2012 NEWS

The Department of

Materials Science & Engineering

MaterialsMatters

Insects to vocal folds

Learn how insect proteins are inspiring biomaterials for vocal fold regeneration on pg 17.

Cover Image courtesy of Duane Perry

INSIDE: read about our biomaterials, high performance fibers and solar cell research!

Dare to be first.

UNIVERSITY OF DELAWARE

Message from the Chair

Colleagues, Alumni, and Friends of the UD's Materials Science and Engineering Department:

Thanks again for your interest in Materials Science and Engineering (MSEG) at the University of Delaware. There were many exciting events over the last year that we describe in more detail elsewhere in this newsletter, including promotions and accolades for our faculty and students, as well as progress in the construction and planning for the new **Interdisciplinary Science and Engineering Laboratory** (ISE-Lab).

The ISE-Lab will provide state-of-the-art space for materials synthesis, physical and chemical characterization and electron and optical microscopy. There is also a large clean room and nanoprocessing facility that will give UD faculty and students access to instrumentation needed in designing, building and testing novel electronic and photonic devices at the molecular and atomic scale. The new Zeiss Auriga 60 dual beam focused ion beam/scanning electron microscope (FIB-SEM), installed temporarily in Spencer Hall last year, is already having a substantial impact on our research capabilities (learn more on page 27).

Our MSEG faculty and students continue to be recognized for their excellence and expertise. Among those earning accolades are Matt Doty, College of Engineering Outstanding Junior Faculty Member; Josh Zide, North American Molecular Beam Epitaxy Young Investigator and Department of Energy Young Scientist Award; and Robert Opila, Fulbright Scholar in Turkey. Ismat Shah was named as an Outstanding Educator for the University of Delaware and was recently named as co-chair of President Harker's Diversity and Equity Commission. Xinqiao Jia was the thematic program chair for the 244th ACS meeting held in Philadelphia, Penn., in August 2012. Additionally, several faculty published cutting edge research results in publications and cover articles in high-visibility journals including ***Advanced Materials***, ***Advanced Functional Materials***, ***Soft Matter*** and ***Applied Surface Science***. We are proud of their accomplishments.

As always, please do not hesitate to contact us; we welcome your questions, concerns and suggestions.

We particularly appreciate those alumni who have generously supported MSEG through gifts and donations, and we encourage others to consider demonstrating their support in this substantive manner, which genuinely impacts our faculty, students and programs.

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

STUDENTS

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MaterialsMatters

Credits:

Department Chair
David Martin

Contributing Writers
Zac Anderson, Tracey Bryant, Jacob Krum, Diane Kukich, Katie Meier, Karen Roberts and Janie Sikes

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Spotlight

MSEG doctoral student earns honorable mention in Laird Fellowship

MSEG doctoral student **OKECHUKWU (TONY) OGBUU** earned honorable mention for the 2012 Laird Fellowship, the prestigious award honoring the memory of University of Delaware mechanical engineering graduate George W. Laird, who died in an accident at the age of 35.

In an unprecedented decision to give honorable mention, the Fellowship Committee this year recognized both Ogbuu and mechanical engineering grad student Hong Yu, citing "the notable strength of the applicant pool." Tyler Josephson, a doctoral student in chemical and biomolecular engineering, is the 2012 Laird Fellowship recipient.

Given since 1997, the fellowship is bestowed upon candidates who exhibit character, creativity, imagination and perseverance.

Adapted from article by Karen B. Roberts

Entrepreneurial honors

UD graduate students bring home Delaware entrepreneurial awards

Five University of Delaware graduate students, including two representing materials science and engineering, won two awards at the 2011 Delaware Governor's Entrepreneurial Conference.

MSEG doctoral students **NANDITA BHAGWAT** and **CHELSEA HAUGHN** are the scientific minds behind Voltaic Coatings, which won "Best StudentPreneur" honors at the conference, as well as the coveted prize of "Best Overall Business."

Voltaic Coatings achieved additional success during the 2011 Alumni Weekend, taking first place in the alumni-judged inaugural Venture Pitch Contest hosted by the Entrepreneurial Studies program at UD's Venture Development Center (VDC).

The team began working on their company under the guidance of Scott Jones, professor of accounting and former director of the VDC; Keith Goossen, associate professor of electrical and computer engineering; and John Rabolt, the Karl W. and Renate Böer Professor of Materials Science and Engineering, in a graduate-level High Technology Entrepreneurship class offered jointly by UD's Alfred Lerner College of Business and Economics and the College of Engineering.

The Voltaic Coatings group includes, from left, Keith Modzelweski, Pat Lowry, Chelsea Haughn and Rick Walsh. Not pictured is team member Nandita Bhagwat.

Throughout the class, student groups were given access to technological innovations created by other UD faculty with the goal of creating a business model around that technology.

According to team members, Voltaic Coatings works with an electro-conductive polymer created by MSEG's department chair, David Martin and Katie Feldman. They are looking at applications in computer displays, touch screens, thin film solar cells and flat panel televisions. Ultimately, they believe this technology could bring a huge change to existing markets and allow for the creation of flexible screens that are paper-thin.

Adapted from article by Kathryn Marrone Meier and Keith Modzelewski
Photo by Kathy F. Atkinson

Startup success

T3D soars beyond Hen Hatch to place among top collegiate startups worldwide in Rice Business Plan Competition

T3D Nanotech, LLC—a high technology startup company working toward safer and more effective oncology services, which spun off from patent-pending nanotech research at the University of Delaware—won third place in the 2012 Rice Business Plan Competition (RBPC).

MSEG doctoral candidates **VINU KRISHNAN** and **SAMEER SATHAYE** are part of the T3D quartet whose work was named among top collegiate startups at the Rice competition. RBPC supports the creation of new startup companies and brings together business and engineering students from the world's top educational institutions with successful venture capital investors, entrepreneurs and business leaders.

Out of a pool of 1,600 applicants, they became one of just 42 teams invited to compete for more than $1.5 million in prizes with their "Tag & Target Therapeutic Delivery – T3D: Oncology" venture.

After presenting a 15-minute business plan and competing in a rapid fire 60-second elevator pitch contest, T3D left the Houston competition in April with a third place win in the "Shark Tank Round" of the contest, $600 in prize money and the honor of representing UD among the top collegiate entrepreneurs in the world. The team appeared in a photo in the May 17, 2012 issue of *Fortune* magazine.

MSEG doctoral candidates Vinu Krishnan and Sameer Sathaye are part of the T3D quartet

Prior to the Rice competition, they also won $1,000 in UD's Hen Hatch business startup funding competition in March, and took home winning honors in the inaugural semi-annual UD Idea Pitch competition sponsored by the University of Delaware's Venture Development Center (VDC) in November 2011.

"We want to develop a solid business plan to commercialize T3D in consultation with the faculty and by utilizing resources at the VDC," said Krishnan, T3D's chief science and technology officer. "We are keen on initiating and completing T3D's pre-clinical trials as fast as possible since it can potentially benefit millions of people who are going to be affected by cancer in the coming decades."

Adapted from article by Kathryn Meier

Qi An
Center for Composite Materials Progress Award

Nandita Bhagwat
Materials Science & Engineering Special Service Award

Yingchao Chen
Materials Science & Engineering Outstanding Graduate Teaching Assistant Award

Sarah Grieshaber
Outstanding Research Symposium in the American Chemical Society, Division of Polymer Chemistry

Linqing Li
Materials Science & Engineering Chairperson's Award

Jinglin Liu
Best Poster Award, Materials Research Society Meeting

Weiwen Liu
UD Competitive Graduate Fellowship Award

Quinn McAllister
Center for Composite Materials R.L. McCullough Scholars Award. 2012 Adhesion Society Peebles Award for Graduate Student Research in Adhesion Science

Christopher McGann
Nominated for Best Poster Award, Materials Research Society Meeting

Okechukwu Ogbuu
George W. Laird Honorable Mention Merit Fellowship

Bradford Paik
MSEG609 Proposal Writing Contest Award

Longxi Xiao
Materials Science & Engineering Chairperson's Award

Xian Xu
UD Competitive Graduate Fellowship Award. TA Instruments Graduate Student Presentation Award, American Chemical Society's Polymeric Biomaterial Symposium

Yujun Zhong
Materials Science & Engineering Outstanding Graduate Student Research Award

Pochan named fellow of the American Physical Society

DARRIN POCHAN, UD professor of materials science and engineering since 1999, is now a Fellow of the American Physical Society (APS).

The fellowship recognizes individuals who help advance physics through original and independent research. Membership as an APS Fellow distinguishes Pochan among the top one-half percent of all APS members.

"Darrin is an excellent scholar and educator and his scientific impact has been extensively and highly admired," remarked David C. Martin, Karl W. and Renate Böer Professor and chair of the department, who nominated Pochan.

Pochan's expertise is in developing new nanostructures and functional materials through the assembly of soft materials like polymers and proteins.

Adapted from article by Zac Anderson | Photo by Ambre Alexander

Kiick selected as AIMBE Fellow

KRISTI KIICK, deputy dean of engineering and professor of materials science and engineering and biomedical engineering, has been inducted into the American Institute for Medical and Biological Engineering (AIMBE) College of Fellows, Class of 2012.

This elite appointment distinguishes Kiick among the top two percent of her peers. AIMBE College Fellows include the top 1,000 outstanding bioengineers in academia, industry and government.

A leader in the medical and bioengineering community, Kiick is an internationally known scholar in the area of biomaterials design, synthesis and characterization. Her work focuses on the synthesis and assembly of biologically-derived macromolecules.

Adapted from article by Karen B. Roberts

Opila wins Fulbright to teach renewable energy in Turkey

ROBERT OPILA, professor of materials science and engineering, won a 2012-13 Fulbright Scholarship to teach and conduct research at Bilkent University in Ankara, Turkey.

While in Ankara, Opila will develop and teach an original course in solid state materials and renewable energy. Broadly, the course will cover the structure of matter, the role of vibrations (thermal energy) and the role of electronic energy in the emerging renewable energy field.

Opila plans to introduce problem-based learning (PBL) in his lectures, a concept that he believes will benefit his Turkish students. He previously used PBL in courses at UD to explore renewable energy solutions in places like Israel and Ghana, where a team of students worked through the technical requirements with the local infrastructure and resources to determine optimal solutions. Bilkent students will examine the role of renewable energy in Turkey and propose a roadmap to increase its use in the country.

Opila will also conduct research with colleague and Bilkent chemistry professor Sefik Suzer. Their work will build upon a method they jointly developed to measure the electrical and material properties of simple electronic devices systematically and nondestructively using photoelectron spectroscopy.

Upon his return to America, Opila plans to incorporate components of the Turkish course to the thermodynamic material covered in his UD courses. He and Suzer may also consider developing a book on the applications of surface science.

"Ideally this interaction will encourage collaborations between the United States and Turkish engineers and scientists and lead to a better understanding between our two countries," Opila concluded. "Personally, it will also enable me to be more sensitive to the challenges faced by non-American students."

Adapted from article by Janie Sikes

Jia's work considered "hot article" in *Soft Matter*

XINQIAO JIA, associate professor of materials science and engineering and biomedical engineering, co-authored a "hot article" in ***Soft Matter***, the global journal featuring interdisciplinary research at the intersection of physics, biology, chemical engineering, materials science and chemistry.

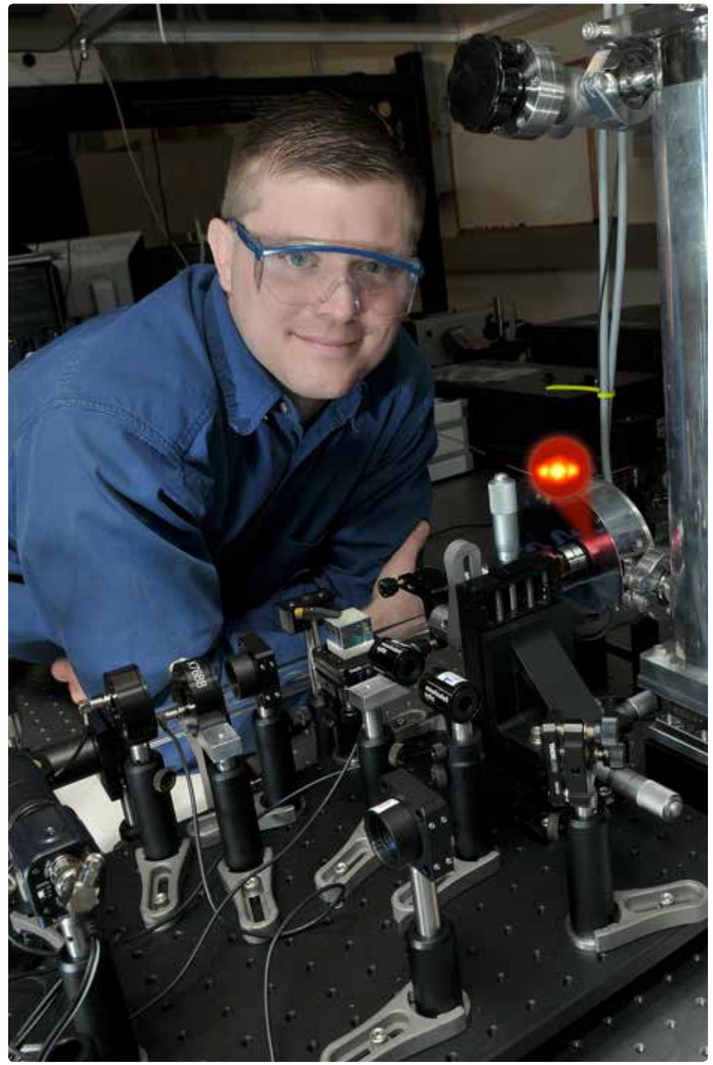
Co-authored with UD research assistant Xian Xu, Jia's article, "Hyaluronic Acid-Based Hydrogels: from a Natural Polysaccharide to Complex Networks," highlights the group's recent efforts in converting naturally occurring polysaccharide to drug releasing hydrogel particles and macroscopic networks, promising materials for tissue repair and regeneration. ❖

Adapted from article by Karen B. Roberts
Photo by Kathy Atkinson

Artificial molecules: Papers by UD researchers explore novel methods for assembly of quantum dots

MATTHEW DOTY, assistant professor, is co-author of two papers exploring novel methods for assembling quantum dots to control how electrons interact with light and magnetic fields for applications in next-generation computing devices and solar energy capture.

The papers recently appeared in *Physical Review B*, a journal of the American Physical Society (APS). Both papers were selected as "Editor's Suggestions," a designation reserved for only five percent of articles submitted to the journal. ❖



Congratulations to **MATTHEW DOTY**, assistant professor, for being named a 2012 **Outstanding Young Faculty** member in the College of Engineering.

Educational Leadership

S. Ismat Shah honored for educational leadership

S. ISMAT SHAH, joint appointed professor in the Departments of Materials Science and Engineering and Physics and Astronomy, has received the 2012 Mentor Award by the Society of Vacuum Coaters (SVC).

The award cites Shah's achievements as chair of the SVC Education Committee over the past decade, specifically in expanding the society's education program internationally and within the organization through ventures on-site and online.

In particular, Shah helped the SVC organize traditional courses taught at meetings, as well as on-site courses where instructors teach at a designated school or company. He also developed educational models that attract international students via the Internet. ❖

Adapted from article by Zac Anderson | Photo by Evan Krape

UD researcher collaborates with Fraunhofer Center for Molecular Biotechnology

Pictured are (from left) Jessica Chichester, Mark Jones and Kristi Kiick.

KRISTI KIICK, professor of materials science and engineering and biomedical engineering at UD, is leading a project to develop and demonstrate the ability of engineered polymer gels to increase the stability, immunogenicity and/or therapeutic efficacy of proteins produced by the Fraunhofer Center for Molecular Biotechnology (CMB).

Kiick is collaborating with **Jessica Chichester** and **Mark Jones** at CMB on the project, which capitalizes on the capabilities of her lab in polymer matrix development and of Fraunhofer in new protein therapeutics.

In contrast to most biologicals produced today, which are grown in either bacteria or yeast, CMB uses a novel plant-based system for rapid, cost-effective production of recombinant proteins. The polymer matrices produced in Kiick's lab will be engineered for specific functions, including protein sequestration, protein stability, slow release or immunological presentation.

"With this combined expertise, we have the potential to develop unique formulations for a range of applications from vaccine development to toxin treatment," Kiick said.

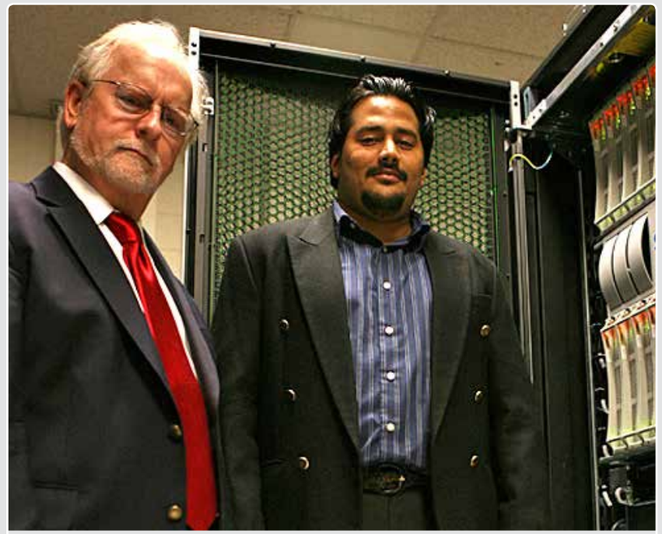
The project is one of two collaborative research projects that were selected for funding under a six-year partnership agreement that includes UD, Fraunhofer and the state of Delaware. **Jung-Youn Lee**, UD associate professor of plant and soil sciences, is partnering with CMB's **Alex Prokhnevsky** to improve the efficiency of "molecular farming" of such pharmaceutically valuable materials as vaccines. The two-year grants total $400,000 to support work to be conducted at UD and Fraunhofer.

Vidadi Yusibov, CMB executive director and research professor in biological sciences, pointed out that these collaborative interdisciplinary projects focus on some key areas of technology and pharmaceutical product development.

"The resulting unique knowledge will facilitate conversion of basic research concepts into applicable data, which will lead to the establishment of uniquely positioned, highly competitive research teams of UD faculty and Fraunhofer scientists," he said. ❖

Adapted from article by Diane Kukich
Photos by Kathy F. Atkinson

Lightning-fast shared memory supercomputer stretches frontiers of science



The Bugatti Veyron is currently the fastest road-legal production car in the world, and the Altix UV1000 is considered the fastest shared memory supercomputer in the world. So when UD's Center for Composite Materials (CCM) recently acquired one of these supercomputers, they couldn't resist naming it after the car.

A team led by CCM director **JOHN W. (JACK) GILLESPIE** and research associate **GAURAV NILAKANTAN** is using Veyron initially to explore the behavior of textile-based composite materials under extreme dynamic environments using multi-scale and probabilistic numerical techniques.

"The challenge to model flexible fabrics is immense," Gillespie said. "The key to fundamentally understanding the impact behavior of these fabrics is bridging the various length scales through innovative numerical multi-scale modeling techniques."

"Predictive numerical models provide us with a unique materials-by-design capability that helps drive the innovation of new materials, including fibers, interphases and polymers, as well as new architectures that will dramatically improve the overall performance of composites at minimal weight for a variety of applications in the aerospace, automotive, wind and national security sectors," explained Gillespie.

According to Nilakantan, what makes the UV1000 so appealing is that all memory is globally shared, and therefore available to all processors.

"This allows extremely large models to be run," he said. "All processors can communicate with each other through very fast interconnects based on proprietary SGI technology, preventing the typical communication bottleneck issues associated with slow data interconnects. Finally, large models scale very well with an increased number of processors."

JIM BYRNES, manager of information technologies for the UD College of Engineering, sees great potential in the supercomputer as a research resource.

"When engineers and scientists have easy access to vast quantities of CPU resources—along with immense magnitudes of shared memory—real-world problems, once intractable, suddenly are in reach," he said. "The frontiers of science can be stretched in ways not previously possible. Exciting discoveries become imminent. This is what the SGI UV brings to CCM."

CCM researchers will also use Veyron to model, at multiple length scales, the permeability, consolidation and infusion of polymer composites and to simulate electromagnetic and thermal responses, impact and wave propagation through heterogeneous materials and fluid-structure interactions in support of various ongoing programs funded by the Department of Defense, the National Science Foundation and industry.

Adapted from article by Diane Kukich

AMPing it up

CCM designed system could revolutionize evaluation, design of new materials and processes

The custom-designed Automated Materials Placement (AMP) robotic system promises to change the way new materials are evaluated and new processes are designed at UD's Center for Composite Materials (CCM).

"Conducting research in composites manufacturing is an evolving environment as new materials and processing methods continuously enter the market," said CCM scientist **JOHN TIERNEY**. "The AMP offers us a 'plug-and-play' approach to assessing new technologies."

The AMP is adaptable, modular and flexible, making it an ideal tool for conducting research on composites, which offer almost limitless combinations of fiber and matrix materials. It is configured with swappable modules for various feed systems, heating sources, and consolidation methods through a Lego-type connection structure. All of the modules use a common column design, and they all slide out the front of the chassis.

"Ideally, our goal is to enable any unit to be changed in under an hour," said **SHRIDHAR YARLAGADDA**, CCM's assistant director of research. "The modular design allows multiple research projects to use the system with little downtime."

CCM researchers have investigated composites manufacturing science for almost three decades. "This new machine is truly a legacy research tool that builds on all of the previous work we've done on composites design and processing," said director John W. (Jack) Gillespie Jr.

The AMP can process both thermoplastic and thermosetting materials up to 8 inches wide and can fabricate components in excess of 100 square feet. The system is designed to be modular so that various heating and consolidation methods can be studied and optimized with low risk on hardware investment. The flexible modules can be swapped or reordered to include high-energy infrared heating, volumetric induction heating, roller or shoe consolidation, sprayable bagging, ultrasonic welding, powder impregnation and in-line fabric stitching.

The system is fully instrumented with thermal and modular force measurement capabilities as well as visual inspection and laser position sensors. Detailed design studies can be carried out to compare AMP process temperatures, pressures and velocities on the final microstructure and the structural performance of a number of composite systems. The system as a whole provides an ideal environment for process design and optimization for a number of industries including aerospace, wind and automotive, while generating original research findings for academia.

Adapted from article by Diane Kukich
Photo by Dawn Fiore

> *"We think this could lead to a faster, better, cheaper way of making a class of nanocomposite materials with pretty exciting applications."*
>
> – Josh Zide, assistant professor of materials science and engineering

UD scientist attempts to grow nanocomposites faster using novel approach

JOSHUA ZIDE, assistant professor of materials science and engineering, has spent nearly a decade engineering nanomaterials using a technique called molecular beam epitaxy (MBE).

In his research, Zide makes a class of materials called nanocomposites that consist of metallic nanoparticles within a semi-conductor. These nanocomposites can be used in electronic devices such as transistors or in energy conversion devices such as solar cells or thermoelectrics. Typically, these devices are made of semiconductors like silicon or gallium arsenide.

While MBE produces nanoscale materials with exquisite control, the technique is slow and expensive. It also doesn't scale well for industrial applications and it isn't flexible in allowing the addition of new materials.

Zide will attempt to grow nanoscale materials in a new way through a 2012 Department of Energy Early Career Research grant from the Office of Basic Energy Sciences. One of only 68 individuals selected from a pool of nearly 850 applicants, the award will provide Zide $750,000 in research funding over five years.

Under the grant, Zide will explore the use of liquid phase epitaxy (LPE) to make nanocomposites for thermoelectrics, which are devices for generating electrical energy from heat. The work shows potential for transitioning these promising materials from the laboratory to the factory, allowing production of innovative electronic, optoelectronic and energy conversion devices.

"People have used LPE many times to make semiconductors. What we're doing is making the same kinds of nanocomposites using a hybrid approach that also employs inert gas condensation," he said.

The research team will first make the metal nanoparticles in the laboratory via inert gas condensation and then use the nanoparticles to grow materials by LPE. According to Zide, combining these two well-established, inexpensive techniques in a new way opens the door to making this class of materials in a commercially viable and scalable way.

"Instead of growing nanomaterials at one micron per hour, which is much slower than grass grows, LPE will enable us to grow nanomaterials at one micron per minute," Zide said.

"We think this could lead to a faster, better, cheaper way of making a class of nanocomposite materials with pretty exciting applications," he added.

Separating the production of the nanoparticles from the production of the film also increases the materials flexibility and enables it to be changed in ways not possible by MBE. In principle, Zide said the technique could also be applied to other materials systems, enabling researchers to combine more dissimilar materials in electronic nanocomposites.

During the project, he will collaborate and share equipment with materials science and engineering colleagues **Ismat Shah**, whose expertise lies in making nanoparticles via inert gas condensation, and **Robert Opila**, whose expertise lies in LPE.

Two graduate students will also participate in the project. One student will focus on creating the nanoparticles and the other will incorporate the nanoparticles into the films designed in Zide's laboratory and to study the materials' characterization and properties.

"This long-term funding will enable me to lead my research in an entirely new direction," Zide said.

Zide joined UD in 2007 as an assistant professor in electrical engineering with a joint appointment in mechanical engineering. He joined the materials science and engineering faculty in 2009.

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

Unusual protein may be a key to unlocking the regenerative power of certain mechanically active tissues.

UD researchers look to insect protein for treatment of vocal fold disorders

A grasshopper can leap a distance of about 20 inches. Cicadas can produce sound at about the same frequency as radio waves. Fleas jump an astonishing 100 times their height in microseconds. They do it using a naturally occurring protein called resilin.

Resilin is a protein in the composite structures found in the leg and wing joints, and sound producing organs of insects. Highly elastic, it responds to exceptionally high rates of speed and demonstrates unmatched resilience after being stretched or deformed.

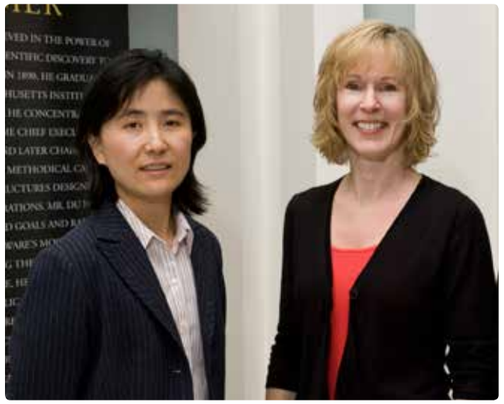
KRISTI KIICK, professor of materials science and engineering and biomedical engineering and deputy dean of the College of Engineering, believes this unusual protein may also be a key to unlocking the regenerative power of certain mechanically active tissues.

Through support from the National Science Foundation and the National Institutes of Health (NIH), the Kiick research group has developed new cell-interactive resilin-like materials that have mechanical properties similar to the natural protein and that are engineered to support the growth of multiple types of cells.

Kiick has teamed with **XINQIAO JIA**, associate professor of materials science and engineering and biomedical engineering, to explore the potential of these resilin-like materials for treating vocal fold disorders in humans.

Through support from National Institute on Deafness and Other Communication Disorders (NIDCD), the Jia research group has made significant progress towards engineering artificial vocal folds via the strategic combination of multipotent cells, biomimetic and bioactive hydrogel matrices and external high frequency vibratory stimulations.

To complement this work, Kiick's research group has developed a new polypeptide hydrogel that displays characteristics and capabilities similar to its natural resilin counterpart.



A critical element of the project is the collaborative work of the Kiick and Jia groups, which "will enable us to design new materials, develop methods to characterize and culture materials at high frequencies, and then test this new class of materials for healing vocal fold tissue," explained Kiick, principal investigator on the NIH grant funding the work.

Now, Kiick and Jia are studying these materials to determine if they can be used in vocal fold regeneration. The research team plans to culture human mesenchymal stem cells (hMSCs), taken from the bone marrow of adult patients, in these matrices under vibrations like those experienced in the vocal fold to determine if the cells become the kinds of cells found in the vocal fold. They will also investigate whether the cell-gel matrices exhibit biochemical and mechanical properties like those of healthy vocal fold tissue.

As a final step, the researchers will work in collaboration with vocal fold specialists at the University of Wisconsin Madison to test the ability of these new materials as injectable therapies to heal vocal fold scarring in laboratory models.

"In addition to their potential use for vocal fold disorders, we are excited that these novel polypeptides may ultimately be useful as a general platform in the design of materials for mechanically demanding regenerative medicine applications," added Kiick.

Article by Karen B. Roberts | Photos by Duane Perry and Kathy F. Atkinson

Advancing amputee care

Amputee Coalition of America visits UD to learn about BADER Consortium

Kendra Calhoun could barely wait to see what the winner would do.

"I called all of the groups in the running before the grant was even announced," she said.

Calhoun heads the Amputee Coalition of America, a nonprofit organization dedicated to helping the 2 million Americans who have lost a limb. The grant that captivated her was awarded by the U.S. Department of Defense - $19.5 million over five years for orthopaedic rehabilitation care to help soldiers with musculoskeletal injuries function in everyday life. It went to UD's newly established BADER (Bridging Advanced Developments for Exceptional Rehabilitation) Consortium.

Calhoun and a colleague visited UD to observe the research already under way on campus and hear about upcoming BADER Consortium projects nationwide.

Prof. Steven Stanhope, the developer of the BADER Consortium, along with several faculty members led the tour, through labs within the departments of physical therapy, mechanical engineering, materials science and engineering, kinesiology and applied physiology, as well as UD's as-yet-undeveloped Science and Technology campus.

"I hope they walk away with the concept that we have unique capabilities here," said Stanhope, professor of kinesiology and applied physiology.

Calhoun said she liked what she saw, calling the concept behind the consortium "very visionary."

Stanhope said he hopes the meeting is the start of something more. "Quite frankly, we are looking to partner with them," he said.

Calhoun arranged the encounter with a similar thought in mind. She noted that, in her experience, a team approach to amputees' care is always the gold standard. She said combining patient care with BADER Consortium research and resources "has potential magic in it."

About the BADER Consortium

Led by the University of Delaware, the BADER Consortium is establishing evidence-based orthopaedic rehabilitation for wounded warriors so that each patient can reach his or her optimal level of function.

The BADER Consortium brings together researchers, health professionals and physicians from the University of Delaware; Spaulding/Harvard Rehabilitation Hospital; the University of Texas at Austin; Christiana Care Health System, headquarters in Wilmington, De.; the Mayo Clinic; the Naval Medical Center in Portsmouth, Va.; the Naval Medical Center in San Diego; San Antonio Military Medical Center; Walter Reed Army Medical Center; C-Motion Inc. in Germantown, Md.; and the University of Michigan.

Funding is provided by the United States Department of Defense's Office of Congressionally Directed Medical Research Program through its Orthopedic Rehabilitation Clinical Consortium.

Initial clinical rehabilitation studies focus on bone health, balance and stability, optimal walking and training to run. ❖

Article by Andrea Boyle
Photo by Kathy Atkinson

Touring a physical therapy lab in McKinly Laboratory are (from left) Katherine Rudolph, associate professor of physical therapy; Steven Stanhope, professor of kinesiology and applied physiology; Brian Thiel, consultant with the Amputee Coalition of America (ACA); and Kendra Calhoun, ACA president.

Matisse mystery

Materials science reveals clues about pigment degrading on painting

Henri Matisse's painting, *Le bonheur de vivre*, is revered as one of the masterpieces that changed the course of painting in the early 20th century.

Unlike anything that came before it, with its shocking colors and radical spatial distortion, the painting caused uproar among French audiences when it was first shown in 1906, according to Martha Lucy, associate curator at The Barnes Foundation.

Matisse used a lot of vibrant yellows in the work, also known as *The Joy of Life*, particularly a warm yellow made from cadmium sulfide. Unfortunately, portions of the painting containing cadmium sulfide are turning alternately white or brown, degrading the work, which is now part of The Barnes Foundation collection in Merion, Pennsylvania, near Philadelphia.

UD materials science Prof. **ROBERT L. OPILA** is collaborating with The Barnes, and with Winterthur's Scientific Research and Analysis Laboratory, to attempt to determine why the cadmium sulfide is changing color.

"It is a very disheartening phenomenon, considering the painting's position in history," he acknowledged.

"The work is known to have invigorated fellow artists, especially Pablo Picasso, who, in an effort to outdo Matisse in terms of shock value, immediately began work on his watershed *Les Demoiselles D'Avignon*," Lucy said.

Opila's team is using X-ray Absorption Near Edge spectroscopy (XANES), sharply focused high energy light to deeply penetrate the microscopic paint chip's layers and map the material's chemical composition. The paint chips measure only about a micron, or a millionth of a meter in diameter.

Preliminary test results conducted by UD doctoral student Jonathan Church at the European Synchrotron Radiation Facility in Grenoble, France, reveal that the cadmium sulfide is deteriorating to cadmium carbonate, which is white. There is also a consistent presence of chloride in the painting, which, Church suspects, is acting as a catalyst. Additionally, carbon dioxide is reacting with the cadmium and forming cadmium carbonate.

While Opila and his research team are not yet sure where the sulfide is going; they theorize that the binder, a drying oil like linseed oil, may be turning brown.

The challenge now involves analyzing the data and developing methods to prevent further degradation of the painting. The Barnes will use this information to determine what kind of light exposure and humidity is advisable, and whether other measures, such as dimming shields, are needed to protect the work.

"The scientific studies being undertaken will contribute significantly to the preservation of the painting and to our understanding of the change that has taken place to the visual appearance of the painting," said Buckley.

Another question is whether science can convert the white and brown materials back to their original yellow form as cadmium sulfide. Opila believes it's unlikely, and said it may even be unadvisable to attempt.

"There is huge philosophy at play here because if you have a work of art that degrades over time – is the work of art the original piece or the time-integrated work of art?" Opila posed. He continued, "We may want to slow the rate of change, but I'm not sure we'd want to change it back, even if we could."

Discoveries made in this project may someday impact other post-impressionist and early modern works.

"Van Gogh's paintings also feature a large amount of cadmium sulfide-based yellow," Opila said. ❖

Article by Karen B. Roberts
Photo by Ambre Alexander

"We don't want to continue with incremental changes, we want to drastically improve the way that energy is produced."

– Robert Opila, professor of materials science and engineering

UD to partner in $18.5 million solar grant with Arizona State University

Materials scientist **ROBERT L. OPILA** is leading efforts with colleagues at Arizona State University to create a new hybrid solar cell with distinct efficiency advantages.

Silicon solar cells, like those perched on top of homes and businesses, only capture up to 20 percent of the sun's energy. Opila's work involves making traditional silicon solar cells thinner and then applying a tandem, thin-film organic solar cell on top that he said will create a huge surge in efficiency, potentially increasing energy capture from 20 to 30 percent.

"UD is setting world records for how long electrons stay excited in silicon," said Opila. "Improving collection of these long-lived electrons will improve the efficiency of the solar cells dramatically."

It could also drive down solar costs "because only sixty percent of the area and materials will be needed to achieve the same result," he added.

Opila's work is part of an inter-university effort to develop technologies and manufacturing processes needed to dramatically increase the amount of solar photovoltaic energy supplying the nation's homes and businesses. Solar currently supplies less than one percent of the electrical energy needs of the United States, according to the National Science Foundation (NSF).

Arizona State University is leading the effort, which includes creation of an Engineering Research Center (ERC) called the Quantum Energy and Sustainable Solar Technologies (QESST). The project is funded by a joint $18.5 million grant from NSF and the Department of Energy (DOE).

UD, the Massachusetts Institute of Technology, the California Institute of Technology and the University of New Mexico are co-principal investigators. In all, the project includes collaborators from eight academic institutions and 40 industry partners.

Remarked Opila, "The opportunity to work with like-minded colleagues devoted to helping solar become part of the real electrical grid is exciting."

The five-year grant will invest $1.65 million in solar funding at UD. In addition to Opila's work, UD researchers will also lead efforts to develop high efficiency thin-film solar cells and advance governmental policies to ensure solar energy technology is viable in the marketplace. ❖

Article by Karen B. Roberts | Photo by Evan Krape

ABOUT THE UD RESEARCH TEAM

The University of Delaware's Institute of Energy Conversion (IEC) has been a leader in the research and development of thin-film photovoltaic solar cells and other photonic devices since 1972. The UD IEC was recognized by the DOE and the National Renewable Energy Laboratory in 1992 for its efforts in thin film photovoltaics, and was designated as a Center of Excellence for Photovoltaic Research and Education.

According to **Bob Opila**, world records for high efficiency thin-film solar cells made from copper-indium-gallium-selenide (CIGS) have only recently reached twenty percent.

William N. Shafarman, assistant professor in materials science and IEC scientist, is developing a way to increase this energy output of CIGS by enhancing the structure from a simple CIGS solar cell to a tandem CIGS solar cell. Shafarman predicts the new CIGS tandems can increase efficiencies from 20 percent to 30 percent.

"Typically as you increase band gap, efficiency suffers dramatically, but we think we have a route forward here," explained Shafarman.

Babatunde A. Ogunnaike, interim dean of engineering and William L. Friend Professor of Chemical Engineering, will design a new state-of-the-art reactor to manufacture the new CIGS cells in conjunction with **Robert Birkmire**, IEC director.

Clean energy economy expert **John Byrne**, director of the Center for Energy and Environmental Policy and Distinguished Professor of Energy and Climate Policy in the College of Engineering, will develop policies to successfully integrate solar into the marketplace in both the near and the long term.

Pictured are: Juejun Hu (left) and Bob Birkmire (right)

DOE SunShot grant helps Hu advance solar research

JUEJUN HU, assistant professor in UD's Department of Materials Science and Engineering, will lead a $1,278,110 project to create a coating on solar cells that will increase the absorption of light and increase solar cell efficiencies.

Funded through the SunShot Initiative sponsored by the U.S. Department of Energy (DOE), the four-year project will be conducted in collaboration with UD's Institute of Energy Conversion, and Clemson University's School of Materials Science and Engineering. Hu's is one of five grants and one subcontract awarded to the University of Delaware.

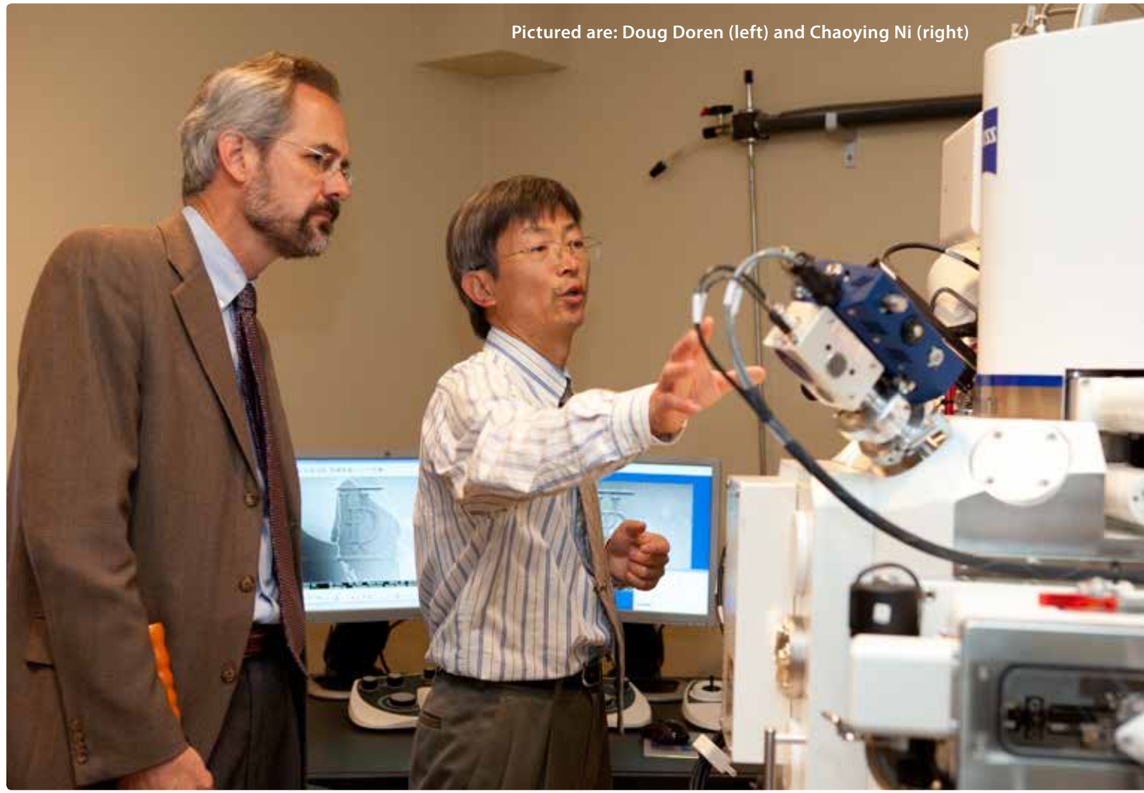
Adapted from article by Tracey Bryant | Photo by Kathy Atkinson

'Sensor-on-a-chip' wins EPSCoR seed grant for monitoring air and water quality

Chaoying Ni of the Department of Materials Science and Engineering will work with Juejun Hu to develop chip-scale sensors for the detection of organic, inorganic and biological species with minimal power consumption.

Their work will be funded through a seed grant from the National Science Foundation's Delaware Experimental Program to Stimulate Competitive Research (EPSCoR). If successful, it may provide the basis for a network of sensors capable of monitoring air and water contaminants in real time.

Adapted from article by Jacob Crum | Photos by Ambre Alexander and Kathy F. Atkinson



Pictured are: Doug Doren (left) and Chaoying Ni (right)

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DuPont Central Research and Development

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KENNETH SCHWEIZER
University of Illinois at Urbana – Champaign

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Chemical Eng. & Materials Science,
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University of Massachusetts

December 5
ARTHI JAYARAMAN
University of Colorado at Boulder

Sophisticated microscope elevates UD research capability

DARRIN J. POCHAN, professor of materials science and engineering, is among many UD researchers now using the new Zeiss AURIGA CrossBeam microscope to advance his work.

From left, Michael Rauscher, director, product segment CrossBeam, Carl Zeiss NTS; Dan McGee, president, Carl Zeiss NTS; David Martin, chair of the UD Department of Materials Science and Engineering; and Jim Sharp, president, Carl Zeiss Microscopy.

The sophisticated dual beam focused ion beam and scanning electron microscope (FIB-SEM), capable of both nanoscale deposition and machining, provides high-resolution imaging and a wide variety of analytical capabilities. It enables research for both soft and hard materials, including polymers, biomaterials, ceramics, metals, semiconductors, composites and more.

Pochan uses it to characterize and engineer nanostructure and materials through the assembly of molecules in solution.

"One area we focus on is the assembly of soft materials from peptides that are excellent candidates for the delivery of drug therapies or the regeneration of diseased tissues inside the body," Pochan explained.

The microscope is designed to derive maximum information out of a material sample using advanced analytics. For materials analysis, researchers can create 3D imaging and analysis of non-conducting materials, patterning of complex nanostructures and high resolution ion imaging, as well as simultaneous detection of topographical and compositional information.

Since the microscope also allows material to be deposited, it opens to the door for designing and creating entirely new structures in the lab at the nanoscale.

"While we currently control the nanostructure of these and other materials through the proper design of the molecules that make them, we would like to be able to further pattern these materials on the nanoscale with FIB after they have been assembled and formed, in order to fine-tune the nanostructure present for desired interactions with living systems," he continued.

The microscope is the first major acquisition for the 194,000-square-foot Interdisciplinary Science and Engineering Laboratory (ISE-Lab) now under construction at UD. Temporarily installed in Spencer Laboratory, the instrument is available to all members of the University community, as well as UD partners in industry, government and academia.

"This instrument is an excellent example of the opportunities that will be provided by the ISE-Lab, including the ability to produce valuable research results," noted David C. Martin, chair of the Department of Materials Science and Engineering.

Adapted from article by Karen B. Roberts
Photo by Ambre Alexander

A few ISE-Lab naming opportunities to consider:

$25,000	Faculty Office or Meeting/Conference Room
$100,000	Group Study Room
$250,000	Rain Garden (the ISE Lab will be a green building)
$500,000	Main Lobby
$1 million	Advanced Materials Characterization Lab or Microscopy Suite
$2.5 million	Clean Room

ISE-Lab to inspire students through problem-based learning with real-world approach

Scheduled for completion in 2013, the University of Delaware's Interdisciplinary Science and Engineering Laboratory (ISE-Lab) will bring together teaching, learning and research in an integrated way, with research providing content for the curriculum and students learning through exploration of real-world problems.

Located at the corner of Lovett Avenue and Academy Street, the 194,000-square-foot ISE-Lab will include classrooms and teaching laboratories, core research facilities for teams of researchers and space for the University of Delaware Energy Institute, the Delaware Environmental Institute and the Catalysis Center for Energy Innovation.

The ISE-Lab 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, among other things.

You can help ensure that future MSEG grads and faculty choose UD for their education and research by supporting the ISE-Lab project and its collaborative learning environments.

Fellow alumnus Chaoying Ni ('97 PhD MSE), associate professor of materials science and director of the College of Engineering's W.M. Keck Electron Microscopy Facility, along with his wife Yi -Wei Dai ('98/BSN), are among those supporting the ISE-Lab through their generous gift of a faculty conference room. "I support the ISE Lab because it will house an advanced microscopy facility that will enable cutting-edge research and training, and will directly contribute to the local and regional economy," he said.

David Martin, Karl W. and Renate Böer Professor and MSEG chair, likewise stresses the importance of supporting the ISE-Lab as a place where scientists and engineers will have "access to the most sophisticated instrumentation and processing equipment."

"This is absolutely the key to retaining current faculty and attracting new faculty and students. In today's world, the best people go where they know they will have the tools to perform their work at the highest level," remarked Martin.

Your gift to the ISE-Lab will help attract the best to UD.

Naming opportunities in the ISE Lab start at $25,000. Think such a gift is beyond your means? When broken down to $5,000 per year over five-years, many would-be alumni donors find their desire to support UD is quite attainable. If your employer offers matching gifts, it's even easier to make a named gift – in your own name, for a family member, in memory of a fellow alumnus or colleague or perhaps in honor of a favorite faculty member. Some donors have even supported the project through their own company or family foundation.

I would be happy to talk to you about your giving goals and find a way to help turn your ideas into reality.

To stay informed of the project's progress, visit the ISE-Lab website, www.udel.edu/iselab. To make a gift, please visit www.udel.edu/development/makeagift.

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College of Engineering

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