMANDA WU** (MSEG Ph.D. 2009), there has been a concerted scientific effort over the last decade to "go big" – to translate the superb physical and mechanical properties of nanoscale carbon nanotubes to the macroscale.

The result, he says, has been the development of continuous fibers comprised solely of carbon nanotubes held together through local entanglements and van der Waals forces, a type of weak molecular interactions.

"Despite a discontinuous microstructure, these carbon nanotube fibers exhibit strengths comparable to current high performance fibers with significantly lower densities, creating new avenues for ultra-light weight multifunctional composite materials and structures," Chou explains.

"Furthermore, their flexibility and electrical conductivity have gained attention and given rise to the potential for carbon nanotube fibers to serve as embedded strain and damage sensors."

The challenge, however, remains how to scale up the material's size without sacrificing performance and functionality.

Lu's article, published in *Advanced Materials*, provides an in-depth analysis of the current carbon nanotube fiber processing methodology, including drawbacks and potential avenues for improvement. The article offers a thorough comparison of the current physical, electrical and mechanical properties of carbon nanotube fibers.

Wu's article, published in *Materials Today*, details the recent experimental characterization of carbon nanotube fibers performed by the Chou group. The review emphasizes the dynamic electromechanical behavior of carbon nanotube fibers and explores opportunities for carbon nanotube fibers in advanced composite applications.

Lu and Wu are both research associates in the Department of Mechanical Engineering and the Center for Composite Materials.

Article by Karen B. Roberts | Photo by Kathy F. Atkinson

Help MSEG continue to expand cutting-edge research with a gift in honor of department's 15th anniversary

The University of Delaware has long been recognized for its academic curriculum, advanced research capabilities and preparation for fieldwork provided by the College of Engineering. With the opening this fall of the new Interdisciplinary Science and Engineering Laboratory (ISE Lab), the university embraces a new era of developing tomorrow's brightest scientific minds through problem-based learning.

While classes from many academic disciplines will be held in the ISE Lab, the facility's research capabilities will be particularly important to materials science and engineering (MSEG) students, who will benefit from the facility's advanced materials characterization lab and microscopy suites. The building also features a 10,000 square-foot nanofabrication facility.

Green elements include:

- Single-stream recycling for construction waste
- Daylight harvesting lighting controls system maximizing use of daylight
- Each air handler equipped with a heat recovery system
- Three green roofs
- Courtyard landscaped with native plants and an onsite drainage system to eliminate storm water runoff

The ISE Lab was constructed following the standards of the U.S. Green Building Council's LEED Silver designation, representing a significant investment in environmentally friendly products, equipment and design standards.

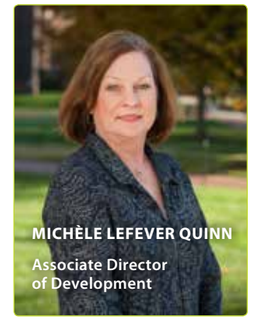
The timing of the ISE Lab opening is significant for MSEG as it coincides with the department's 15th anniversary. In recognition of this milestone, we hope you will consider a gift to support this exciting new facility – one which will help transform materials science and engineering education and research and serve as a magnet for both students and faculty.

Naming opportunities start at $25,000, and, thanks to a $5 million commitment from the Unidel Foundation, Inc., your gift of $50,000 or more will receive a 1:1 match for the purpose of naming opportunities. So, your gift of $50,000 allows you to name a group study room valued at $100,000. What a meaningful tribute for a family member, favorite faculty member, fellow MSEG alumnus or colleague.

You may also choose to make a gift that supports the advanced scientific equipment required for the cutting-edge research that will help drive MSEG into its next 15 years.

The time has never been better to give back to your alma mater and pave the way for the next generation of materials science engineers. To learn more, visit www.udel.edu/development/makeagift, or you may call me directly at (302) 831-0840.

P.S. The Unidel challenge ends with 2013, so please contact me right away for naming opportunities.



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Materials Science & Engineering
Celebrating 15 years

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