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RESEARCH AT

NEBRASKA

THE UNIVERSITY OF NEBRASKA–LINCOLN

2015-2016 REPORT

Laser Creates Surfaces that Mimic Nature

Shark skin, rose petals and moth eyes.

This isn't a weird memory test. It's the seemingly random starting point of Dennis Alexander's research. Each of these biological systems has a unique capability that the UNL engineer's team is exploiting for defense and industrial purposes.

Alexander and colleagues use lasers to copy microscopic structures found in nature onto metal surfaces, giving them similar unique properties already honed by Mother Nature.

"Our structures are very important to the military, Boeing and NASA," said Alexander, Kingery Professor of Electrical and Computer Engineering. "We're emphasizing using these structures in harsh environments, but there really isn't any metal surface we can't functionalize."

His team uses femtosecond laser surface processing, or short-burst laser pulses, to alter the top 100 microns of a metal surface, about the depth of a human hair, producing surfaces that mimic nature. Altering the laser angle and other parameters creates surfaces with different properties.

Sharks, for example, are highly efficient swimmers. By copying their microscale skin onto metal, researchers create a super-hydrophilic, or wicking, material. This property reduces drag, so a shark skin-like submarine shell, for example, would be able to travel farther using less power.

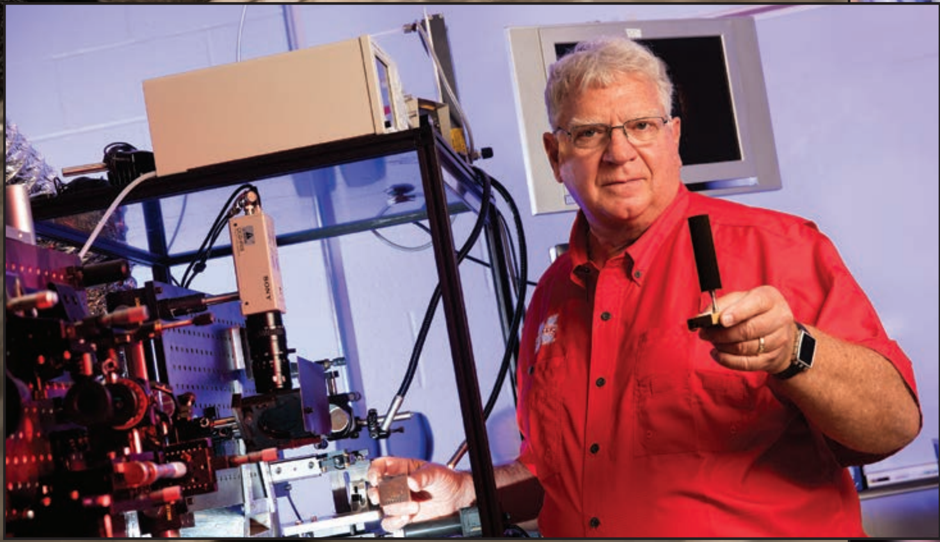
UNL's laser-created surfaces also improve heat transfer, important to many military and commercial systems.

Rose petals, in contrast, are super-hydrophobic. Rainwater slides off in beads. Super-hydrophobic surfaces also reduce drag. Applications include medical supplies that can't be contaminated by blood or other fluids, antibacterial metals for joint replacements, reducing ice buildup on traffic lights and improving condenser heat exchangers, including those used to reclaim water in space.

Current hydrophobic materials are created with a polymer coating that adds weight and eventually breaks down, creating undrinkable water. For the International Space Station, where recycling water is paramount, a super-hydrophilic condenser would avoid these problems. Alexander's team works with NASA on improved heat exchangers.

Remember moth eyes? To see at night and avoid detection by predators, moths absorb a wide spectrum of light. Mimicking the eye's surface creates an anti-reflective metal, improving solar panel efficiency and making stealth aircraft harder to track.

NU's National Strategic Research Institute and NASA fund this research.



Dennis Alexander

Demonstrating super-hydrophilic material

USSTRATCOM Delegation Visits UNL

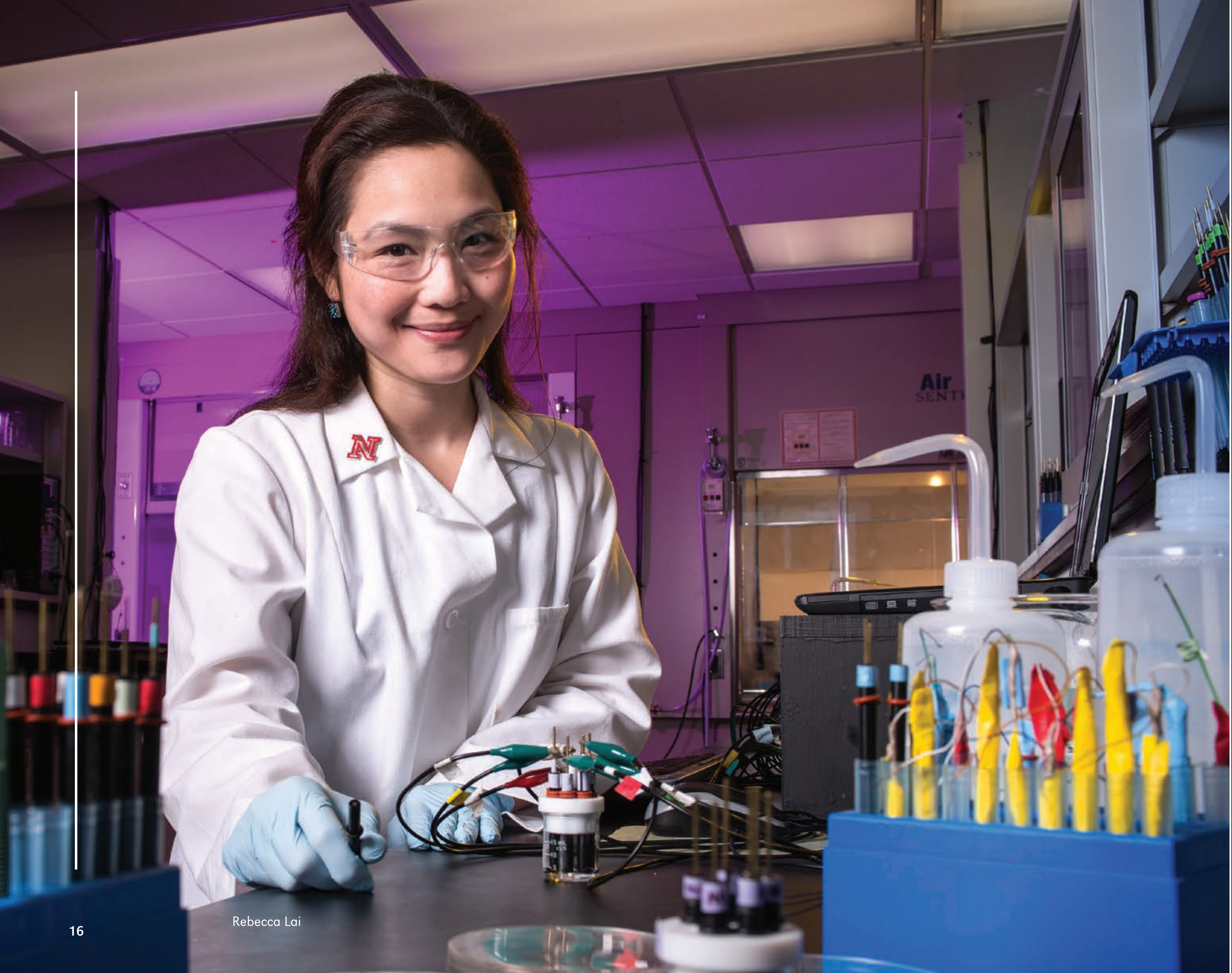
UNL is expanding its innovative defense-related research through the National Strategic Research Institute at the University of Nebraska, one of only 13 U.S. Department of Defense-sponsored University Affiliated Research Centers in the nation.

NSRI-funded projects like engineer Dennis Alexander's laser surfacing of metals have put UNL research on the radar of NSRI's sponsor, the U.S. Strategic Command.

USSTRATCOM executives learned about UNL research with potential defense applications and explored potential areas of collaboration during an April 2016 campus visit. Tours of the Extreme Light Laboratory, Holland Computing Center, Center for Brain, Biology and Behavior and the Nebraska Athletics Performance Laboratory and presentations by faculty from business, computer science, transportation, engineering, physics and food microbiology provided an overview of UNL's capabilities.

Three areas of potential UNL-USSTRATCOM collaboration grew from the visit: developing innovative leadership education and training programs through UNL's Don Clifton Strengths Institute to meet USSTRATCOM's workforce development needs; researching security against cyber threats with UNL computer scientists; and creating simulations with UNL engineers to detect and disrupt proliferation of nuclear weapons.

U.S. Army Maj. Gen. Allen W. Batschelet (left) and USSTRATCOM executives hear from NSRI research director and UNL associate vice chancellor for research Bill Charlton at a campus visit.



Rebecca Lai

Prospecting with Biosensors at Home or in the Field

Prospecting – whether for gold in a mountain or lead in a city's water supply – may one day be as quick and easy as a litmus test.

UNL chemist Rebecca Lai is developing a series of hand-held biosensors to detect a variety of metals, including gold, silver, lead, platinum and mercury. Instead of sending samples away for time-consuming tests, Lai's portable devices can be used in the field or home, saving much time and money.

The reusable sensors, fabricated on paper strips, can handle water, air and solid samples. This flexibility opens numerous opportunities, for mining companies foraging for gold or regulators hunting down water or air contaminants. Homeowners may one day be able to use the sensors to test their tap water or yards for heavy metals.

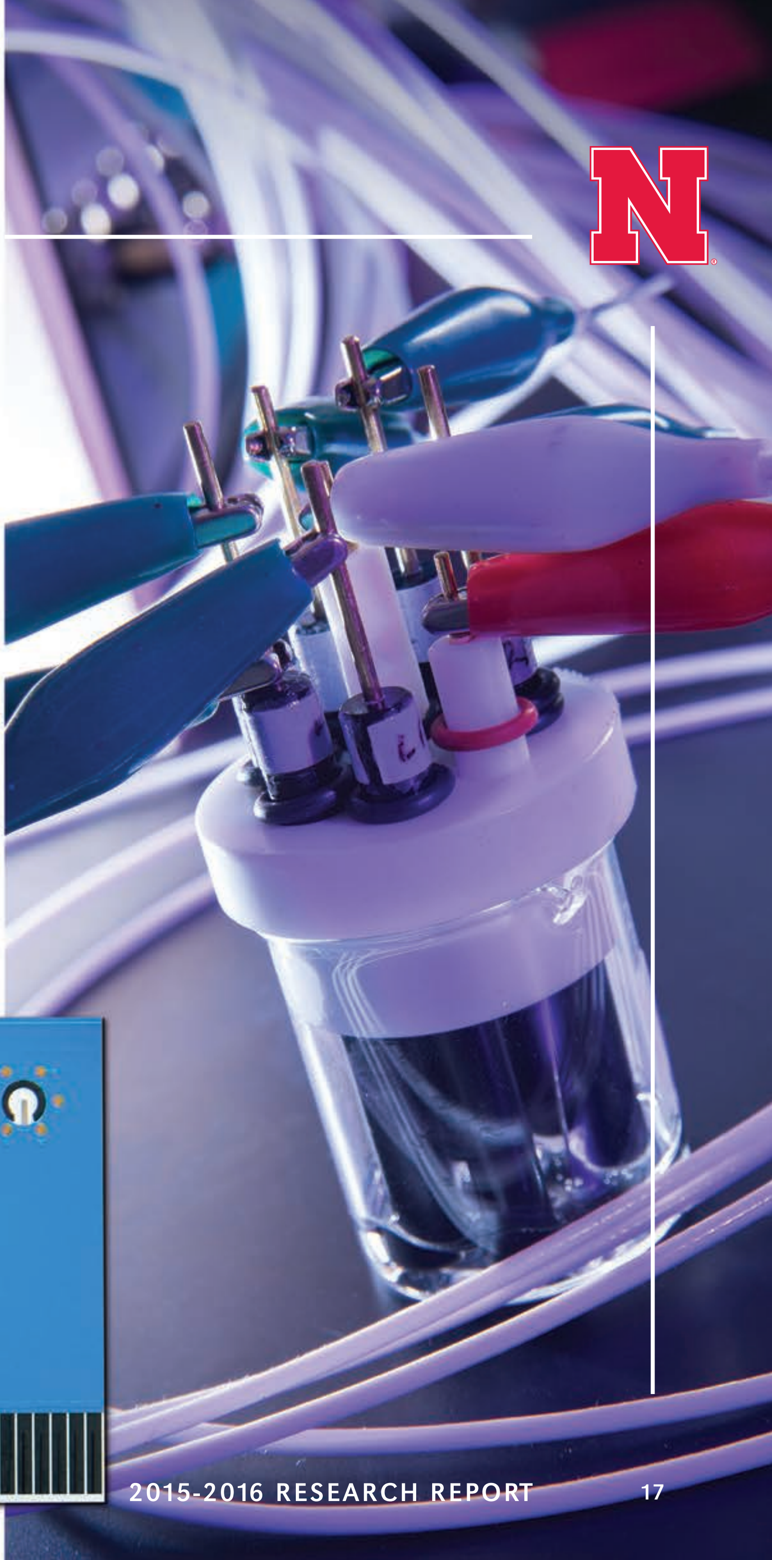
"Geochemical exploration for gold is becoming increasingly important to the mining industry," Lai said. "There is a need for developing sensitive, selective and cost-effective analytical methods capable of identifying and quantifying gold in complex environmental samples."

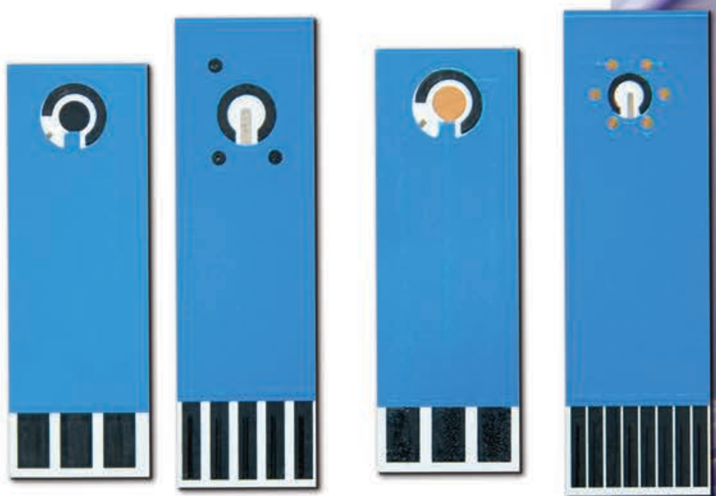
The metal sensors rely on a surprising source: DNA's building blocks. Researchers have long known that metal ions recognize and react to different DNA or other molecular building blocks. Lai's sensors exploit that reaction.

They work by measuring the electric current passing from an electrode to methylene blue, a tracer molecule, attached to a molecular probe specific to each metal type. The current changes in the presence of the metal being tested.

To help combat contaminants found in groundwater, Lai also plans to develop biosensors to detect arsenic, uranium and selenium. She uses a similar approach to devise biosensors for viral antibodies, antibiotics and nitrates.

Lai is working with NUtech Ventures, UNL's technology commercialization affiliate, to patent and license the biosensors. The National Science Foundation and the U.S. Environmental Protection Agency support her research.





Paper-based sensor strips detect target substances, including mercury, gold, lead and uranium.

Strengthening Region's Nanotech Assets

University and industry scientists across the region are tapping a new resource at UNL designed to strengthen the nation's nanoscience research.

UNL became home to the Nebraska Nanoscale Facility, a center of excellence in nanoscience and nanotechnology, in fall 2015. A nearly $3.5 million grant from the National Science Foundation funds the center, one of only 16 nationwide that constitute the National Nanotechnology Coordinated Infrastructure.

"There is a need for regional facilities," said center director David Sellmyer, George Holmes University Professor of Physics. "Most universities do not have the resources to buy and operate these very expensive pieces of machinery."

The center builds on UNL's highly regarded reputation in materials and nanoscience research. While state-of-the-art facilities have helped UNL researchers make significant contributions to nanotechnology advancements, the university previously had limited capacity to serve researchers and industries beyond UNL, he said.

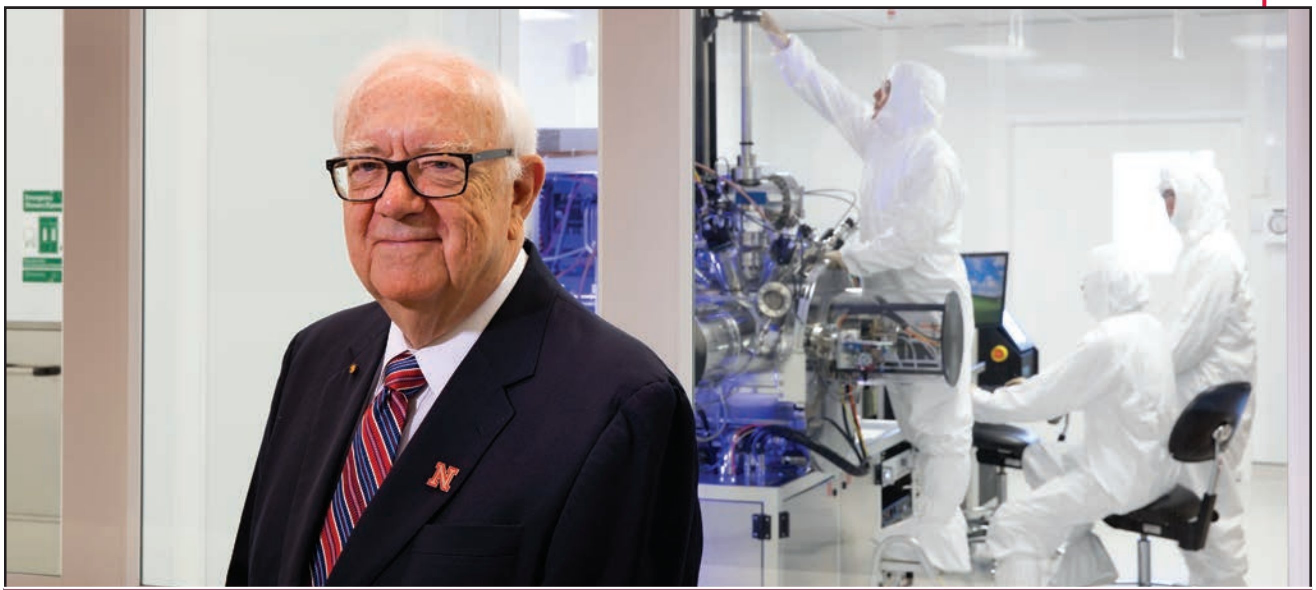
The new center uses shared laboratory facilities and specialized equipment, principally housed in UNL's Voelte-Keegan Nanoscience Research Center, which opened in 2012.

Through the center, UNL makes instrumentation and technical support available to researchers from neighboring universities, companies and others. It has added personnel, purchased new equipment and is offering workshops and mini-courses to introduce visiting scientists to available resources.

Bolstering nanoscience and nanotechnology strengthens regional and national research collaborations and contributes to economic development throughout the U.S., Sellmyer said.

"We are well set up to do a lot of things now," he said. "With a larger scientific staff, we're able to do a better job at helping companies in Nebraska and neighboring states with their technical problems."

The facility reinforces the university's materials and nanoscience programs and centers, including the Nebraska Center for Materials and Nanoscience; the NSF-funded Materials Research Science and Engineering Center; the Center for NanoFerroic Devices, funded by the Semiconductor Research Corp. and the National Institute of Standards and Technology; the National Strategic Research Institute, which partners with USSTRATCOM; and others.

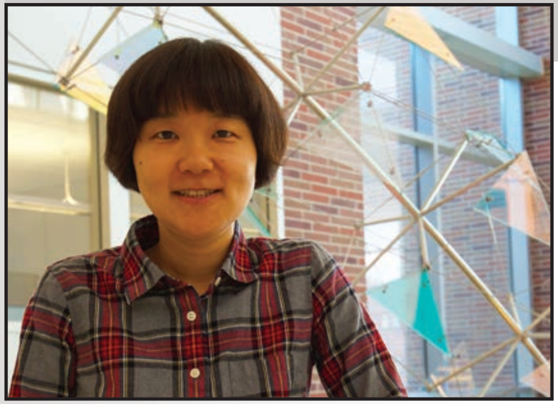


David Sellmyer

Early Career Awards Boost Promising Research

From smarter computers, robots and power grids to genetic advances and greener chemistry, UNL researchers are solving diverse problems with early career awards from the National Science Foundation and U.S. Department of Energy. These prestigious five-year awards support research by promising pre-tenure faculty. Eight UNL assistant professors won these awards in 2015-2016.

Gaining Control at the Nanoscale

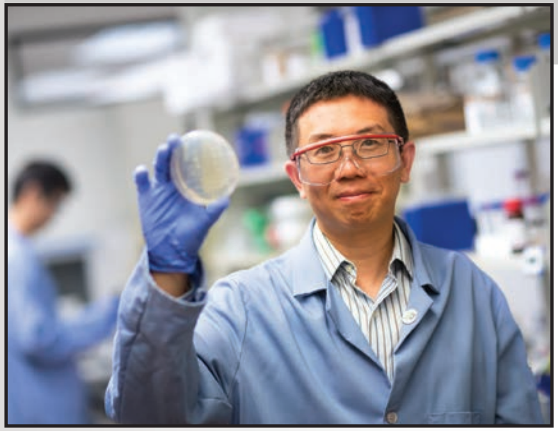


Controlling certain materials' polarization and other properties at the nanoscale could make electronics smaller, faster and less expensive. Physicist Xia Hong received a $750,000 DOE Early Career Award to upgrade equipment and hire researchers essential to that pursuit.

Hong studies extremely thin ferroelectric films, meaning their polarization – the alignment of their positive and negative charges – can be reversed when exposed to an electric field. Combining ferroelectric films with other 2-D materials could produce reconfigurable electronic states that help her team observe new quantum phenomena and expand the versatility of technologies ranging from solar cells to transistors.

Hong said her approach also could help overcome uncertainty inherent in manufacturing and testing nanoscale technology.

Expanding the Genetic Code



Chemist Jiantao Guo envisions expanding the genetic code to create innumerable possibilities for research and commerce, from developing pharmaceuticals to improving crop yields. He earned a $622,000 NSF CAREER award to continue working on a promising new method for incorporating new amino acids into proteins.

Organisms build proteins by linking amino acids, the order specified by the sequence arrangement of nucleotides, DNA's basic structural unit. Three-nucleotide sequences, called codons, identify a single amino acid. Increasing from three-nucleotide to four-nucleotide codons would significantly expand the repertoire of potential amino acids.

Previously, Guo created a tRNA, a molecule critical to linking amino acids together, that is capable of reading quadruplet codons. His discovery expands the potential to encode more artificial amino acids into living cells. With this award, Guo continues investigating quadruplet codon-reading tRNAs.

Spintronics for Ultralow-power Devices

Physicist Alexey Kovalev studies the fundamental properties of magnetic systems at the nanoscale with a $750,000 DOE Early Career Award.

Kovalev's theoretical research focuses on spintronics, which controls electron spin in addition to charge, to generate power and store digital information. His research could lead to developing ultralow-power memory devices for computers and other electronic devices.

Today's hard drives manipulate electron charge and magnetic spin to store information. Kovalev is investigating the strong spin-orbit interactions and interplay between spin and energy flows in magnetic systems. His work also could improve harvesting energy available in temperature gradients (or differences) to power electronic devices.

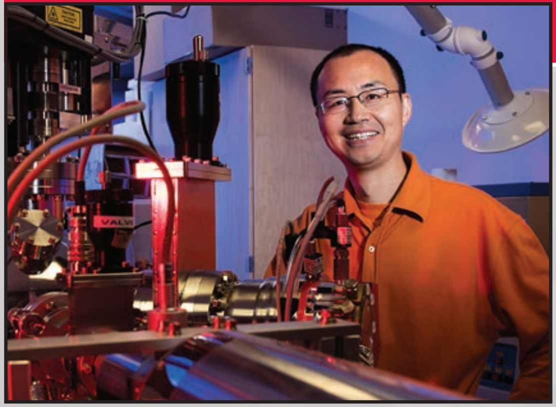
Stretching Possibilities for Hybrid Materials

Combining soft, organic materials with hard, inorganic ones could add important functionality to robotics and other emerging technologies. With a $650,000 NSF CAREER award, chemist Stephen Morin is crafting hybrid materials that could provide diverse properties for many applications.

Morin is exploring how best to deposit rigid films atop the surfaces of elastic polymers. One challenge lies in the different thermal and mechanical properties of the two materials; another is melding a brittle material with something as elastic as a rubber band.

Morin is especially interested in how stretching a polymer affects the harder material's formation and structure. He's already built adaptable patterns of microscopic crystals on rubber films and created elastic materials that become highly reflective when stretched.

Harnessing a Nanomaterial's Novel Properties

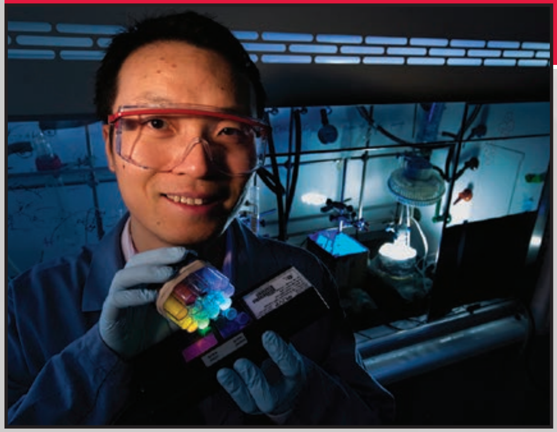


To make electronics smaller, faster and more energy efficient, physicist Xiaoshan Xu earned a $590,000 NSF CAREER award. He's investigating hexagonal ferrite, a nanomaterial with the rare quality of having both magnetic and electric polarizations.

Harnessing that unique property could help shift electronics away from requiring an electric current, which uses energy and produces heat, limiting the efficiency and size of devices.

Previously, Xu helped discover the nanomaterial's multiferroic properties. Now, he's studying the fundamental mechanism underlying the coexistence of electric and magnetic properties and how to couple them for use in devices. The material's multiferroic capability functions at a nippy minus 220 degrees Fahrenheit, so Xu also is investigating ways to raise its functional range to above room temperature.

Green Chemistry Catalyst



Producing clean energy fuels and other "green" chemicals using solar energy isn't as sustainable as it could be. Solar-powered chemical reactions often require a catalyst made with rare and expensive metals.

Chemist Jian Zhang developed a solar-powered, organic-based catalyst to facilitate chemical reactions. With a $527,000 NSF CAREER award, he is further investigating and improving its properties for industrial uses. The material, a type of porous organic framework, acts like a semiconductor, encouraging electrons to move when hit with solar energy.

Industry could use the organic catalyst to develop more environmentally friendly products, including cleaner hydrocarbon-based fuels. Zhang also is investigating using the catalyst to break down lignin, an abundant plant-based carbon source, for use in creating industrial products, such as pharmaceuticals and biofuels.

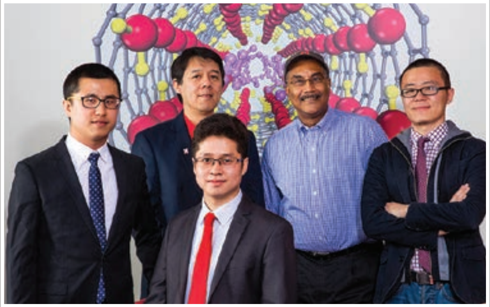
From left, Heriberto Cerutti, Zhen Wang, Jean-Jack Riethoven and Chi Zhang

Finding Genetic Clues to Drought Resistance

UNL biologists have uncovered clues about the collective role two genes play in protecting plants against drought. Their discoveries are an important step toward developing crops better able to defend against challenging environmental conditions. Heriberto Cerutti and colleagues studied the results of breeding a mutant variety of model plant species *Arabidopsis thaliana* that effectively deactivated both genes. The mutations stunted plant growth and increased susceptibility to drought. The team discovered that the double-mutant plants lack two kinases, catalysts required to facilitate histone phosphorylation. Research suggests that adding phosphate molecules to histone proteins helps optimize plant responses to environmental cues. They reported their findings in the *Proceedings of the National Academy of Sciences*. The National Science Foundation funded the research.

Solving Nitrous Acid Puzzle

UNL chemists have solved the long-standing puzzle of how nitrous acid forms in Earth's lower atmosphere, where it contributes to both cleansing and polluting. Scientists first detected nitrous acid in the 1970s, but how it forms in the ionosphere remained unclear. Through quantum mechanics-based simulations, the UNL team identified how the atmosphere's charged atoms and electrons combine to form nitrous acid 40 to 55 miles above the Earth. This discovery contributes to better understanding of how to manage human activities that harm health and the environment, said study co-author Joe Francisco, Elmer H. and Ruby M. Cordes Chair in Chemistry and dean of the College of Arts and Sciences. Xiao Cheng Zeng, Ameritas University Professor of Chemistry, and colleagues co-authored the study, which appeared in the *Proceedings of the National Academy of Sciences.*



From left, Chongqin Zhu, Xiao Cheng Zeng, Lei Li, Joe Francisco and Jie Zhong

McCornick Heads Water for Food Institute

Peter G. McCornick, an internationally known water and food researcher, became the new executive director of the Robert B. Daugherty Water for Food Global Institute at the University of Nebraska in August 2016. McCornick is former deputy director general for research at the International Water Management Institute in Colombo, Sri Lanka. He has dedicated his career to improving sustainable water resource management and has led research and development programs on water, agriculture and the environment in Africa, Asia, the Middle East and the U.S. McCornick earned his doctorate in agricultural engineering from Colorado State University and has been a senior fellow at Duke University's Nicholas Institute for Environmental Policy Solutions. The Scotland native grew up on a livestock and dairy farm. He succeeded Roberto Lenton, the institute's founding executive director.

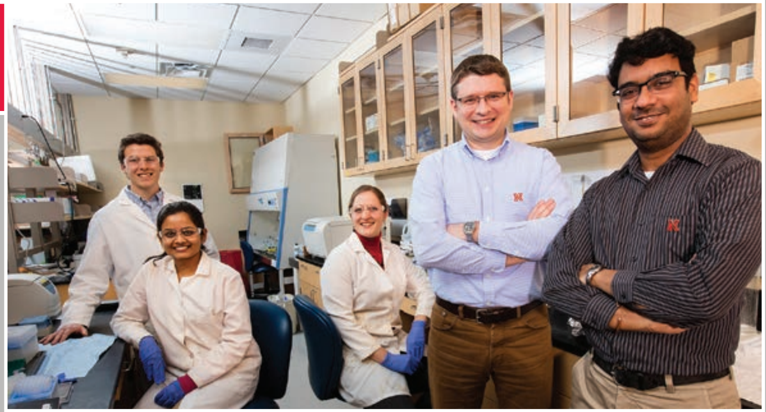
Fritz Co-leads Climate Change Group

UNL geoscientist Sherilyn Fritz is co-chairing the international Scientific Steering Committee for Past Global Changes, or PAGES. The organization includes scientists from 125 countries and sponsors research exploring climate shifts across millions of years to better predict future climate and environment. During her two-year term, Fritz will guide decisions on the diverse international PAGES-sponsored research. She'll also advance the organization's effort to engage more closely with policymakers, resource managers and business leaders. Sharing research results with those who can use them is increasingly important in promoting sustainable practices, she said. Formed in 1991 with support from the U.S. and Swiss National Science Foundations, PAGES features a co-chair from each country. Fritz, George Holmes University Professor of Earth and Atmospheric Sciences, studies North and South American lakes to better understand historic climate change.

Research Highlights

Common Nanoparticle May Harm Brain

Even moderate concentrations of a common nanoparticle used to whiten foods, milk and toothpaste could compromise the brain, UNL research found. Biochemist Oleh Khalimonchuk, engineer Srivatsan Kidambi and colleagues examined how three types of titanium dioxide nanoparticles affect the functioning of astrocyte cells, which play important roles in cognition, memory and learning. The team found that many rat-derived astrocyte cells died following exposure to titanium dioxide and those cells that survived were severely impaired. Evidence suggests these nanoparticles can cross the blood-brain barrier, but more research is needed, Khalimonchuk said. The study was featured on the cover of *Nanoscale.* The National Institutes of Health funds this research.

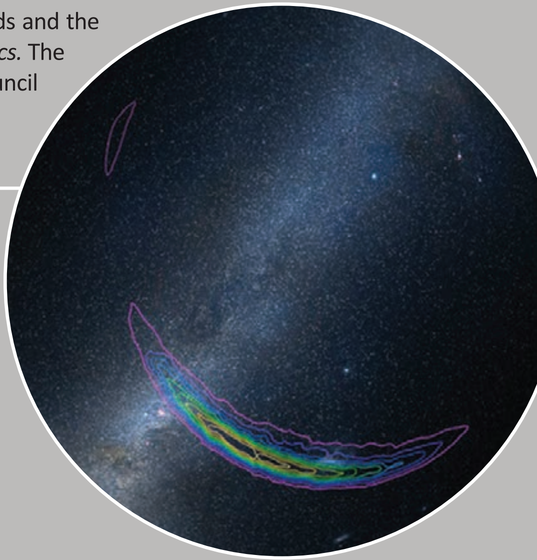


From left, Stephen Hayward, Vaishaali Natarajan, Christina Wilson, Oleh Khalimonchuk and Srivatsan Kidambi

Methylammonium lead tribromide crystals

Safer Material for X-rays

UNL engineers have identified a material that could reduce the risk of X-ray exposure. Used for more than a century to detect broken bones, X-rays are increasingly employed at security checkpoints. But exposure poses a cancer risk, particularly for youngsters. Jinsong Huang, Susan J. Rosowski Associate Professor of Mechanical and Materials Engineering, and colleagues discovered that methylammonium lead tribromide, a type of perovskite crystal, is four times more sensitive to X-rays than leading commercial detectors. This property could allow for lower X-ray doses in medical and security settings, making the material a substantial upgrade over the commonly used amorphous selenium, Huang said. Huang and collaborators at Ohio State University, University of Groningen in the Netherlands and the University of Rochester reported their findings in *Nature Photonics.* The Defense Threat Reduction Agency, the European Research Council and the National Science Foundation funded this research.



Detecting Gravitational Waves

The university's Holland Computing Center helped make history as part of the global supercomputing network that detected gravitational waves emerging from colliding black holes, a scientific first. UNL is part of the Open Science Grid, which provided computing assistance to the U.S.-based Laser Interferometer Gravitational-Wave Observatory, or LIGO, which led the research. The grid, a global consortium of over 125 institutions, offers its collective large-scale computing power to scientific projects. Holland served as a hub for distributing LIGO's data to 15 computing clusters nationwide, said UNL computer scientist Brian Bockelman, who leads an Open Science Grid division.

Accolades

Eight UNL Faculty Named AAAS Fellows

David Berkowitz, Scott Gardner, Ronnie Green, Andrzej Rajca, Mark Riley, Daniel Schachtman, Janos Zempleni and **Tian Zhang** were named American Association for the Advancement of Science Fellows in 2015. It was the first time eight UNL scientists were elected fellows in the same year.

- **Berkowitz,** Willa Cather Professor of Chemistry and chair of chemistry, was recognized for contributions to chemical biology and synthetic chemistry.
- **Gardner,** professor of biological sciences and parasitology curator at the University of Nebraska State Museum, was recognized for contributions to parasitology and biodiversity.
- **Green,** UNL chancellor and professor of animal science, was honored for contributions to quantitative genetics and advancement of science through academic and federal administration, advocacy and service.
- **Rajca,** Charles Bessey Professor of Chemistry, was recognized for contributions to organic magnetic materials.
- **Riley,** professor and department head of biological systems engineering, was recognized for contributions to biological engineering.
- **Schachtman,** professor of agronomy and horticulture and director of UNL's Center for Biotechnology, was honored for service to the life sciences and contributions to plant molecular physiology.
- **Zempleni,** Willa Cather Professor of Molecular Nutrition and director of the Nebraska Center for the Prevention of Obesity Diseases through Dietary Molecules and of the Nebraska Gateway to Nutrigenomics, was recognized for contributions to nutrition research.
- **Zhang,** professor of civil engineering, was honored for exemplary professional work and research, prolific contribution to technical literature and voluntary activities as a technical expert and global adviser.

William G. Thomas III, John and Catherine Angle Professor in the Humanities and professor of history, received a John Simon Guggenheim Memorial Foundation Fellowship to research his book *A Question of Freedom: The Ordeal of an American Family in the Age of Revolution,* which chronicles a mixed-race family's history over four generations in Maryland. Thomas, a pioneer in digital history, specializes in the Civil War, the U.S. South and slavery.

Terri Norton, associate professor of construction engineering, earned a Fulbright Scholar grant to travel to Japan and research the country's faster-than-expected recovery from a devastating earthquake and tsunami in 2011. The grant also allows her to investigate how people in the U.S. have responded to major disasters.

Galen Erickson, Nebraska Cattle Industry Professor of Animal Science, received the American Feed Industry Association Award in Ruminant Nutrition Research from the American Society of Animal Science.

William Kranz, professor of biological systems engineering, received the 2015 Heermann Sprinkler Irrigation Award from the American Society of Agricultural and Biological Engineers in recognition of his outstanding contributions toward the advancement and worldwide adoption of sprinkler irrigation systems.

Kathy Krone, professor of communication studies, received the Charles H. Woolbert Research Award from the National Communication Association. The award honors scholars whose journal article or book chapter stimulates new concepts of communication phenomena. The award recognizes Krone's work with a colleague for a *Journal of Applied Communication Research* article, "The policy exists but you can't really use it: Communication and the structuration of work-family policies."

James Van Etten, William B. Allington Distinguished Professor of Plant Pathology, earned the Award of Distinction of the American Phytopathological Society. The society's highest honor, this award is presented on rare occasions to people who have made exceptional contributions to plant pathology. An international leader in algal virology, Van Etten is a member of the National Academy of Sciences.

John Brunero, Robert R. Chambers Distinguished Associate Professor of Philosophy, won the 2016 Article Prize from the American Philosophical Association for his "Cognitivism about Practical Rationality," published in *Oxford Studies in Metaethics, Volume 9.*

Tian Zhang, professor of civil engineering, and **John Stansbury,** associate professor and associate chair of civil engineering, won the Rudolph Hering Medal from the American Society of Civil Engineers. The award honors their *Journal of Environmental Engineering* article, "Contributions of Internal and External Fouling to Transmembrane Pressure in MBRs: Experiments and Modeling."

Patricio Grassini, assistant professor of agronomy and horticulture, received the 2016 Early Career Professional Award from the American Society of Agronomy for outstanding contributions in agronomy. Grassini is an internationally recognized authority on crop yield gaps and input-use efficiency.

Research Driving Nanomaterials' Huge Potential

The semiconductors powering modern electronics are fast approaching their functional limits, threatening further advancements in computing technology.

Scientists and engineers in UNL's Materials Research Science and Engineering Center lead basic research needed to create a new generation of electronic and computing technologies.

UNL established this highly collaborative center in 2002 with a $5.4 million National Science Foundation grant. In 2008, NSF awarded $8.1 million to continue the center. A new $9.6 million grant funds its work through 2020.

"Ten years ago, it was hard to imagine how vigorously nanomaterials research would advance in Nebraska. Now, we are among the leaders in the field," said Evgeny Tsymbal, George Holmes University Professor of Physics and MRSEC director.

Major advances in understanding nanomaterials' unique properties underpin the center's success.

Now called Polarization and Spin Phenomena in Nanoferroic Structures, or P-SPINS, the center focuses on two key research areas. Each aims to create new nanomaterials to enable smaller, more powerful and energy-efficient computers and other electronics.

Magnetoelectric materials and functional interfaces research builds on UNL physicist Christian Binek's advances in spintronics and nanomagnetism. This team is developing voltage-powered logic and memory devices.

The second focus on polarization-enabled electronic phenomena evolved from Tsymbal's theoretical predictions and physicist Alexei Gruverman's experimental work on quantum tunneling through a nano-thin ferroelectric barrier. This team is investigating novel ferroelectric materials and structures to advance nanoelectronics.

MRSEC faculty also are developing more efficient solar cells, superior magnetic and nanoscale structural materials, and techniques to better understand nanomaterial properties.

Through the center, 18 UNL researchers from diverse disciplines share expertise. Faculty also collaborate with scientists nationally and internationally.

To transform MRSEC's discoveries into products, the center partners with industry. For example, faculty work with UNL's Center for Nanoferroic Devices, funded jointly by an industry consortium and the National Institute for Standards and Technology.

MRSEC also is known for its educational and outreach programs.

"I believe we now have the strongest, most coherent, most accomplished team yet," said Axel Enders, a UNL physicist and associate center director. "I have no doubts we're going to be awesome."

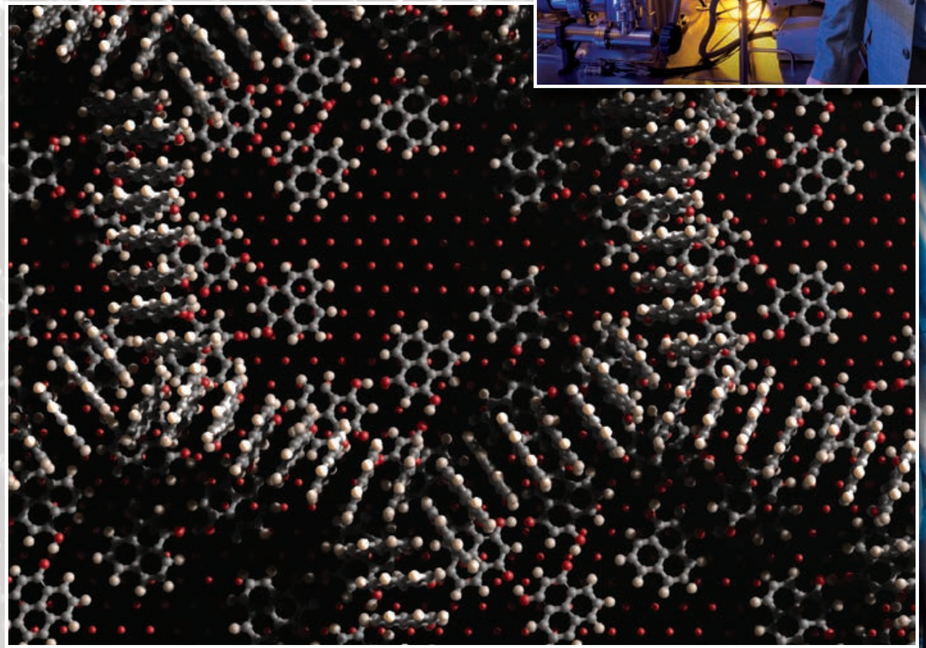
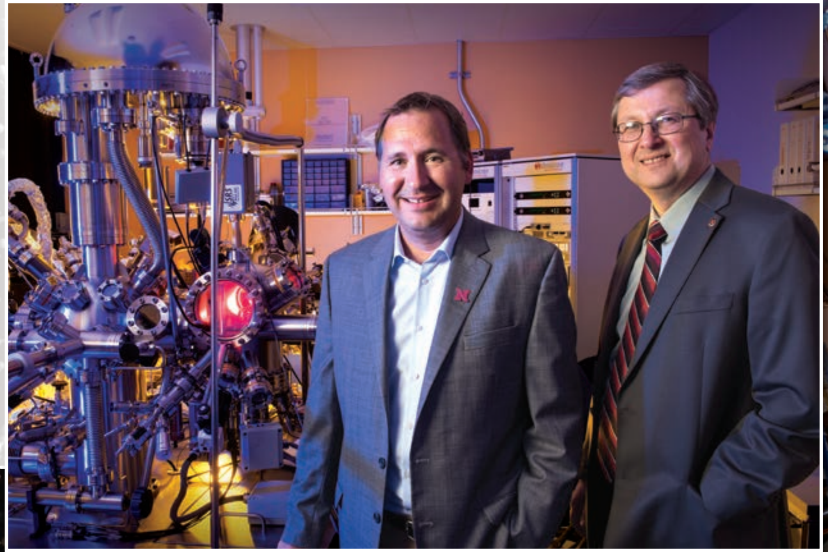
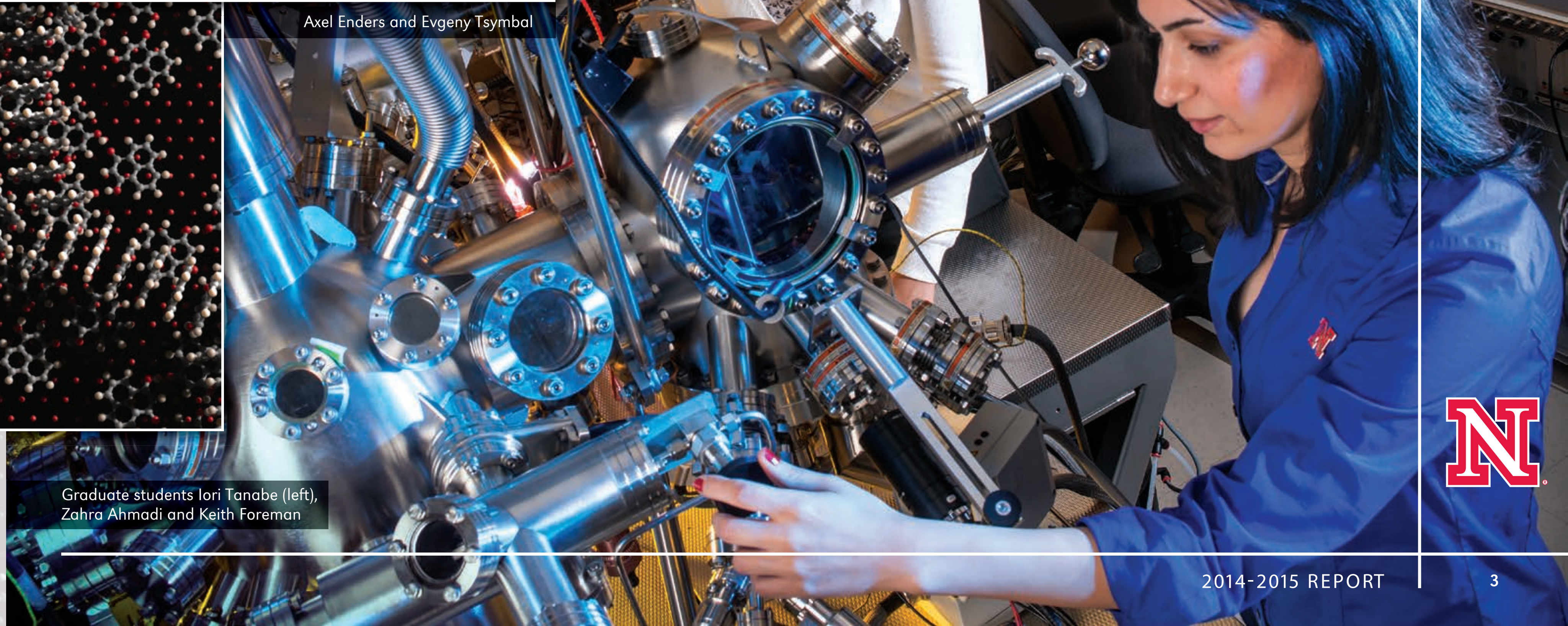


Illustration of 3-hydroxyphenalenone (3-HPLN) molecules assembled on a copper surface. MRSEC research showed that 3-HPLN molecules self-assemble into a network that enables them to stand upright.



Axel Enders and Evgeny Tsymbal



Graduate students Iori Tanabe (left), Zahra Ahmadi and Keith Foreman

Putting Graphene to the Test

Graphene has the potential to improve electronics, solar cells and other devices. UNL chemist Alexander Sinitskii is testing this promising nanomaterial with a $538,500 National Science Foundation CAREER award.

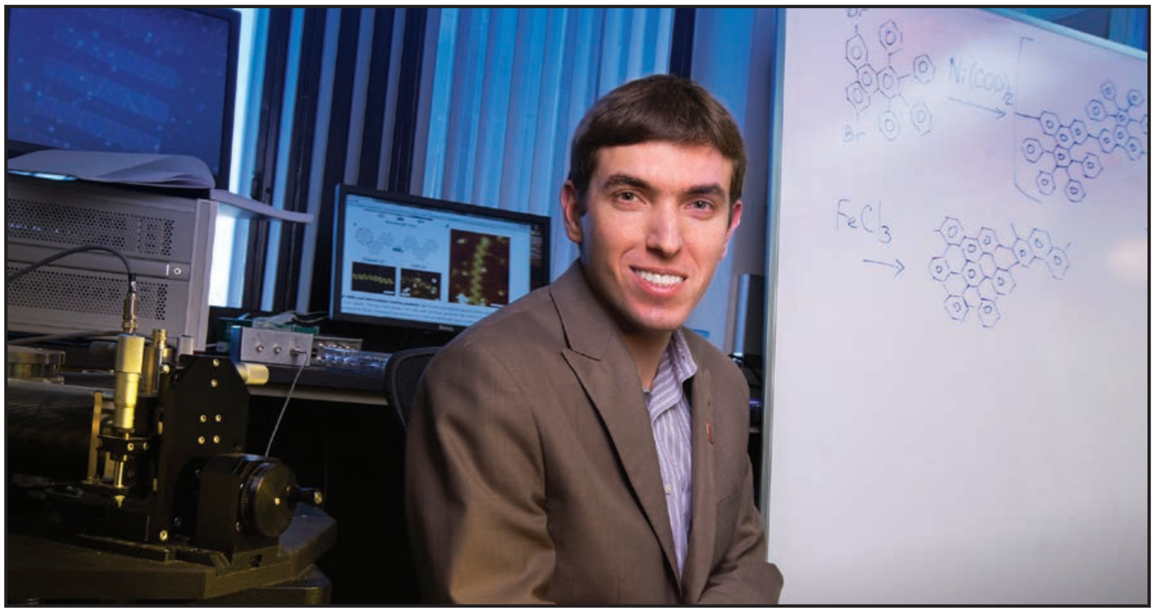
He's capitalizing on a technique he developed to create atomically precise graphene nanoribbons, ultranarrow bands of one-atom thick sheets of carbon. The precision allows Sinitskii to create nanoribbons with different widths and edges. Now, he's investigating how these differing characteristics influence the nanoribbons' properties.

Understanding changes in nanoribbon properties will help Sinitskii and others design materials that improve performance in diverse applications, such as semiconductors, solar cells and fuel cells. He plans to develop prototype devices incorporating graphene nanoribbons.

Sinitskii is an affiliate of both UNL's NSF-funded Materials Research Science and Engineering Center and the Nebraska Center for Materials and Nanoscience.

He's the latest MRSEC faculty member to earn a prestigious NSF CAREER award, which supports pre-tenure faculty who exemplify the role of teacher-scholars through research, education and the integration of education and research. Other MRSEC-affiliated CAREER award winners are:

- 2006-2012: Christian Binek, physics and astronomy, $500,000 for education and research on nanoscale spintronic systems and heterostructures. Binek leads one of MRSEC's research teams.
- 2008-2013: Axel Enders, physics and astronomy, $412,000 to study self-assembled magnetic nanostructures to improve data storage and other computing devices. Enders is MRSEC's associate director.
- 2009-2014: Eva Franke-Schubert, electrical engineering, $400,000 for research on hybrid chiral nanostructures to enhance computing, electronics and solar cells or batteries.
- 2012-2017: Xia Hong, physics and astronomy, $600,000 for work on nanomaterials with both magnetic and ferroelectric properties, which may lead to novel materials and devices.
- 2013-2018: Jinsong Huang, mechanical and materials engineering, $400,000 to study methods for increasing solar cell efficiency using organic polymers as a semiconductive material.



Alexander Sinitskii

Consortium Targets Ultrafast Processes

When light strikes an object, it triggers atomic changes that happen too fast for scientists to observe. But UNL physicists are honing ultrafast techniques to decipher how light interacts with molecules, atoms and nanostructures.

Their discoveries could lead to much faster computers, more efficient solar technology and other enhanced light-based technologies, such as lasers.

“Ultrafast science is the next step in humanity’s ability to understand nature and ultimately control these processes,” said Anthony Starace, George Holmes University Professor of Physics.

From left, Anthony Starace, Martin Centurion and Herman Batelaan

UNL’s physicists have partnered with colleagues at Kansas State University and the University of Kansas in a Nebraska-Kansas Consortium that expands all three universities’ capacity to study atomic, molecular and optical physics.

The consortium is taking two approaches to observe ultrafast processes. The first is based on stop action made famous by 1925 Nebraska alumnus Harold Edgerton and his iconic image of a bullet piercing an apple. Today, scientists use superfast electron and laser pulses instead of strobe lights.

UNL physicists are designing and building a new source of electron pulses that uses high-powered lasers to accelerate electrons even faster. The souped-up equipment will be housed in UNL’s Extreme Light Laboratory.

The device also may help elucidate transformations in solids, which could open new avenues in materials science research.

The second approach uses light pulses to overcome electronics’ relatively slow speed. Merging light with the electrons used in electronics may result in much faster computers and other devices.

The consortium also will provide educational and outreach activities to small Nebraska and Kansas colleges and students underrepresented in science and engineering.

Thirteen UNL physicists and engineers participate in the consortium. Starace and physicists Herman Batelaan and Martin Centurion lead UNL’s participation.

The National Science Foundation’s Experimental Program to Stimulate Competitive Research, or EPSCoR, funds the consortium with a three-year, nearly $6 million award, of which UNL received nearly $3 million. It is one of three science and engineering consortia funded by the program nationwide.

Making Solar Energy More Affordable, Efficient

Solar energy remains tantalizingly out of reach as a widely used power source, but a UNL engineer is making big strides in his quest to harness the sun.

Current silicon-based solar cells are too expensive and inefficient, said Jinsong Huang, Susan J. Rosowski Associate Professor of Mechanical and Materials Engineering. "Our target is to reduce solar cell costs by half, so it can compete with energy from fossil fuels."

He's attacking that goal on several fronts with grants of more than $1.2 million from the U.S. Department of Energy and $2.6 million from the National Science Foundation.

Perovskites, a class of abundant crystalline compounds, are a promising solar cell material that potentially could cost a thousand times less than silicon, Huang said.

His evolving techniques are helping to set records in perovskite solar energy efficiency. Thanks to his and others' advances, the material now rivals silicon's 20 percent energy efficiency and promises greater improvements.

Huang and his team also created a single, large perovskite crystal using a low-cost fabrication technique. They demonstrated the material's potential capacity as a sun catcher is thousands of times greater than previously reported. Their findings, published in *Science,* provide insight into future improvements. Huang continues to study what makes perovskite crystals so exceptional.

He's also investigating a new fabrication technique to make inexpensive, large-scale solar cells for a variety of applications.

Perovskite degrades easily so more research is needed before it can replace silicon.

As an intermediate step and to take advantage of established technology, Huang is investigating ways to overlay silicon with an ultrathin film of perovskite to increase current solar cell efficiency.

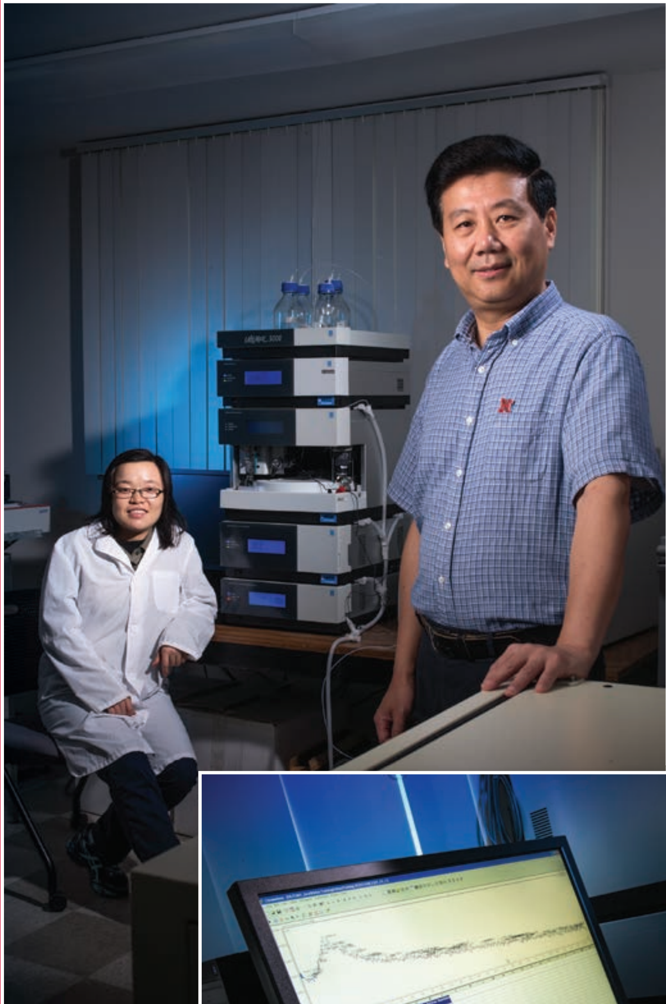
Another major solar cell avenue replaces silicon with less expensive organic polymers, or plastics, which are cheaper and more flexible, but also less energy efficient. Huang continues exploring ways to improve organic polymer semiconductors.

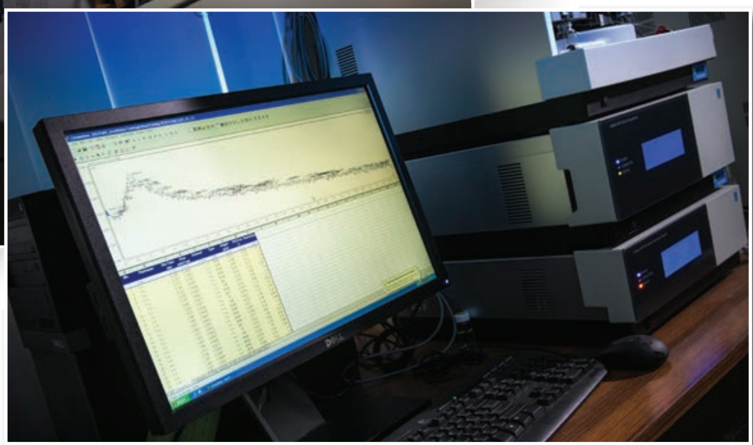
"Renewable energy is the No. 1 issue for the future," Huang said. "Solar energy still has a relatively long way to go, but the path is clear to me. I firmly believe renewable energy will one day be a major energy source."

Jinsong Huang and colleagues in his lab
Single crystal perovskite
UNL research shows fabricating an organic solar cell on a nonwetting plastic surface makes it 1.5 times more efficient at turning sunlight into energy.

"Our target is to reduce solar cell costs by half, so it can compete with energy from fossil fuels."

Protecting Nanoparticles Carrying Therapeutic Drugs





Top: Yiqi Yang and research assistant professor Helan Xu
Above: Calibration curves show protein cross-linking reactions with polycarboxylic acids.

The liver and spleen have been thwarting researchers' attempts to deliver a nanoparticle carrying therapeutic drugs to its target. A UNL team has discovered that citric acid is the key ingredient in armoring the nanoparticle against the organs' molecule chomping.

Nanoscale drug delivery techniques are potentially safer and more effective methods of administering drugs than conventional treatments.

One method of slipping synthetic drugs past the body's immune defenses is to use a Trojan horse, enveloping the drug in a nanomaterial made from zein, a corn protein that appears nonthreatening. Zein is widely used in the food, paper and other industries.

But that friendly exterior also makes it susceptible to the liver and spleen, which break down proteins and other biological products.

The UNL team learned that citric acid acts as a kind of mortar to bind the nano-particle's protein molecules together more tightly, creating a much more durable structure. They've shown that zein nanoparticles fortified with citric acid successfully delivered the cancer drug 5-Fluorouracil to the kidneys in mice.

Importantly, citric acid is nontoxic, said project leader Yiqi Yang, Charles Bessey Professor in textiles, merchandising and fashion design and biological systems engineering. Other successful strengtheners are carcinogenic, limiting their medical usefulness.

The reinforced structure also has potential for use in regenerating human tissue, he added.

Earlier, Yang and his colleagues improved the zein nanoparticle's functionality as a drug delivery system by creating a hollow center that increases its loading capacity.

Yang said he hopes to work with an industry partner to develop the enhanced zein nanoparticles for use in delivering targeted drug therapies.

He was prompted to work on zein because the protein is a ubiquitous byproduct of the corn industry.

"In Nebraska, we have a lot of corn protein left after utilization of corn starch," Yang said. "Our initial motivation was to figure out a way to add value to our agricultural industry."

Accolades

- **John Woollam,** George Holmes University Professor of Electrical Engineering, was named a Fellow of the National Academy of Inventors. Woollam, an internationally known expert in ellipsometry and a UNL faculty member since 1979, also is founder and president of the J.A. Woollam Co. A university spinoff, Woollam's company is a worldwide leader in the production of spectroscopic ellipsometry instrumentation. The company manufactures ellipsometers for a wide range of applications and, with distributorships in more than a dozen countries, has sold over 2,500 ellipsometers worldwide. Woollam is named on 57 patents and his company has secured more than 100 patents.

- **Waskar Ari,** associate professor of history and ethnic studies, received a fellowship from the American Council of Learned Societies for the fall 2015 semester. During his fellowship, he is focusing on his research project, Women's Strategies of Autonomy: Segregation, Sexuality, and Agrarian Reforms in Bolivia, 1870-1964.

- *The Counter-Cinema of the Berlin School,* authored by **Marco Abel,** associate professor of English and film studies, won the German Studies Association's 2014 Book Prize, which recognizes the best book in the fields of German language literature and Germanistik, or culture studies. The book examines the political role of a new wave of filmmakers in Germany and argues that the Berlin School films comprise a counter-cinema that depicts a German people that has not yet come to be.

- **Stephen Taylor,** professor of food science and technology, received the Institute of Food Technologists' 2015 Nicholas Appert Award. This achievement award recognizes preeminence in and contributions to food technology. Taylor was honored for his comprehensive investigative work on food allergens.

- Two UNL biological systems engineers won prestigious Gold Medal awards from the American Society of Agricultural Engineers in 2014. **Suat Irmak,** Harold W. Eberhard Professor of Biological Systems Engineering, received the John Deere Gold Medal Award for global leadership and contributions to improved understanding of soil, water and plant relationships through advances in evapotranspiration modeling and environmental biophysics. Irmak also received the Heermann Sprinkler Award for work that leads to more efficient, effective sprinkler irrigation. **David Jones,** professor of biological systems engineering, won the 2014 Massey-Ferguson Educational Gold Medal Award for contributions to development and delivery of biological systems engineering education.

- **Stephen Burnett,** professor of classics and religious studies, earned a fellowship at the Institute for Advanced Study in Princeton, New Jersey, for the 2015-2016 academic year. He is conducting research for a book about Martin Luther and is part of a group of about 30 humanities scholars in the institute's School of Historical Studies. Burnett also received a Humboldt Research Award from Germany's Alexander von Humboldt Foundation. The award, which recognizes researchers whose work has significant impact and who are expected to continue cutting-edge work, will allow Burnett to conduct research for his book in Germany.

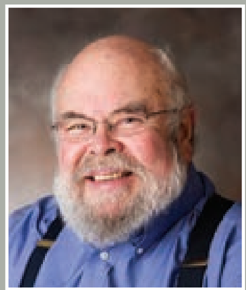
- **Jim Lewis,** Aaron Douglas Professor of Mathematics and director of UNL's Center for Science, Mathematics and Computer Education, earned the Mathematical Association of America's Gung and Hu Award for Distinguished Service to Mathematics, which honors extraordinary contributions that have shaped mathematics and mathematical education nationally. He also received the American Mathematical Society's 2015 Award for Impact on the Teaching and Learning of Mathematics, the organization's highest award for service.

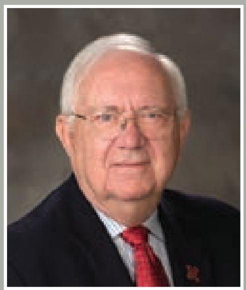
Accolades


Judy Diamond


Concetta DiRusso


Sherilyn Fritz


Alan Kamil


David Sellmyer


Charles Wood

Six UNL Faculty Named AAAS Fellows

Judy Diamond, Concetta DiRusso, Sherilyn Fritz, Alan Kamil, David Sellmyer and **Charles Wood** were named American Association for the Advancement of Science Fellows in 2013. It was the first time six UNL scientists were elected fellows in the same year. Diamond, professor and curator of informal science education at the University of Nebraska State Museum, was recognized for distinguished contributions to promoting scientific literacy. DiRusso, professor of biochemistry, was honored for advancing understanding of nutritional fatty acids and for education advocacy. Fritz, George Holmes Professor of Earth and Atmospheric Sciences, was recognized for distinguished contributions to paleolimnology and paleoclimatology. Kamil, George Holmes Professor of Biological Sciences, was recognized for distinguished contributions to research into animal behavior and cognition. Sellmyer, George Holmes Professor of Physics, was honored for distinguished contributions to the physics of magnetic materials and nanostructures and for his leadership as director of UNL's Nebraska Center for Materials and Nanoscience. Wood, Lewis Lehr/3M Professor of Biological Sciences and director of UNL's Nebraska Center for Virology, was recognized for significant contributions to molecular virology and HIV/AIDS epidemiology and to building global scientific capacity.

National Academy of Inventors Fellow

Biochemist **Donald Weeks** was named a National Academy of Inventors Fellow in 2013. The distinction is a high honor bestowed on academic inventors whose inventions improve quality of life, spur economic development and benefit society. Weeks, the Maxcy Professor of Agriculture and Natural Resources, was recognized for contributions in plant and algal biology, especially his novel approach to engineering herbicide-resistant crops. He holds 10 U.S. patents and 22 international patents. Weeks' selection marks the second year members of the UNL faculty have been named NAI Fellows.

Jefferson Science Fellow

Concetta DiRusso, professor of biochemistry, is a 2014-2015 Jefferson Science Fellow. DiRusso is known for her work to understand nutritional fatty acids and their impact on human health, including diabetes and other diseases commonly linked to obesity. The National Academies program gives fellows the opportunity to spend one year in Washington, D.C., as advisers on science and engineering policy issues to the Department of State and U.S. Agency on International Development.

Faculty Recognized

- The Fulbright Program offers UNL scholars opportunities to grow in teaching and research. **Carole Levin**, Willa Cather Professor of History, will spend the spring 2015 semester in York, England, studying the Celtic queen Boudicca's leadership style and her connections to modern female political leadership. **Wendy Weiss,** emeritus professor of textiles, merchandising and fashion design, received a Fulbright-Nehru Senior Scholar grant to travel to Gujarat, India, to study development and design of the ikat print. **Gary Kebbel,** professor of journalism, and **Sriyani Tidball,** assistant professor of practice in advertising and public relations, earned Fulbright Specialist grants. Kebbel is helping the U.S. Mission to the African Union, based in Ethiopia, draft a strategic communications plan. In January, Tidball will work with the Centre for Women's Research in Sri Lanka to form a communications strategy for helping migrant workers stay in touch with their families.

- **Tyler White,** professor of composition and conducting, won a Global Music Awards silver medal in composition for his opera *O Pioneers!* that reimagined the Willa Cather classic novel in musical form. He also was a finalist for The American Prize in Composition in opera/theater/film.

- **Xiao Cheng Zeng,** Ameritas University Professor of Chemistry, was named a Fellow of the United Kingdom's Royal Society of Chemistry. Zeng has made groundbreaking discoveries using computer modeling to reveal how matter behaves under extreme conditions, and in computer-aided molecular and materials design.

- **Gregg Rothermel,** Dale M. Jensen Chair of Software Engineering, earned 2013 Distinguished Scientist and Distinguished Member honors from the Association for Computing Machinery for significant accomplishments in computer science. Rothermel's research areas include application of program analysis techniques, software maintenance programs and end-user software engineering.

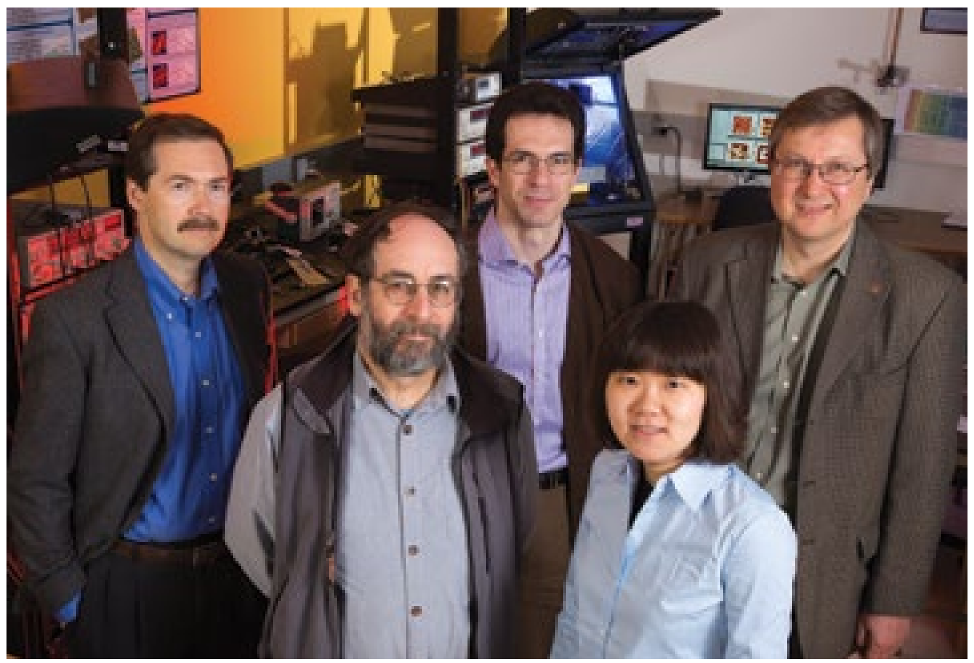
- Two UNL faculty members became American Mathematical Society Fellows in 2013: **John Meakin,** Milton Mohr Professor of Mathematics, and **Srikanth Iyengar,** Willa Cather Professor of Mathematics. Meakin was selected for contributions to semigroup theory and leadership in UNL's mathematics department. Iyengar has lent his expertise in commutative algebra to numerous international research collaborations. UNL has a strong tradition of mathematics excellence, with five researchers joining the inaugural class of AMS Fellows in 2012.

- **Cory Forbes,** associate professor of science education in the School of Natural Resources, received the 2014 Early Career Research Award from the National Association for Research in Science Teaching for his potential to significantly contribute to science education. Forbes has studied third-grade students' learning about biological structure and function and the hydrologic system, and teachers' implementation of curricula to help students learn about water and food systems.

Collaborating on Nanoelectronics

Transforming university nanoscience discoveries into smaller, faster electronics is the aim of a new multi-institutional collaboration.

A UNL physics team leads the Center for NanoFerroic Devices, a $7.125 million research collaboration involving six universities and an industry consortium. Funded by the Semiconductor Research Corp. and the National Institute of Standards and Technology, it's one of three new multi-university research centers that are part of the second phase of the Nanoelectronics Research Initiative.



From left: Alexei Gruverman, Peter Dowben, Kirill Belashchenko, Xia Hong and Evgeny Tsymbal (not pictured, Christian Binek)

The center builds on advances that UNL and its Materials Research Science and Engineering Center have made in exploring nanomaterials to surpass current technological limitations, said physicist Evgeny Tsymbal, George Holmes Professor of Physics who co-directs the new center with UNL colleague Peter Dowben, Charles Bessey Professor of Physics. Tsymbal also directs UNL's MRSEC, which the National Science Foundation funds.

"The new center is a natural continuation of the research that we've been doing. Now we're rising to a new level," Tsymbal said.

Today's electronics use an electric charge to store and process information, which limits the number of transistors that can occupy a chip. The new center is pursuing three alternatives to take advantage of nanoscale properties that require less energy, which could enable more compact and powerful devices.

UNL physicist Alexei Gruverman leads a team focused on nano-thin ferroelectric oxide, a material with both positive and negative polarization directions that can be read like a binary code to store information. A second initiative relies on UNL physicist Christian Binek's work with spintronics, which manipulates electron spin to store information. The third initiative, led by Ilya Krivorotov at the University of California, Irvine, focuses on how electrons carry information by generating spin waves. UNL physicists Kirill Belashchenko and Xia Hong also work with the center.

Tsymbal said collaboration among researchers and industry is critical to moving fundamental principles from the laboratory to specific devices.

UNL's university partners are University of California, Irvine; University of Wisconsin-Madison; University at Buffalo, SUNY; University of Delaware; and Oakland University. Industry partners include IBM, Intel, Micron Technology, Texas Instruments and GLOBALFOUNDRIES. Semiconductor Research Corp. is the world's leading university-research consortium for semiconductors and related technologies.

Aftercare Critical for At-risk Teens

Going home after months, even years, in an out-of-home care program is an exciting milestone for at-risk teens and their families.

It's also a vulnerable time. Youth with emotional or behavioral disorders can make laudable progress in treatment, but they may backslide into old, familiar behaviors if their home and school environments don't reinforce new skills. That leaves them at risk for further problems, including quitting school, strained relationships, drug and alcohol abuse, and criminal behavior.

Alex Trout, research associate professor in special education and communication disorders, leads a team of researchers, educators and family service workers from UNL, Boys Town and five other residential agencies in eastern Nebraska to evaluate On the Way Home, a set of programs to help youth make a successful transition.

"These youth receive lots of targeted help and education while they're in treatment," Trout said. "It's heartbreaking to watch them fall apart after they've made big strides."

The aim is to involve the teen's parents, school and workplace in the transition. Interventions include parent training, dropout prevention and intervention, and homework support. A family consultant is available 24/7 for parents to seek advice. Weekly check-ins help identify struggles and problematic behaviors early.

Preliminary findings show that nearly 91 percent of participants maintained their home placement after one year, and approximately 88 percent had graduated or were still enrolled in school.

With a nearly $3.5 million grant from the U.S. Department of Education's Institute for Education Sciences, the team is building on earlier research, evaluating educational, family and behavioral outcomes at a larger scale and expanding services to additional agencies. More than 4,000 Nebraska youth receive out-of-home care; Trout hopes to include 250 in the research.

The need for proven, research-based programs is huge, Trout said. UNL researchers developed On the Way Home in collaboration with researchers elsewhere, with support from an earlier IES grant. With further research, the program could become a national model for aftercare support.

"The children, families and schools have confirmed the value of supporting these youth through this often difficult transition," said Patrick Tyler, director of the aftercare program at Boys Town. "On the Way Home provides an important service, at the right time, so these children can sustain the gains they've made."

Above: Alex Trout (front) with, from left, Patrick Tyler, Maryia Schneider, Heidi Menard, Scott Johnson and Regina Costello

Nanoscience Center Strengthens Research

UNL's new Voelte-Keegan Nanoscience Research Center strengthens UNL's capacity to address some of the nation's pressing problems through nanoscience.

Completed in early 2012, the 32,000-square-foot center houses the seven core facilities and two shared laboratories of the Nebraska Center for Materials and Nanoscience. It consolidates UNL's state-of-the-art nanoscience research facilities in a single, central location accessible to the more than 80 faculty affiliated with the NCMN.

The building also provides researchers access to specialized equipment, such as a National Science Foundation-funded transmission electron microscope and a high-tech clean room that eliminates dust particles.

"This truly puts us on the map," said David Sellmyer, NCMN director and George Holmes University Professor of Physics and Astronomy. "It makes for much greater ease of collaboration and a lot more efficiency."

UNL's Materials Research, Science and Engineering Center, funded by the NSF and focused on quantum and spin phenomena in nanomagnetic structures, relies on these core facilities, said physicist Evgeny Tsymbal, MRSEC's director and a Charles Bessey Professor. Thanks to the facility's centralized services and new equipment, faculty are pursuing research that wasn't previously possible.

"The center will boost research and collaborations in nanoscience and create the infrastructure necessary to enhance our competitiveness," Tsymbal said.

Funding agencies increasingly are encouraging large collaborative projects that engage cutting-edge expertise and facilities worldwide to solve formidable challenges, Sellmyer said. The new center strengthens UNL's competitiveness for grants, both for individual researchers and for UNL's increasing participation in these large multi-institutional collaborative projects.

Improving UNL's nanoscience research facilities also benefits Nebraska, Sellmyer added. The center enhances collaboration with industries that also use these facilities and is an incentive for startup companies to locate here.

Major funding for the research center came from a $5 million donation from UNL alumnus Don Voelte and his wife, Nancy Keegan, a University of Nebraska Foundation board member, and a $7 million competitive federal grant from the National Institute of Standards and Technology through the American Recovery and Reinvestment Act.

Above: Graduate students in Nanofabrication Clean Room Facility
Top right inset: Researchers use new transmission electron microscope
Bottom right inset: Graduate student Rui Zhang in Materials Preparation Core Facility

"The center will boost research and collaborations in nanoscience and create the infrastructure necessary to enhance our competitiveness."

Expanding Data Storage Potential

Nanoscience is blazing new trails in making the technology of daily life – from computers to cell phones and memory storage devices – more powerful and efficient. Now, a UNL-led team's recent discovery is expanding possibilities for data storage.

A team led by physicist Alexei Gruverman, a researcher in UNL's Materials Research Science and Engineering Center and the Nebraska Center for Materials and Nanoscience, identified a way to store data significantly more densely than previously possible.

Gruverman's research on electronic materials is done at the nanoscale, where objects exhibit unexpected chemical and physical properties. Central to his research is the scanning probe microscopy technique, which uses a tiny physical probe to exert highly localized mechanical, electrical or magnetic influence on an object and then measure its response.

The probe's tip – invisible to the naked eye – can be used to electrically change the properties of the electronic or ferroelectric materials used in memory devices.

Data storage has always relied on electrical voltage. But Gruverman's team found that the same nanoscale-sized bit of data could be written simply by pressing harder against the ferroelectric material's surface without damaging it, working much like a nanoscopic typewriter.

The team was the first to demonstrate that mechanical force can be used to change an area's polarization. Gruverman, UNL graduate student Haidong Lu and researchers from Spain and the University of Wisconsin reported their findings in the journal *Science*.

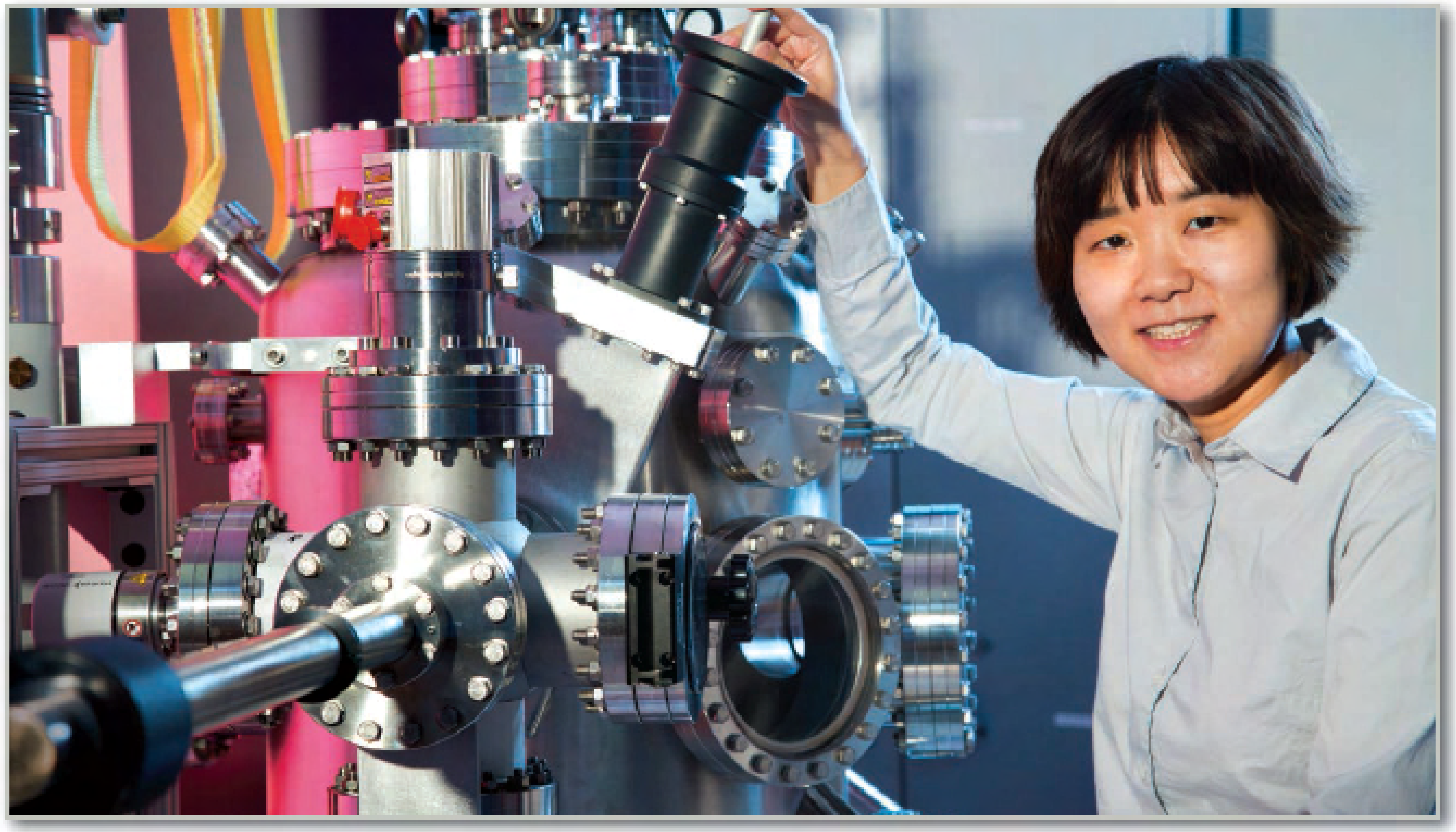
"It's a completely voltage-free switching of polarization, which is what makes the results of this research unique," Gruverman said. The finding establishes a scientific basis for creating more powerful storage devices. The team hopes to build on the discovery by investigating other possible applications.

Grants from the U.S. Department of Energy and the National Science Foundation support Gruverman's broader research. NSF also funds UNL's MRSEC, which focuses on nanomagnetism.

Above: Alexei Gruverman
Inset: Checking data

Designing New Nanomaterials

A key to making computers and other electronics smaller, faster and less expensive lies in overcoming the limitations of existing materials. UNL physicist Xia Hong's research into nanoscale materials may one day help break through current barriers.



For decades, scientists have been squeezing more power out of today's silicon-based electronics, which are approaching the material's fundamental limits. To continue advancing, researchers are exploring materials that exhibit unusual physical, chemical or biological properties at the nanoscale and fabricating new nanomaterials with multifunctional properties.

Hong is combining two oxides to create a nanomaterial with both magnetic and ferroelectric properties. Ferroelectric materials have positive and negative polarization directions. Applying electricity can reverse the polarization and control magnetism. Storing data with an electric charge alone or using electricity to manipulate magnetic signals would be more energy efficient and allow greater storage capacity in a smaller space.

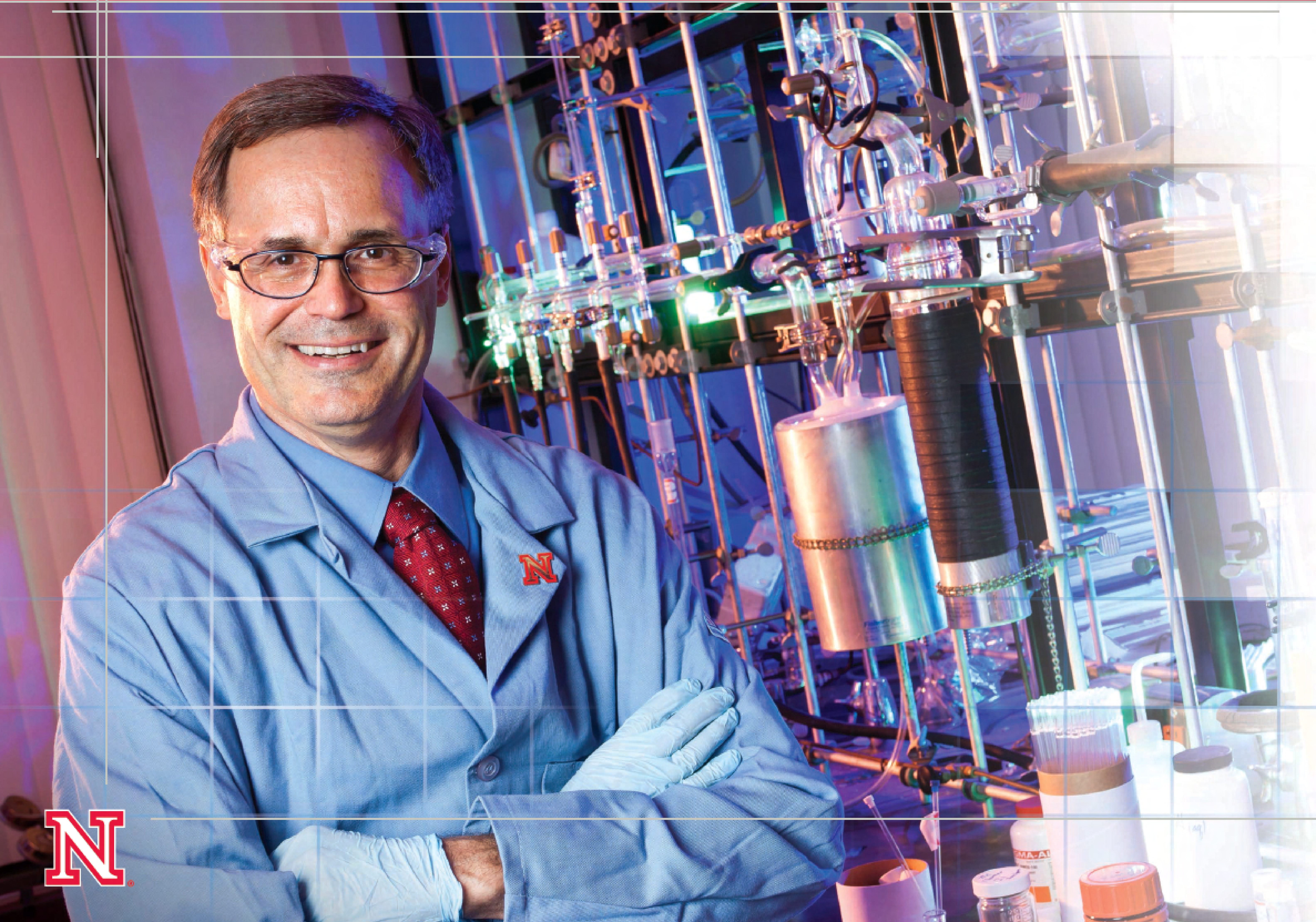
Hong predicts it will take one to two years to fabricate the new nanostructure. She'll then study the material's characteristics. Her research promises to advance the understanding of magnetoelectric coupling and could lead to novel materials and devices. Hong, a member of UNL's Materials Research Science and Engineering Center, earned a prestigious $600,000, five-year National Science Foundation CAREER program award for this research.

The expertise of other MRSEC faculty and the center's focus on nanoscale magnetism and magnetoelectric interfaces aid her research, Hong said. "My research is very complementary to the existing efforts here. There is a lot of collaboration."

The award also allows her to make physics accessible to young people, particularly girls, by using her drawing skills to develop educational cartoons.

"Many people think physics is very difficult," Hong said. "I thought it was a good idea to use a teenage girl's point of view to illustrate physics principles … to make physics more likable."

Above: Xia Hong



Game-changing Research Sparks Startup

UNL chemist Stephen DiMagno was confident his research could revolutionize medical imaging with positron emission tomography, or PET scans. But was it commercially viable?

With help from two National Science Foundation programs designed to guide promising NSF-supported scientific discoveries into the marketplace and assistance from NUtech Ventures, a nonprofit affiliate that helps commercialize UNL research, DiMagno realized the answer was yes.

His new company, Ground Fluor Pharmaceuticals, develops imaging agents for PET scans. PET is a widely used diagnostic tool for detecting and managing certain cancers, heart disease and neurodegenerative disorders including Alzheimer's and Parkinson's diseases. This technology might also help companies develop new drugs.

A nuclear medicine imaging technique, PET relies on radiotracers to give information about the function and metabolism in the body's organs. DiMagno developed a technique to attach the radioactive isotope fluorine-18 to different carrier molecules. The isotope enables a PET scanner to detect a compound's metabolic fate.

"Our methodology allows us to create more potent imaging agents more rapidly, reliably and in high yield," DiMagno said. "Previously, these agents were unknown or very difficult to synthesize."

A $50,000 NSF Innovation Corps award, or I-Corps, enabled DiMagno to meet with more than 100 potential customers, suppliers and distributors to gauge their interest in the technology. These meetings helped DiMagno revise his business plans and identify potential partners.

NUtech Ventures helped him license the technology and introduced DiMagno to Allan Green, a Boston physician, scientist and lawyer who became Ground Fluor's co-founder and chief executive officer. The company is based in Lincoln, Neb.

A $150,000 NSF Small Business Innovative Research award supports the startup's activities, including hiring two scientists and expanding its network of academic collaborators. Ground Fluor is testing its method in labs across the country to ensure it can be replicated in a variety of settings.

This technology could increase the availability of existing experimental PET agents and support development of new ones, DiMagno said.

Left: Stephen DiMagno
Above: Pouring liquid nitrogen

Discovery Could Spark Smaller, Faster Electronics

Nanopods, cameras the size of credit cards, computers that run trillions of calculations per second. Can gadgets get any smaller or more powerful?

Yes, engineers say, but the limit is looming.

To help head off this predicted size barrier, a team at UNL's Materials Research Science and Engineering Center (MRSEC) has made an important breakthrough in spintronics, which exploits electron spin for use in advanced information technologies.

"In a nanometer, there are only so many atoms next to each other. After you reach that level, you can't make things smaller," said physicist Christian Binek, the project's lead investigator. "To move on from that point, we have to do something fundamentally new."

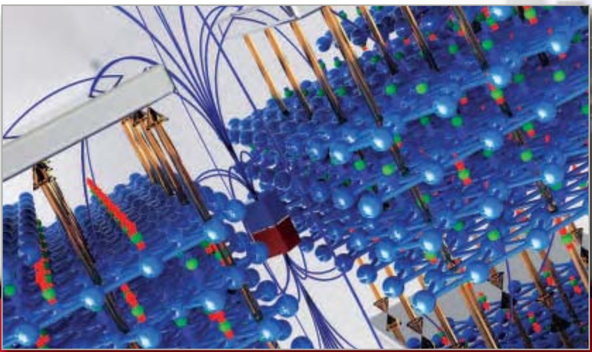
Today's electronics use an electric current to store and process information. But currents generate heat, limiting the number of transistors that can be packed onto a chip. Currents also use energy, reducing battery life. Based on their findings, the UNL researchers envision a conceptually new generation of ferromagnetic transistors overcoming these limitations.

Binek's team discovered how to switch ferromagnets' magnetization using voltage, which doesn't generate heat. The magic ingredient is chromia, the oxide form of chromium, which can be magnetized with voltage. Making a precisely ordered thin film of chromia, bringing it into contact with a ferromagnet and applying voltage also switches the ferromagnet's magnetization.

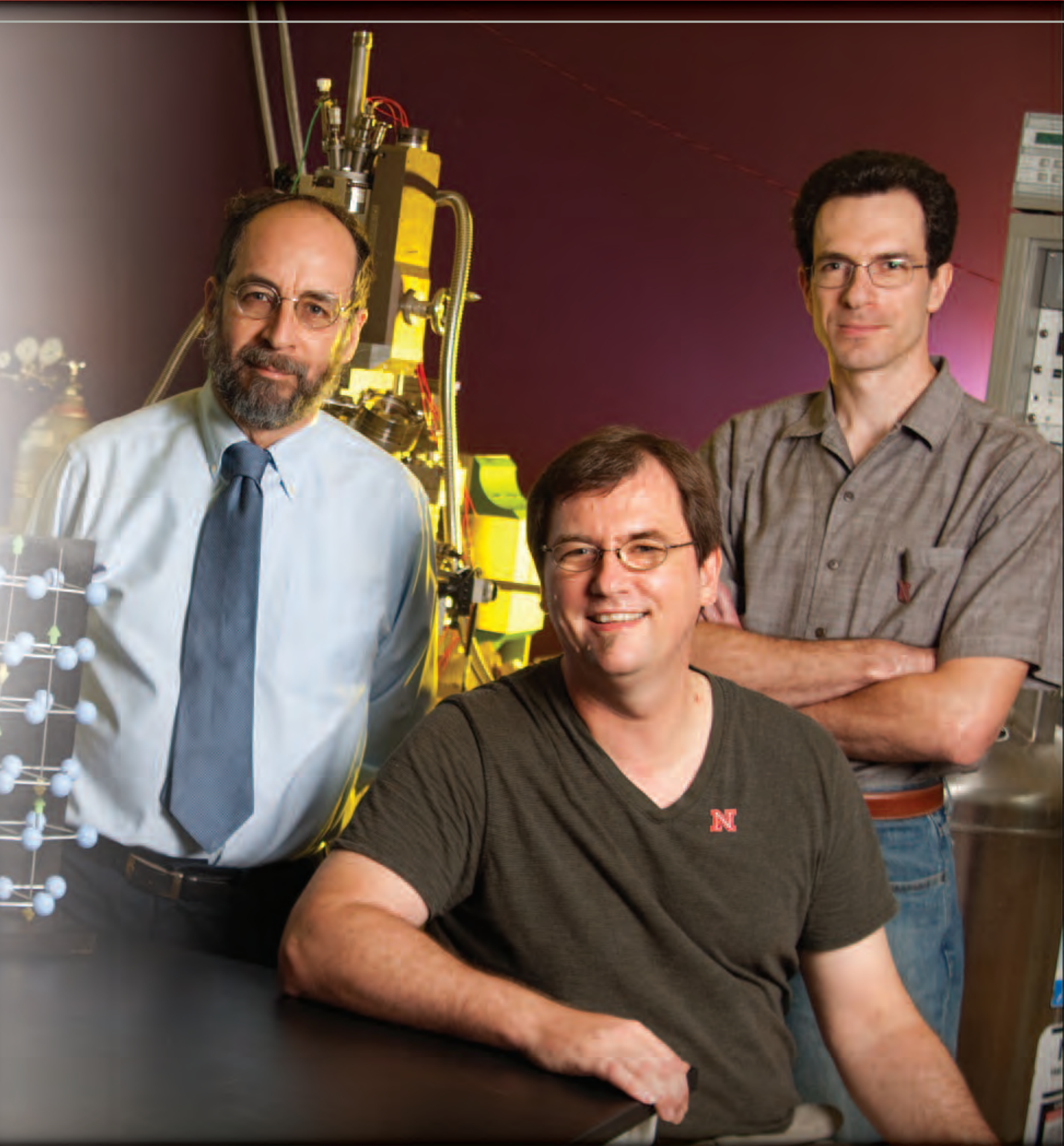
Binek now is developing voltage-powered logical and memory devices, which could lead to less expensive, smaller and more powerful gadgets that use less energy. Consumers, for example, would be able to store more movies on longer-powered mobile devices. Researchers also may one day have the computing power to run mind-blowingly complex calculations, enabling new scientific discoveries.

Binek credits collaborations made possible by MRSEC, which is funded by the National Science Foundation. Co-investigators, UNL physicists Kirill Belashchenko and Peter Dowben, a Charles Bessey Professor, contributed invaluable expertise. The team reported its discovery in *Nature Materials*.

"I was forced to leave my comfort zone and look more broadly, with different methods and different ideas. Working together gave us this breakthrough," Binek said.



Spintronics illustration



From left: Peter Dowben, Christian Binek and Kirill Belashchenko

MRSEC Fosters Collaboration

UNL's Materials Research Science and Engineering Center provides valuable collaborative and financial opportunities for nanoscientists studying new magnetic structures and materials.

That's paying off, said physicist Evgeny Tsymbal, MRSEC's director, and a Charles Bessey Professor at UNL.

In addition to the Christian Binek team's breakthrough in spintronics, Tsymbal cites other MRSEC collaborations. Physicist Alexei Gruverman's group used advanced scanning probe techniques to improve ferroelectric tunnel junctions for use in nanoelectronic devices and data storage. Physicist Axel Enders is able to grow and characterize nanoscale films and new nanomaterials, which may lead to improved high-density magnetic recording.

Strong ties with industry ensure scientists concentrate on problems industries face and provide opportunities for industry-financed support. Several researchers have received MRSEC supplemental funds provided by an industry consortium.

Established in 2002 with a $5.4 million National Science Foundation grant, MRSEC received an $8.1 million, six-year renewal grant in 2008. Its research focuses on quantum and spin phenomena in nanomagnetic structures. This research has potential applications in advanced computing, data storage, energy production, handheld electronic devices, sensors and medical technologies.

"MRSEC plays a very significant role," said Tsymbal, "providing opportunities for collaborations, infrastructure, access to facilities and very important educational and outreach programs."

Harnessing Laser Power Creates Precise Nanostructures

Carbon, the ubiquitous element of life, has many special properties. Harnessing it at the atomic level to create nanostructures promises to transform many everyday products, from computer chips to sunglasses.

Discovering fast, cost-effective ways to mass produce these nanostructures is key to their practical use. It's Yongfeng Lu's specialty.

"Carbon nanostructures have very large potential in different applications," said Lu, Lott University Professor of Electrical Engineering.

His UNL team has developed several unique processes that use lasers to make precise carbon nanostructures. They are refining their techniques and exploring new applications for their nanostructures. Since 2003, they have earned more than $14 million in research grants.

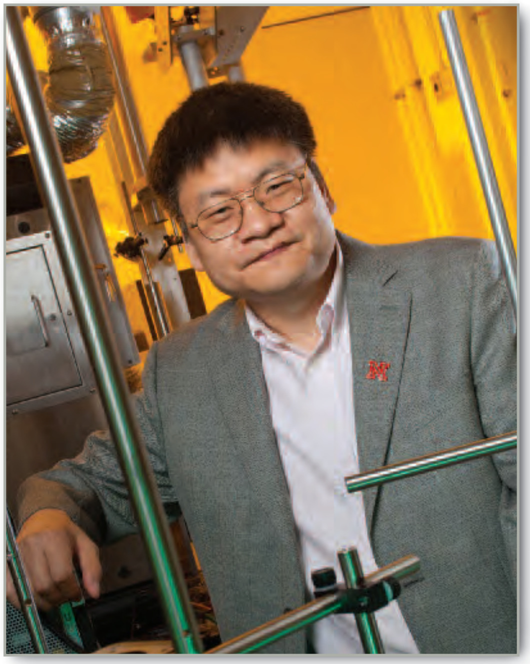
Their laser-based production techniques can precisely control the length, diameter and properties of carbon nanotubes. Using these highly electrically and thermally conductive nanotubes, Lu's team developed methods to improve transistors and sensors that may one day speed up computers and other electrical devices, while minimizing energy consumption and heat generation.

They also discovered how to control a carbon nanotube's diameter from one end to the other, which alters its characteristics. Lu envisions variable-diameter nanotubes customized for specific uses.

Now they're studying how to join carbon nanotubes to make smaller, lighter wires that carry large amounts of current for use in electric cars and other products.

Another breakthrough process creates carbon nano-onions, spherical nanostructures resembling onion layers that have unique electrical, optical and magnetic properties. Nano-onions can store large amounts of energy on their extensive surface area. Using nano-onions, Lu's team has developed supercapacitors for high-density energy storage.

Nano-onions also have optical limiting properties, absorbing light as it intensifies. Lu's research could lead to improved eye protection, optical sensors, satellites and other optical-dependent materials.



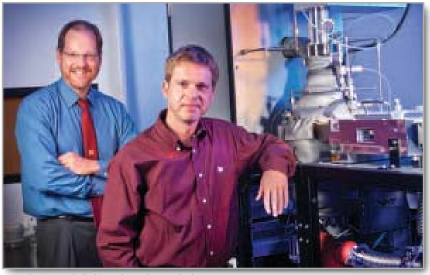
Yongfeng Lu

Lu's team also developed a fast, single-step process using lasers to write graphene patterns on surfaces. A basic building block for other nanostructures, graphene resembles nanoscale chicken wire. Its electrical conductivity and transparency could be used in products such as LCD televisions and solar panels.

"Carbon is everywhere, so the future of electronics, photonics and many high-tech industries will not be limited by supplies," Lu said.

Nanohybrids Promise 'Best of Both Worlds'

Scientists are always seeking better ways to find and quantify minute things, such as toxins in the air or cancer particles in blood. UNL researchers lead a collaboration to create more powerful detection devices by combining manmade nanoparticles with nature's inherent recognition capabilities.



Patrick Dussault (left) and Mathias Schubert

Creating these "nanohybrids" requires the diverse expertise of researchers in biology, chemistry and nanomaterials engineering. A Nebraska team recently launched the UNL-based Center for Nanohybrid Functional Materials, which brings together 15 researchers from UNL, the University of Nebraska Medical Center, the University of Nebraska at Kearney, Creighton University and Doane College.

With nanohybrids, "you get the best of both worlds," said UNL chemist Patrick Dussault, a Charles Bessey Professor, who co-leads the center with Mathias Schubert, associate professor of electrical engineering.

Nanohybrids combine nanostructures – which can be engineered to behave uniquely under certain conditions, such as when subjected to a beam of light or radio energy – with chemical or biochemical agents, such as RNA or antibodies that can bind a specific substance. This new nanomaterial can both find and reveal its target.

Materials often behave differently at nanoscales, Dussault said. Understanding the basic sensing principles of nanohybrids is a major goal of the new group. With this knowledge, researchers hope to develop tools with enhanced detection capabilities.

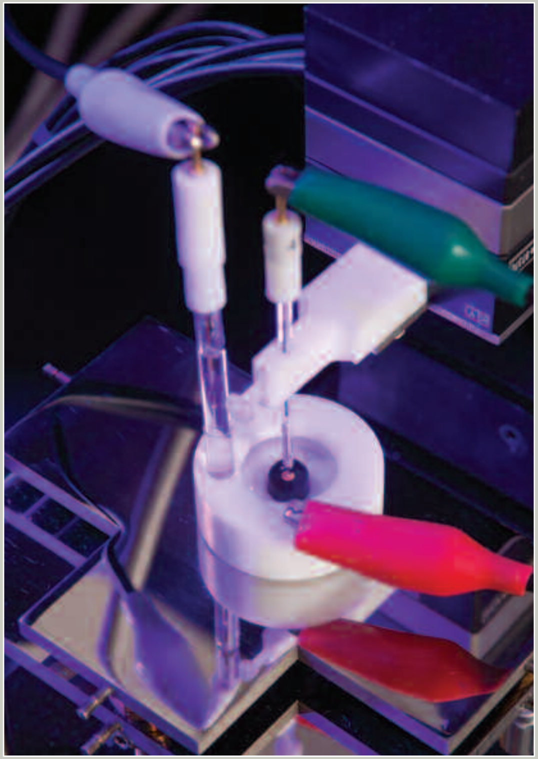
Potential applications include devices that more selectively or sensitively diagnose diseases or find environmental contaminants. The ability to better detect toxins in air or water also could benefit national security.

The center builds on UNL's strength in nanomaterials. With about $7.5 million in funding from the National Science Foundation through Nebraska EPSCoR, the center is creating a new core facility and partnering with several departments to hire new faculty, enhancing UNL's leadership in nanoscience.

The center also has begun developing partnerships with industries in Nebraska and beyond.

"I think potentially it can attract a lot of companies, big and small, to Nebraska," said Fred Choobineh, Nebraska EPSCoR director. "It's very creative and cutting-edge research."

Biosensor Work Aims for Simple HIV Test



A cheaper and quicker way to detect HIV would be invaluable in fighting the HIV/AIDS epidemic worldwide. UNL chemist Rebecca Lai's research on electrochemical biosensors may one day lead to developing a simple device for identifying HIV.

Lai's strategy for detecting the virus is to look for the presence of HIV antibodies, proteins the immune system produces to identify and neutralize the virus by binding to viral molecules called antigens.

Many antigens change shape when they interact with antibodies. By developing a method that monitors the structural change of the antigen, Lai can detect the presence of the antibody. In the case of HIV, the presence of antibodies to HIV indicates infection with the virus.

She labels the antigen with methylene blue, a tracer molecule that accepts electrons when a specific voltage is applied. If antibodies are present, they interact with the antigens, causing a structural change and preventing the methylene blue from accepting electrons. The sensor will detect a large decrease in current in the presence of HIV antibodies. The current remains the same if no HIV antibodies are present.

"Our biggest goal is to make a handheld biosensor similar to the glucose sensor, but for the specific detection of HIV."

"Our biggest goal is to make a handheld biosensor similar to the glucose sensor, but for the specific detection of HIV," Lai said.

Electrochemical sensing has the potential for diverse applications, ranging from cancer detection to finding toxins, explosives or drugs in the body and in the environment.

Lai recently earned a $455,000, five-year National Science Foundation CAREER Program award, which supports outstanding pre-tenure faculty, to continue her research.

Educating young people in science and being a role model for young women and minorities in science are important facets of Lai's career. The CAREER award also will take her into Nebraska's classrooms. She plans to develop hands-on summer workshops in biosensing technologies for Nebraska high school teachers. The first workshops will be in summer 2011.

Above left: Electrochemical biosensor
Right: Rebecca Lai (left) and graduate student Jennifer Gerasimov

Developing Stronger Nanomagnets

Building better hybrid cars, wind turbines and computers reduces global warming, but the nanomagnets used in these devices require rare earth metals. Experts in UNL's Nebraska Center for Materials and Nanoscience (NCMN) aim to change that.

As partners in a $4.5 million Advanced Research Projects Agency-Energy grant from the U.S. Department of Energy led by the University of Delaware, UNL researchers collaborate with several universities, laboratories and companies to improve nanomagnets. The grant is funded through the American Recovery and Reinvestment Act.

Many clean energy and electronic devices rely on magnetic materials made from rare earth metals that, despite the name, are common in the earth's crust. However, nearly all of the world's supply of rare earth metals comes from China. Demand for these metals is skyrocketing, China is restricting exports, and the extraction process is an environmental concern.

From left, Jeff Shield, Ralph Skomski and David Sellmyer

"There's huge interest in energy research and development now. Our country definitely needs to get better at creating energy for all kinds of power applications," said physicist David Sellmyer, NCMN director.

Sellmyer, physicist Ralph Skomski and materials engineer Jeff Shield are developing materials with stronger magnetic properties that do not contain rare earth metals. Stronger magnets produce more energy for powering wind turbines and hydroelectric generators. They also reduce the size and power consumption of everything from hybrid and electric cars to computer memory.

To better manipulate the magnetic properties, researchers are building materials at the atomic scale. The ability to precisely position every atom in a nanoparticle allows full control of the material's magnetic properties.

This is high-risk, high-reward research. "The best magnets that we've got now were discovered in 1985 or so," Sellmyer said. "We've made advances, but nothing that's a big quantum leap. That's what we want: a home run rather than a single."

NCMN is home to one of the nation's leading magnetism research groups and is largely funded by National Science Foundation, Department of Energy and Department of Defense grants.

Nanoscience Facility in the Works

The more than 70 physicists, chemists and engineers who collaborate on UNL's nationally recognized materials and nanoscience research soon will share a new, centralized research facility.

The new Nanoscience Metrology Facility will provide much-needed research space for this interdisciplinary program of excellence, whose core facilities, equipment, labs and faculty currently are located in several campus buildings. The new facility will feature centrally located laboratories, research facilities and administrative space. Construction is under way with completion slated for 2011.

Construction was made possible by a $6.9 million grant from the National Institute of Standards and Technology (NIST), funded by the American Recovery and Reinvestment Act, to cover nearly half of the $14.8 million cost. Private donations and university funds will finance the rest. NIST is a non-regulatory agency in the U.S. Department of Commerce.

The 32,000-square-foot building is being constructed adjacent to the new Theodore Jorgensen Hall, which houses the physics and astronomy department. It is designed with flexible, multi-use research space to facilitate interdisciplinary collaboration. It will provide a low-vibration, temperature-controlled, low-electromagnetic field environment and clean rooms necessary for world-class research and measurements.

"It will provide modern central facilities for nanofabrication, electron microscopy and other synthesis and characterization laboratories," said David Sellmyer, director of the Nebraska Center for Materials and Nanoscience. "Also, it will permit new collaborative research that cannot be pursued in our present ... buildings and laboratories that are scattered across campus."

UNL is home to one of the nation's top nanomagnetism research groups. Materials scientists, nanoscientists and engineers from across UNL collaborate through the Nebraska Center for Materials and Nanoscience, and in UNL's National Science Foundation-funded Materials Research Science and Engineering Center focused on nanomagnetics and spintronics.

Above: Drawing of Jorgensen Hall (left) and adjacent Nanoscience Metrology Facility (right)

Powerful Microscope Will Aid Research

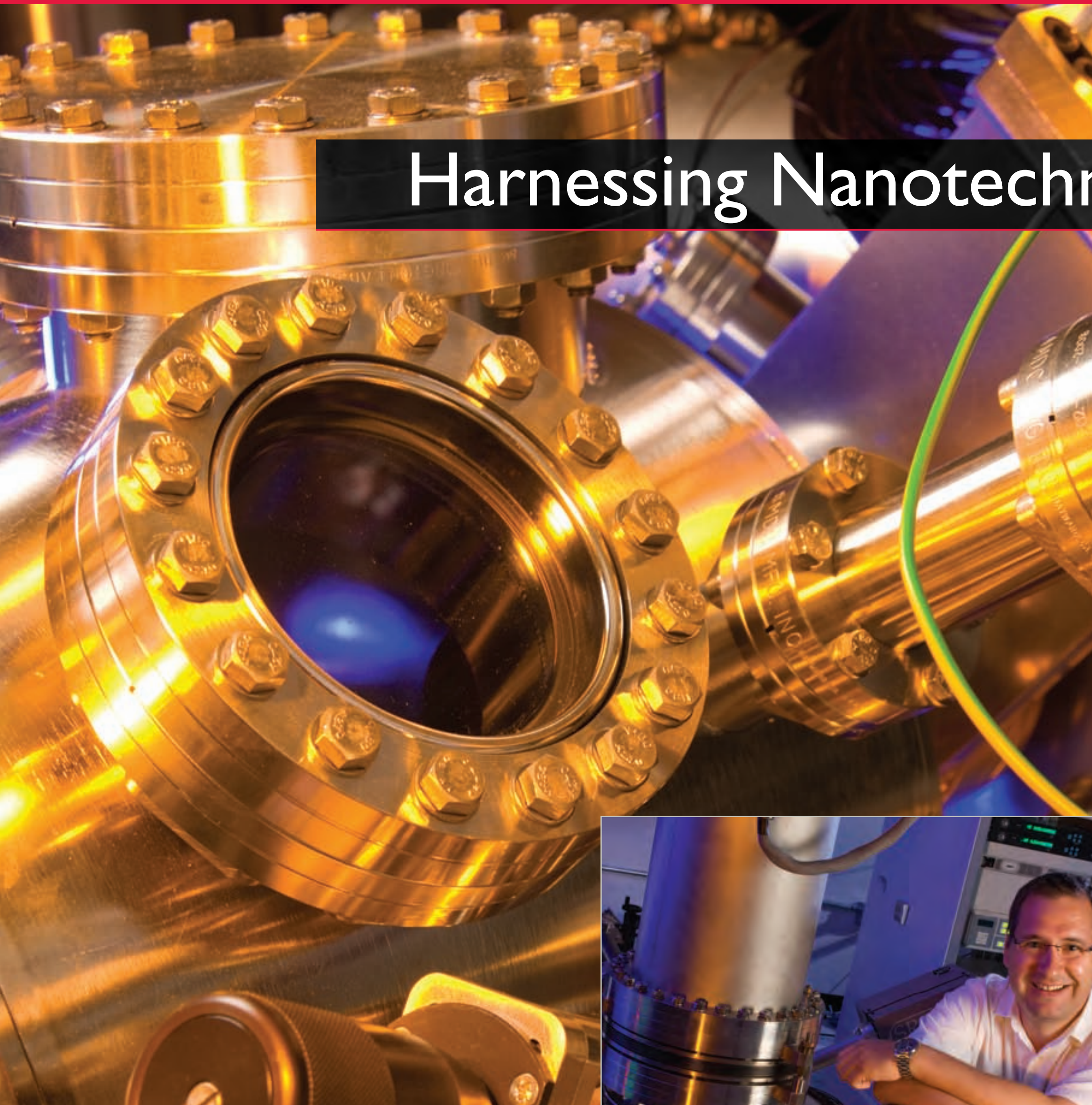
Sophisticated equipment in UNL's Nanoscience Metrology Facility will include a new transmission electron microscope to characterize the structure and properties of nanoscale materials and devices.

Such state-of-the-art equipment is important "so that you can do the best science," said physicist David Sellmyer, director of the Nebraska Center for Materials and Nanoscience. The center received a $1.3 million Major Research Instrumentation grant from the National Science Foundation through the American Recovery and Reinvestment Act for the microscope, which should be installed in early 2011.

The powerful microscope can characterize nanomaterials such as thin films, patterned surfaces, particles and wires. It can map structure, composition and properties and provide 3-D analysis. UNL researchers currently must travel out of state to use such equipment.

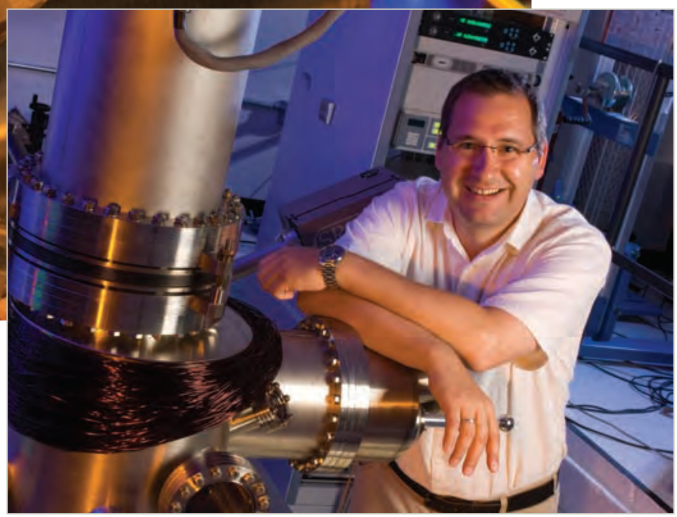
"Knowing the structure of nanomaterials is extremely important," Sellmyer said. "When you make particles that small, they can have structures that don't exist normally. You can't clearly understand how the particles are functioning without knowing the structure."

Harnessing Nanotechnology's Potential



From medicine and electronics to energy and the environment, nanotechnology promises to change our world. Researchers at UNL's Materials Research Science and Engineering Center (MRSEC) are exploring how to harness this nanopower.

More than 20 UNL physicists, chemists and engineers collaborate to study new magnetic structures and materials as small as one-billionth of a meter. Understanding the properties and performance of nanomaterials is a key step toward using them to create advanced technologies, said physicist Evgeny Tsymbal, MRSEC's director.



Axel Enders

For example, physicist Christian Binek studies magnetism for use in spintronics, which exploits the spin of electrons in addition to their conventional electrical charge. This could lead to exponentially smaller, faster and more powerful computers and electronic devices.

Multidisciplinary collaboration is essential, Binek said. "We are combining materials that don't happen in nature, which might be causing a chemical reaction that produces unwanted results. For a

chemist that may seem obvious, but for a physicist, if we aren't talking, it may be a painful learning curve."

MRSEC researchers share equipment as well as expertise. For his research, physicist Axel Enders built an ultrahigh-vacuum chamber to exclude oxygen when creating nanomaterials and a unique low-temperature scanning tunneling microscope that makes atoms of nanostructures visible. Both aid broader MRSEC research.

"Collaborating with others is very inspiring. Now, we can do things that any one of us could not do alone. MRSEC is one of the reasons I came to UNL," said Enders, who recently won a prestigious National Science Foundation CAREER award.

Established in 2002 with a $5.4 million NSF grant, MRSEC received an $8.1 million, five-year renewal grant in 2008. Its research, which focuses on quantum and spin phenomena in nanomagnetic structures, has garnered international attention.

MRSEC's research has potential applications in advanced computing, data storage, energy production, handheld electronic devices, sensors and medical technologies. The center also has a strong education and outreach program and collaborates with industry, national laboratories and scientists internationally.

"Our long-term goal is to be the leading interdisciplinary center for integrated research and education in nanomagnetism," Tsymbal said.

Above: Christian Binek (left) with graduate students Yi Wang and Srinivas Polisetty

Stimulus Bolsters Research

UNL faculty are aggressively pursuing funding available through the American Recovery and Reinvestment Act of 2009 to expand their research and scholarship, and to help stimulate the nation's economy.

The stimulus package, which provides unprecedented funding for research, infrastructure and education, is designed to jump-start the economy and create or retain jobs. Prem Paul, UNL vice chancellor for research and economic development, said stimulus funding will lead to new technologies and information with short- and long-term economic benefits. “Money spent on research creates and retains jobs,” Paul said. “These dollars will be spent in Nebraska and will truly have multiple benefits for our economy.”

UNL faculty are successfully competing for stimulus funding, Paul said. Examples of early success included:

- A $375,670, two-year grant from the National Institute of Allergy and Infectious Diseases to Robert Powers, associate professor of chemistry, for research to enhance his team’s functional annotation screening technology by nuclear magnetic resonance spectroscopy (FAST-NMR) assay. Perfecting this tool will help researchers determine the function of proteins identified by gene sequencing and their therapeutic potential in developing new drugs.

- A $360,000, three-year grant from the National Science Foundation to Jeffrey Shield, professor of mechanical engineering, to establish a Research Experiences for Undergraduates (REU) program in nanomaterials and nanoscience. Sponsored by the Nebraska Center for Materials and Nanoscience, this REU will build on UNL’s research strengths in nanotechnology. It will bring to campus students from colleges and universities that lack a strong research emphasis, especially those in the upper Midwest, as well as students from underrepresented groups for 10 weeks of intensive research with UNL faculty.

- A $300,002, three-year NSF grant to Li Tan, assistant professor of engineering mechanics, for research exploring how best to produce free-standing nanoparticle fibers that could be used to make far more efficient organic photovoltaic cells.

Credits

The 2008-2009 Annual Report is published by the University of Nebraska–Lincoln Office of Research and Economic Development. More information is available at http://research.unl.edu or contact:

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Projects Aim to Ease Research Space Shortage

Demand for research space is growing along with UNL's research enterprise. Several current or planned projects will begin to address this critical space shortage, providing state-of-the-art facilities and improving infrastructure. Here's a rundown:

Physical Sciences Building: In early 2010, physics and astronomy faculty will move from cramped labs and offices in three older buildings to the new $37 million Physical Sciences Building. Construction is under way on the four-story, 121,000-square-foot building to house laboratories and offices for physics and astronomy faculty along with teaching labs, lecture halls and classrooms.

Physical Sciences Building

NanoScience Facility: Construction of the adjacent NanoScience Facility will begin when the Physical Sciences Building is complete. The $13.5 million facility will provide 32,500 square feet of laboratory, core facilities and administrative space for College of Engineering and College of Arts and Sciences researchers who collaborate through UNL's Nebraska Center for Materials and Nanoscience.

Schorr Center: The Paul and June Schorr III Center for Computer Science and Engineering opened in early 2008 in redesigned space in South Stadium. The 18,400-square-foot center houses UNL's Research Computing Facility and its supercomputers, which support research campuswide. A major gift in their parents' honor from the children of Paul and June Schorr III of Lincoln, Neb., helped fund the center.

Whittier Renovation: A $23.6 million phased renovation is transforming the historic Whittier Building into space for two major research centers – the Nebraska Transportation Center and the Nebraska Center for Energy Sciences Research. The first phase, slated for completion in late 2009, will provide about 26,000 square feet of laboratory, office and meeting space for faculty, staff and students affiliated with these two new centers.

Whittier Building

Animal Research Facility: UNL is renovating its 31-year-old Animal Research Facility to better accommodate researchers' changing needs for laboratory animals. Upgrades will increase space for housing rodents and other animals and modernize operating systems. The first phase of renovations will be completed in 2009.

Summer Programs Share Nanoscale Research

Steve Ducharme (center) with visiting student-professor team, Stella Stephens and Horacio Vasquez, University of Texas-El Paso.

Visiting school teachers, undergraduate students and their professors get a macroscale immersion in nanoscale research through summer programs at UNL's Materials Research Science and Engineering Center (MRSEC).

The center fosters collaboration among UNL physicists, chemists and engineers to advance nanomaterials research. Education and outreach is part of the National Science Foundation-funded center's mission. Each summer, its 14 faculty members invite middle and high school teachers, and student-professor teams from four-year colleges to participate in MRSEC research.

"We're inviting folks to gain some new skills, learn some new things and to take what they learn here back home to disseminate to their students, some of whom will become scientists or engineers," explained Roger Kirby, chair of the Physics and Astronomy Department who heads the summer outreach programs. "We're building for the future."

MRSEC's summer programs give participants the chance to work closely with UNL scientists and engineers on cutting-edge research in nanomagnetics. One program brings five middle and high school teachers to UNL for eight weeks; another invites six students and their professors from smaller colleges for fellowships ranging from two weeks to two months.

In summer 2007, the program's fifth year, more than half the teachers and professors were women or minorities. Organizers hope the participating teachers return to their classrooms and inspire young women and minority students to consider careers in materials science.

Visiting students and teachers work on a variety of nanomaterials research projects, including investigating ferroelectric properties, x-ray diffraction and making nanoscale clusters of atoms, which can be used in various technologies, such as hard disk drives.

UNL physicist Steve Ducharme said the fellowships spark ongoing collaborations and encourage students to consider graduate school.

For example, a professor and her student took their knowledge of nanoscale clusters back to the University of Wisconsin-Platteville and involved other students in making clusters and investigating potential applications.

To Kirby, that demonstrates the program's success. UNL researchers also benefit through visitors' contributions of time, effort, new ideas and fresh perspectives.

NANO DISCOVERY IS GOLDEN

Talk about your gilded cage. UNL scientists studying gold's structure at the nanoscale discovered hollow cage-like structures made of pure gold atoms.

Research by UNL chemist Xiao Cheng Zeng, graduate research assistant Satya Bulusu and colleagues revealed the first free-standing hollow cage structures composed of clusters of pure metal atoms. They are the metallic equivalent of buckyballs, the hollow carbon clusters made famous partly by their catchy name. Their findings were featured on the cover of the *Proceedings of the National Academy of Sciences* in May 2006.

Unlike carbon buckyballs, which contain 60 atoms, the golden hollow cages are composed of 15, 16, 17 or 18 atoms and can hold an atom inside. Scientists might someday be able to harness these nanocages to carry useful guest atoms for medical or industrial purposes.

Zeng's team was the first to combine quantum chemistry calculations with a powerful computerized search technique to identify previously unknown nanoscale structures and substances. With the help of UNL's PrairieFire supercomputer, researchers generated many theoretical fingerprints of the gold clusters' structure.

UNL researchers worked with physicist Lai-Sheng Wang of the Pacific Northwest National Laboratory and Washington State University. Wang's team provided spectral data or fingerprints of the gold clusters, made by smashing gold with a laser beam. Clusters containing different numbers of atoms produce a unique spectral fingerprint.

By comparing spectral and theoretical fingerprints, UNL researchers identified the structures of the 15-, 16-, 17- and 18-atom gold clusters. "We were shocked when we first saw these," Zeng said. "No one expected the cage structure."

Zeng's team is studying the golden hollow cages' potential to carry nanomaterials and their prospects as catalysts to speed chemical processes.

Grants from the U.S. Department of Energy, the National Science Foundation-funded Materials Research Science and Engineering Center at UNL and the Nebraska Research Initiative support this research.

Above: Xiao Cheng Zeng (right) and graduate research assistant Satya Bulusu.
Opposite: An illustration shows a hollow nanocage made of 17 gold atoms.

"We were shocked when we first saw these. No one expected the cage structure."

Xiao Cheng Zeng