McCormick

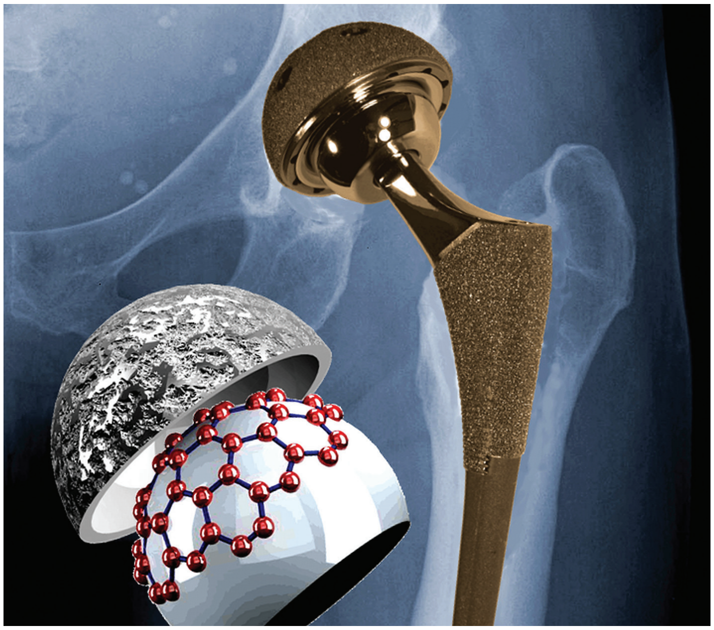
Northwestern Engineering

Materials Science and Engineering

Robert R. McCormick School of Engineering and Applied Science
Northwestern University

WINTER 2012

Researchers Create Hips that Function Better and Last Longer



Northwestern researchers have found that graphitic carbon is the key element in metal-on-metal hip implant lubrication.

A team of engineers and physicians have made a surprising discovery that offers a target for designing new materials for hip implants that are less susceptible to the joint's normal wear and tear.

Researchers from Northwestern University, Rush University Medical Center, Chicago, and the University of Duisburg-Essen Germany found that graphitic carbon is a key element in a lubricating layer that forms on metal-on-metal hip implants. The lubricant is more similar to the lubrication of a combustion engine than that of a natural joint. The study, "Graphitic Tribological Layers in Metal-on-Metal Hip Replacements," was published in December by the journal *Science*.

Prosthetic materials for hips, which include metals, polymers and ceramics, have a lifetime typically exceeding 10 years. However, beyond 10 years the failure rate generally increases, particularly in young, active individuals. Physicians would love to see that lifespan increased to 30 to 50 years. Ideally, artificial hips should last the patient's lifetime.

"Metal-on-metal implants can vastly improve people's lives, but it's an imperfect technology. Now that we are starting to understand how lubrication of these implants works in the body, we have a target for how to make the devices better." – Professor Laurence D. Marks

"Metal-on-metal implants can vastly improve people's lives, but it's an imperfect technology," said Professor Laurence D. Marks, a co-author on the paper who led the experimental effort at Northwestern. "Now that we are starting to understand how lubrication of these implants works in the body, we have a target for how to make the devices better."

The ability to extend the life of implants would have enormous benefits, in terms of both cost and quality of life. More than 450,000 Americans, most with severe arthritis, undergo hip replacement each year, and the numbers are growing. Many more thousands delay the life-changing surgery until they are older, because of the limitations of current implants.

"Hip replacement surgery is the greatest advancement in the treatment of end-stage arthritis in the last century," said co-author and principal investigator Dr. Joshua J. Jacobs, the William A. Hark, M.D./Susanne G. Swift Professor of

Continued on page 7

Please Join us for the 25th Annual Hilliard Symposium and First Annual Alumni Celebration

Thursday, May 17, 2012, Evanston

The Department of Materials Science and Engineering is pleased to host its 25th Annual Hilliard Symposium and First Annual Alumni Celebration on Thursday, May 17.

We are especially excited to announce the morning keynote speaker for the symposium: NU alum **John Cahn** (Hon. '90), one of the founders of our field, renowned for his many contributions to the thermodynamics and kinetics of phase transformations, and most recently as a winner of the 2011 Kyoto Prize. His presentation will be followed by graduate student talks, providing an opportunity to reflect on our shared history and learn about the most current research in the department.

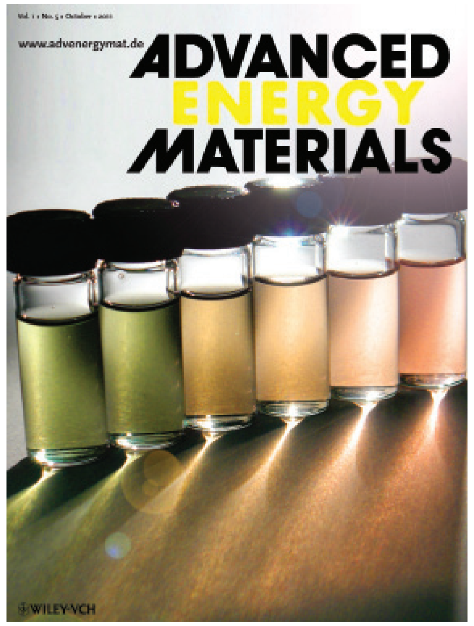
Following the day-long Hilliard Symposium, the Alumni Celebration will celebrate accomplishments by faculty, students and alumni, and several milestones: 25 years of the Hilliard Symposium, 30 years since Cahn-Hilliard Day, and 55 years since the development of the Cahn-Hilliard equation. Program and registration details will be sent via e-mail and are available on the departmental website: www.matsci.northwestern.edu.

Researchers Use Carbon Nanotubes to Make Solar Cells Affordable, Flexible

Researchers from Northwestern University have developed a carbon-based material that could revolutionize the way solar power is harvested. The new solar cell material — a transparent conductor made of carbon nanotubes — provides an alternative to current technology, which is mechanically brittle and reliant on a relatively rare mineral.

Because carbon is so abundant, carbon nanotubes could make solar power more viable in the long term by providing a cost-efficient option as demand for the technology increases. In addition, the material's mechanical flexibility could allow solar cells to be integrated into fabrics and clothing, enabling portable energy supplies that could impact everything from personal electronics to military operations.

The research, headed by Mark C. Hersam, professor of materials science and engineering and professor of chemistry, and Tobin J. Marks, Vladimir N. Ipatieff Professor of Catalytic Chemistry and professor of materials science and engineering, was featured on the cover of the October issue of *Advanced Energy Materials*, a new journal that specializes in science about materials used in energy applications.



Solar cell research conducted by Mark Hersam and Tobin Marks was featured on the cover of Advanced Energy Materials.

Solar cells are comprised of several layers, including a transparent conductor layer that allows light to pass into the cell and electricity to pass out; for both of these actions to occur, the conductor must be electrically conductive and also optically transparent. Few materials concurrently possess both of these properties.

> *"With this mechanically flexible technology, it's much easier to imagine integrating solar technology into everyday life, rather than carrying around a large, inflexible solar cell." – Professor Mark Hersam*

Currently, indium tin oxide is the dominant material used in transparent conductor applications, but the material has two potential limitations. Indium tin oxide is mechanically brittle, which precludes its use in applications that require mechanical flexibility. In addition, indium tin oxide relies on the relatively rare element indium, so the projected increased demand for solar cells could push the price of indium to problematically high levels.

"If solar technology really becomes widespread, as everyone hopes it will, we will likely have a crisis in the supply of indium," Hersam said. "There's a great desire to identify materials, especially earth-abundant elements like carbon, that can take indium's place in solar technology."

Hersam and Marks' team has created an alternative to indium tin oxide using single-walled carbon nanotubes, tiny, hollow cylinders of carbon just one nanometer in diameter.

The researchers have also gone further to determine the type of nanotube that is most effective in transparent conductors. Nanotubes' properties vary depending on their diameter and their chiral angle, the angle that describes the arrangement of carbon atoms along the length of the nanotube. These properties determine two types of nanotubes: metallic and semiconducting.

Metallic nanotubes, the researchers found, are 50 times more effective than semiconducting ones when used as transparent conductors in organic solar cells.

Because carbon nanotubes are flexible, as opposed to the brittle indium tin oxide, the researchers' findings could pave the way for many new applications in solar cells. For example, the military could incorporate the flexible solar cells into tent material to provide solar power directly to soldiers in the field, or the cells could be integrated into clothing, backpacks, or purses for wearable electronics.

Mark Hersam

Tobin Marks

"With this mechanically flexible technology, it's much easier to imagine integrating solar technology into everyday life, rather than carrying around a large, inflexible solar cell," Hersam said.

Researchers are now examining other layers of the solar cell to explore also replacing these with carbon-based nanomaterials.

Besides Hersam and Marks, other authors include Timothy P. Tyler, Ryan E. Brock, and Hunter J. Karmel. The work was supported by the Argonne Northwestern-Northwestern Solar Energy Research Center, an Energy Frontier Research Center funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences.

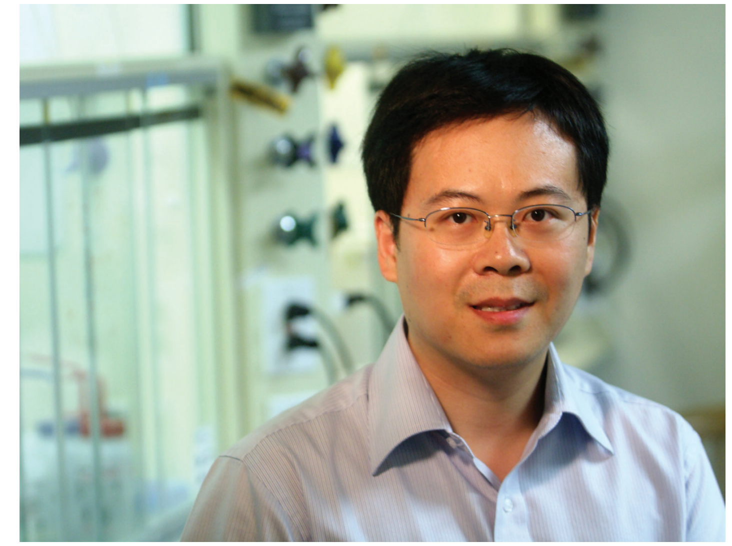
MARK HERSAM RECEIVES $1 MILLION GRANT FROM W. M. KECK FOUNDATION

Mark Hersam was awarded a $1 million grant last summer from the W. M. Keck Foundation to support his research on graphene, a one-atom-thick sheet of carbon with exceptional mechanical and electrical properties that could ultimately be used to make better electronics and sensors.

The properties of graphene have been discovered only within the last decade, and researchers are still working to understand all the possibilities it offers. We know graphene is the thinnest material in the world, and one of the strongest. It can conduct electricity as well as copper, conduct heat better than any other material, and is so thin it is practically transparent. With this funding, Hersam will develop and characterize techniques for modifying graphene to increase its potential, such as adding inorganic and organic materials to the material.

The W. M. Keck Foundation was established in 1954 by William Myron Keck, the founder of the Superior Oil Company. The foundation funds science and engineering research, medical research, and undergraduate education.

Frustration Inspires New Form of Graphene: Researchers Find Promise in 'Crumpling'



Jiaxing Huang

> *"Crumpled paper balls usually express an emotion of frustration, a quite common experience in research. However, here 'frustration' quite appropriately describes why these particles are resistant to aggregation." – Professor Jiaxing Huang*

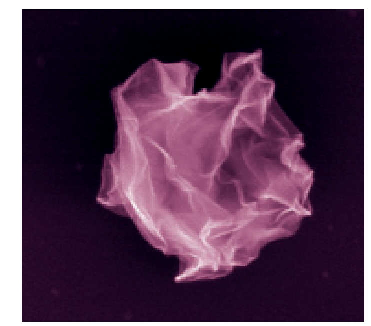
They're the building blocks of graphite — ultra-thin sheets of carbon, just one atom thick, whose discovery was lauded in 2010 with a Nobel Prize in Physics.

The seemingly simple material is graphene, and many researchers believe it holds potential for many applications, from electronic devices to high-performance composite materials. Graphene is extremely strong, an excellent conductor, and with no internal structure at all, it offers an abundance of surface area — much like a sheet of paper.

When it comes to producing and utilizing graphene on a large scale, however, researchers have come upon a major problem: the material's tendency to aggregate. Like paper, graphene sheets easily stack into piles, significantly reducing their surface area and making them unprocessable.

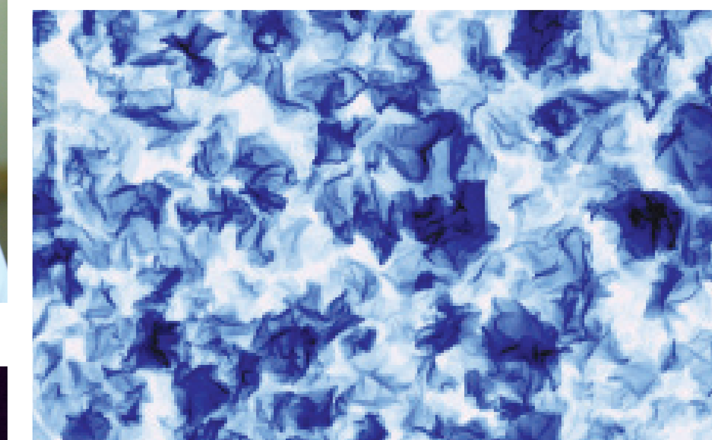
Researchers at Northwestern University have now developed a new form of graphene that does not stack. The new material — inspired by a trash can full of crumpled-up papers — is made by crumpling the graphene sheets into balls.

A paper describing the findings, "Compression and Aggregation-resistant Particles of Crumpled Soft Sheets," was published in October in the journal *ACS Nano*.



Graphene-based materials are very easily aggregated due to the strong interaction between the sheets, called "Van der Waals attraction." Therefore, common steps in materials processing, such as heating, solvent washing, compression, and mixing with other materials, can affect how the sheets are stacked. When the paper-like sheets band together — picture a deck of cards — their surface area is lost; with just a fraction of its original surface area available, the material becomes less effective. Stacked graphene sheets also become rigid and lose their processability.

Some scientists have tried to physically keep the sheets apart by inserting non-carbon "spacers" between them, but that changes the chemical composition of the material. When graphene is crumpled into balls, however, its surface area remains available and the material remains pure.



"Crumpling" sheets of graphene could make the material more processable, McCormick researchers have discovered.

"If you imagine a trash can filled with paper crumples, you really get the idea," said Jiaxing Huang, Morris E. Fine Junior Professor in Materials and Manufacturing, the lead researcher of the study. "The balls can stack up into a tight structure. You can crumple them as hard as you want, but their surface area won't be eliminated, unlike face-to-face stacking."

"Crumpled paper balls usually express an emotion of frustration, a quite common experience in research," Huang said. "However, here 'frustration' quite appropriately describes why these particles are resistant to aggregation — because their uneven surface frustrates or prevents tight face-to-face packing no matter how you process them."

To make crumpled graphene balls, Huang and his team created freely suspended water droplets containing graphene-based sheets, then used a carrier gas to blow the aerosol droplets through a furnace. As the water quickly evaporated, the thin sheets were compressed by capillary force into near-spherical particles.

The resulting crumpled graphene particles have the same electrical properties as the flat sheets but are more useful for applications that require large amounts of the material. The ridges formed in the crumpling process render the particles a strain-hardening property; the harder you compress them, the stronger they become. Therefore, the crumpled graphene balls are remarkably stable against mechanical deformation, Huang said.

"We expect this to serve as a new graphene platform to investigate application in energy storage and energy conversion," Huang said.

Other authors of the paper were Jiayan Luo, Hee Dong Jang, Tao Sun, Li Xiao, Zhen He, Alexandros P. Katsoulidis, Mercouri G. Kanatzidis, and J. Murray Gibson.

Letter from the Chair

Michael Bedzyk

Dear Friends,

This is my first opportunity to write to you as chair of the Department of Materials Science and Engineering. I would like to start by thanking my predecessor, Peter Voorhees, for eight years of dedicated service and leadership as chair. I would also like to thank Ken Shull for his service as associate chair, a position that Lincoln Lauhon now fills. Peter and Ken both did a wonderful job of leading the department forward and overseeing growth of the department. During their tenure we added five new faculty members and the number of graduate students and post-doctoral fellows grew substantially. Undergraduate awards in honor of John Hilliard were introduced in 2007 and continue to be presented annually to graduating seniors.

Peggy Adamson retired from her position as business administrator in July, and we thank her for many years of dedication to the well-being of our department. We were very fortunate in finding Laura Gerety to assume this very important role of directing the department's office staff.

We have seen another record-breaking year in research and education as marked by research expenditures, publications, and numbers of degrees granted. Our faculty members continue to provide leadership in Northwestern's research centers and facilities. Milestones this year have included the successful six-year renewal of NSF funding for the Materials Research Science and Engineering Center and the five-year partner contract renewal for operating the DuPont-Northwestern-Dow Collaborative Access Team at the Advanced Photon Source of Argonne National Lab.

> *"We have seen another record-breaking year in research and education as marked by research expenditures, publications, and numbers of degrees granted. Our faculty members continue to provide leadership in Northwestern's research centers and facilities." – Michael J. Bedzyk*

As indicated on page one, we are planning our First Annual Alumni Celebration on Thursday, May 17. This event will be an opportunity to reflect on our history as a department as well as to share the most recent research and accomplishments of faculty, students, and alumni. Most importantly, we hope it will be a chance to visit with old friends and provide insight into the future of the department. We hope to see you here.

Michael J. Bedzyk
Chair, Department of Materials Science and Engineering

SUPPORT MATERIALS SCIENCE

Generous alumni support has enabled endowment of the Fine and Cohen lectures, support of computing facilities in the Bodeen-Lindberg Design Studio, enhancement of our lab facilities, and summer support for undergraduate research.

Please remember to designate the Department of Materials Science and Engineering when you give to Northwestern.

McCormick Alumnus Named Head of MIT's Materials Science and Engineering Department

Christopher A. Schuh, a McCormick alum and highly respected contributor to the materials science field, was appointed in October as the new head of MIT's Department of Materials Science and Engineering.

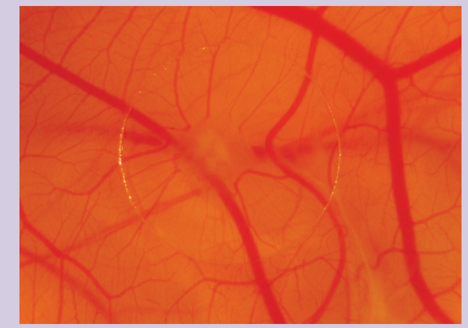
Since receiving his PhD in materials science and engineering from McCormick in 2001, Schuh has become internationally known for his contributions to processing-structure-property relationships in structural metals. His work particularly focuses on the role of structural disorder and its effect on mechanical properties.

Schuh most recently served as MIT's Danae and Vasilios Salapatas Professor of Metallurgy. In February 2011, he was also named to a 10-year appointment as a MacVicar Faculty Fellow, one of MIT's most prestigious awards for recognizing excellence in undergraduate education. Schuh is also co-founder and chief scientist of Xtalic Corporation, a manufacturer of nanostructured alloy coatings for electronics components, where he co-invented technology that permits control over grain size in nanocrystalline alloys.

From 2001 to 2002, Schuh served as Ernest O. Lawrence Postdoctoral Fellow at Lawrence Livermore National Laboratory. Before coming to Northwestern, he received a BS in materials science and engineering in 1997 from the University of Illinois at Urbana-Champaign.

Nanostructure Promotes Growth of New Blood Vessels, Mimics Natural Protein

Tissue deprived of oxygen (ischemia) is a serious health condition that can lead to damaged heart tissue following a heart attack and, in the case of peripheral arterial disease in limbs, amputation, particularly in diabetic patients.



Left: Researchers designed a peptide nanostructure in order to promote extensive new blood vessel growth as a strategy to treat cardiovascular diseases; right: Samuel Stupp in his lab

> *"Using simple chemistry, we have produced an artificial structure by design that can trigger complex events. Our nanostructure shows the promise of a general approach to mimicking proteins for broader use in medicine and biotechnology." – Samuel I. Stupp, Board of Trustees Professor of Chemistry, Materials Science and Engineering, and Medicine*

Northwestern University researchers have developed a novel nanostructure that promotes the growth of new blood vessels and shows promise as a therapy for conditions where increased blood flow is needed to supply oxygen to tissue.

"An important goal in regenerative medicine is the ability to grow blood vessels on demand," said Samuel I. Stupp, Board of Trustees Professor of Chemistry, Materials Science and Engineering, and Medicine. "Enhancing blood flow at a given site is important where blood vessels are constricted or obstructed as well as in organ transplantation where blood is needed to feed the cells properly."

Stupp led the study, which was published in August by the *Proceedings of the National Academy of Sciences* (PNAS).

Stupp and his team designed an artificial structure that, like the natural protein it mimics, can trigger a cascade of complex events that promote the growth of new blood vessels. The protein the nanostructure mimics is called vascular endothelial growth factor, or VEGF.

The nanostructure, however, exhibits important advantages over VEGF: it remains in the tissue where it is needed for a longer period of time; it is easily injected as a liquid to the tissue; and, relative to the protein, it is inexpensive to produce. (VEGF was tested in human clinical trials but without good results, possibly due to it remaining in the tissue for only a few hours.)

"One of the major challenges in the field of ischemic tissue repair is sustained delivery of therapeutic agents to target tissue," said Douglas W. Losordo, M.D., a co-author of the paper and director of Northwestern's Feinberg Cardiovascular Research Institute. "Native VEGF has a very short tissue half-life, limiting its potency and requiring repeat dosing. By virtue of its engineering, this nanomaterial mimics VEGF but is capable of much longer life in the tissue, greatly enhancing its potency."

Losordo also is the Eileen M. Foell Professor of Heart Research at Northwestern's Feinberg School of Medicine and director of the Program in Cardiovascular Regenerative Medicine at Northwestern Memorial Hospital.

"We approached this as an engineering problem," said first author Matthew Webber, a doctoral student in Stupp's research group at the Institute for BioNanotechnology in Medicine (IBNAM). "To be able to design and create a small molecule that can assemble into nanostructures that function therapeutically is rewarding."

Stupp and his team created a nanostructure in the form of a fiber that displays on its surface a high density of peptides (potentially hundreds of thousands) per fiber. The peptides mimic the biological effect of VEGF, initiating the signaling process in cells that leads to blood vessel growth.

The extremely large number of active peptides results in a very potent therapeutic, and the size and stability of the nanofiber ensure the structure is retained longer in the tissue after injection.

After developing the nanostructure, Stupp and Webber teamed up with Losordo to test the nanostructures in vivo.

The researchers used an animal model of peripheral arterial disease and demonstrated the effectiveness of the nanofiber in treating the condition. In animals whose limbs were restricted to only 5 to 10 percent of normal blood flow, treatment with the nanofiber resulted in blood flow being restored to 75 to 80 percent of normal levels.

Treatment with the peptide alone did not produce the same therapeutic effect; the nanostructure was needed to display the peptides to produce results.

"Using simple chemistry, we have produced an artificial structure by design that can trigger complex events," said Stupp, who is director of IBNAM. "Our nanostructure shows the promise of a general approach to mimicking proteins for broader use in medicine and biotechnology."

The researchers next plan to investigate the protein mimic in a heart attack animal model.

The National Institutes of Health supported the research.

The paper is titled "Supramolecular Nanostructures that Mimic VEGF as a Strategy for Ischemic Tissue Repair." In addition to Stupp, Losordo and Webber, other authors of the paper are Jörn Tongers, Christina Newcomb and Katja-Theres Marquardt, of Northwestern University; and Johan Bauersachs, of Hannover Medical School, Hannover, Germany.

FACULTY NEWS

The Czech Society for Mechanics has named an engineering prize after Czech-born **Zdeněk P. Bažant**. The Z.P. Bazant Prize for Engineering Mechanics will be awarded annually to the author of an article or series of articles on an original topic, a book, monograph, or PhD thesis.

David Dunand was named a 2012 fellow of The Minerals, Metals & Materials Society (TMS), one of only four.

Mark Hersam named 2012 fellow of SPIE, the society for optics and photonics. And last April, six samples of new nanotube and graphene thin films from the Hersam group were placed on-board the space shuttle Endeavor. The researchers analyzed them to see it they degrade in the harsh radiation environment of outer space or are stable. Hersam was also named MSE Teacher of the Year in December 2011.

Emilie Ringe, **Richard Van Duyne** and **Laurence Marks** described use of the Wulff construction to determine shape of alloy nanoparticles based on size and composition in an article published in *ACS Nano Letters*.

David Seidman was named to the Editorial Advisory Board of *Materials Today*.

Ramille Shah was profiled as Scientist of the Month (October) by Chicago-Area Association for Women in Science.

STUDENT NEWS

Graduate students **Heather Arnold** (Hersam) and **Sarah Miller** (Faber) have received NASA Space Technology Research Fellowships. **Heather Arnold**, **Lauryn Baranowski** (Hersam), **James Riley** (Lauhon) and **Catherine Tupper** (Brinson/Dunand) were also selected last spring to receive 2011 National Defense Science and Engineering Graduate (NDSEG) Fellowships.

NSF Graduate Research Fellowships were awarded last April to graduate students **Bernard Beckerman**, **Dana Frankel, Andrew Koltonov** and **Catherine Tupper,** senior **Anthony Tan** and alumnus **Phillip Barton** (UCSB). Students cited for honorable mention include graduate students **Heather Arnold**, **Peter Bocchini**, **Kayla Culver**, **Alex Hryn**, **Adam Jakus**, **Arpus Nagaraja**, **Michael Rawlings** and **John Thompson**, senior **Tejas Shastry**, and alumni **Christopher Liman** (USCB) and **Matthew Chastain** (MIT-Archeology).

Peter Bocchini (Seidman/Dunand) was awarded one of only five NASA Aeronautics Scholarships last spring.

Ryan Brock ('11), a BS/MS materials science and engineering student who received both degrees after just four years, was the recipient of the 2011 Harold B. Gotaas Undergraduate Research Award. Brock's presentation was titled, "Electronically Monodisperse Single-Walled Carbon Nanotube Thin Films as Transparent Conducting Anodes in Organic Photovoltaic Devices." Finalists in the McCormick-wide competition also included MSE seniors **Tejas Shastry** (Hersam), **Alvin Tan** (Huang), **Anthony Tan** (Faber) and ME senior **Grace Wittman** (Voorhees).

Last spring, PhD candidate **Laura Cote** (Huang) was awarded a highly competitive Josephine de Karman Fellowship and a prestigious PEO (Philanthropic Educational Organization) scholar award.

Graduate student **George Fraley** (Olson) was named MSE Teaching Assistant of the Year in December 2011.

John Gibbs (Voorhees) received a DOE National Nuclear Security Administration (NNSA) Stewardship Science Graduate Fellowship.

Graduate students **Francisco Lopez** (Lauhon group) and **Jaemyung Kim** (Huang group) were selected to receive MRS graduate student awards at the spring MRS Meeting in San Francisco.

Martin McBriarty (Bedzyk) received a Fulbright Scholarship to spend the 2011-12 academic year at the Fritz Haber Institute in Berlin.

PhD candidate **Bryce Meredig** (Wolverton) was awarded a Presidential Fellowship, the most prestigious fellowship offered by Northwestern, in April 2011.

Alvin Tan ('11) won first place in the undergraduate competition at the Chicago ASM meeting last April for his poster "Graphene Oxide Nanocolloids." Alvin was also awarded the ASM Chicago Regional Chapter Award for outstanding undergraduate students pursuing a materials science career and was among eight McCormick students named to "Fifty for the Future" by the Illinois Technology Foundation.

HILLIARD SYMPOSIUM STUDENT PRESENTERS, MAY 19, 2011

"Weibull Analysis of Dielectric Breakdown in Self-Assembled Nanodielectrics" — **Ruth Schlitz** (Adviser: Lincoln Lauhon)

"New phases of silicon and germanium nanowires as promising building blocks for polytype heterojunction devices" — **Francisco Lopez** (Adviser: Lincoln Lauhon)

"Improved Monodispersity of Plasmonic Nanoantennas via Centrifugal Processing" — **Tim Tyler** (Adviser: Mark Hersam)

"Investigating Biomineralization with X-ray Microscopy: Selective Sequestration of Ba and Sr in Green Algae" — **Minna Krejci** (Adviser: Derk Joester)

"Tribological investigation of 'N3FC' diamond-like carbon films using *in situ* TEM" — **Ariel M'Ndange-Pfupfu** (Adviser: Laurie Marks)

"Theoretical Study of Water Adsorption on Oxide Surfaces" — **Andres Becerra-Toledo** (Adviser: Laurie Marks)

"First-principles study of ordering and adsorption on bimetallic surface alloys" — **Wei Chen** (Adviser: Chris Wolverton)

"The Mechanical Properties of Acicular Mullite" — **Harold Hsiung** (Adviser: Katherine Faber)

"Mechanical & Fracture Response of Silicone Gels" — **Katie Otim** (Adviser: Ken Shull)

"Regenerative Behavior of Pd-substituted (La,Sr)CrO3-δ Solid Oxide Fuel Cell Anodes" — **David Bierschenk** (Adviser: Scott Barnett)

"Materials Design for Joinable, High Performance Aluminum Alloys" — **Ryan Glamm** (Adviser: Greg Olson)

"Defect analysis and optimization of transparent conducting oxides for energy applications" — **Mitch Hopper** (Adviser: Thomas Mason)

ALUMNI NEWS

Mary C. (BS '98) and **Ethan Meister** have generously provided funding for scholarships that will support MSE freshmen and sophomore materials research over the summer that will support MSE freshman and sophomore student research during summers.

David Rowenhorst (PhD, Voorhees, 2004), now at the U.S. Naval Research Laboratory, will be awarded the AIME Rossiter W. Raymond Memorial Award at the March 2012 TMS meeting.

A study of prehistoric Cahokian metallurgy by alum **Matt Chastain**, grad student **Alix Deymier-Black**, **David Dunand**, and co-authors in anthropology was published last May in the *Journal of Archeological Science*. The work is profiled in an article and video.

Recent alumna **Emma Dutton** (BS '11) is the recipient of a 2011-12 Alumnae of Northwestern University Graduate Fellowship. Emma is pursuing a master of science in journalism from the Medill School of Journalism.

NEWS BRIEFS

Shark Steroid Research Receives Wide Acclaim

Research by Professor **Erik Luijten**'s lab about the promise of shark steroids for medical uses received wide coverage last summer by the news media. Luijten and graduate students **Bernard Beckerman** and **Wei Qu** contributed modeling results to new research that reveals how a steroid found in sharks may be able to fight a range of virus infections in humans, through electrostatic binding to cell membranes. The research was published in the September 20 issue of the *Proceedings of the National Academy of Sciences* and has been featured in a wide variety of news outlets, including *National Geographic*, BBC News, *the L.A. Times*, and *C&E News*.

Hilliard Undergraduate Awards Presented

Hilliard Undergraduate Awards were presented at the final Senior Project Symposium on June 8, 2011. The winner of the award for Research and Design was **Alvin Tan** for his project "All-Carbon Composites for Energy Applications" with the Huang group. The winner of award for Leadership, Scholarship and Service was **Ryan Brock**, who completed BS/MS degrees with the Hersam group and has served as president of Tau Beta Pi and Slivka Residential College. Ryan was active as coordinator and participant in the M.E.S.S. outreach project.

Tobin Marks Receives $250,000 Dreyfus Prize in the Chemical Sciences

Northwestern University chemist and materials scientist **Tobin J. Marks**, a world leader in the fields of organometallic chemistry, chemical catalysis, materials science, organic electronics, solar energy, photovoltaics and nanotechnology, has received the 2011 Dreyfus Prize in the Chemical Sciences from the Camille and Henry Dreyfus Foundation. The prize, given biennially by the Dreyfus Foundation and this year conferred in catalysis, recognizes exceptional and original research in a selected area of chemistry that has advanced the field in major ways. The prize consists of a monetary award of $250,000 — one of the largest awards dedicated to the chemical sciences in the United States — a citation and a medal.

Hips That Function Better

from cover

Orthopedic Surgery and professor and chair of the department of orthopedic surgery at Rush. "By the time patients get to me, most of them are disabled. Life is unpleasant. They have trouble working, playing with their grandchildren or walking down the street. Our findings will help push the field forward by providing a target to improve the performance of hip replacements. That's very exciting to me." (Jacobs received his BS in materials science from Northwestern in 1977.)

Earlier research by team members Alfons Fischer at the University of Duisburg-Essen and Markus Wimmer at Rush University Medical Center discovered that a lubricating layer forms on metallic joints as a result of friction. Once formed, the layer reduces friction as well as wear and corrosion. This layer is called a tribological layer and is where the sliding takes place, much like how an ice skate slides not on the ice but on a thin layer of water.

But, until now, researchers did not know what the layer was. (It forms on the surfaces of both the ball and the socket.) It had been assumed that the layer was made of proteins or something similar in the body that got into the joint and adhered to the implant's surfaces.

The interdisciplinary team studied seven implants that were retrieved from patients for a variety of reasons. The researchers used a number of analytical tools, including electron and optical microscopies, to study the tribological layer that formed on the metal parts.

The electron-energy loss spectra, a method of examining how the atoms are bonded, showed a well-known fingerprint of graphitic carbon. This, together with other evidence, led the researchers to conclude that the layer actually consists primarily of graphitic carbon, a well-established solid lubricant, not the proteins of natural joints.

"This was quite a surprise," Marks said, "but the moment we realized what we had, all of a sudden many things started to make sense."

Metal-on-metal implants have advantages over other types of implants, Jacobs said. They are a lower wear alternative to metal-on-polymer devices, and they allow for larger femoral heads, which can reduce the risk of hip dislocation (one of the more common reasons for additional surgery). Metal-on-metal also is the only current option for a hip resurfacing procedure, a bone-conserving surgical alternative to total hip replacement.

"Knowing that the structure is graphitic carbon really opens up the possibility that we may be able to manipulate the system in a way to produce graphitic surfaces," Fischer said. "We now have a target for how we can improve the performance of these devices."

"Nowadays we can design new alloys to go in racing cars, so we should be able to design new materials for implants that go into human beings," Marks added.

The next phase, Jacobs said, is to examine the surfaces of retrieved devices and correlate the researchers' observations of the graphitic layer with the reason for removal and the overall performance of the metal surfaces. Marks also hopes to learn how graphitic debris from the implant might affect surrounding cells.

The science of tribology is the study of friction, lubrication and wear. The term comes from the Greek word "tribos," meaning rubbing or sliding.

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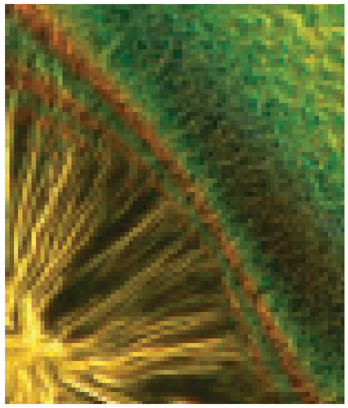
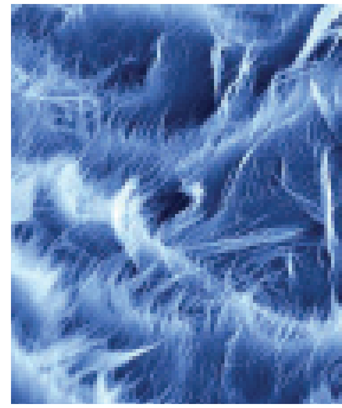
In addition to Marks, Jacobs, Fischer and Wimmer, other authors are Yifeng Liao (first author), from Northwestern, and Robyn Pourzal, from the University of Duisburg-Essen, Germany.

Materials Science in Art

Materials science student work was well represented in the 2011 Northwestern Scientific Images Contest. The competition is sponsored by Science in Society, a Northwestern University outreach initiative that strives to connect science to the community. Pieces were judged by a panel of local artists, scientists, and community leaders.





From left to right, photos by Andrew Koltonow, Rongrong Cheachareon, and Laila Jaber-Ansari.

First Place: Graduate student Andrew Koltonow (Huang/Stupp)

More efficient solar cells may be the solution to cleaner, greener energy. These clusters of zinc oxide nanoparticles are used to help engineers design new materials for organic solar cells. They're used in a coating that allows electric current to flow only in the correct direction, blocking unintended leakage. This allows researchers to study the energy-harvesting material more reliably. Clusters in the lower left formed more slowly than the rest, producing the large, spindly crystals. Variations in color relate to the thickness of the clusters.

Honorable Mention: Undergraduate student Rongrong Chearcharoen (Lauhon)

Determining the best way to test a new material is a crucial early step along the path of scientific discovery. This silicon oxide gel, seen here as a fractured pink film, can be used to coat incredibly small materials prior to testing. For example, by protecting one half of a nanowire, researchers can change the conditions surrounding only the other side, allowing them to compare the two.

Honorable Mention: Graduate student Laila Jaber-Ansari (Hersam)

Improving the efficiency of energy storage devices, like batteries, is one exciting application of nanotechnology. Here, bundles of carbon nanotubes, each made up of a single layer of carbon atoms, form a freestanding film. The film, which can store energy much faster than other commonly used materials, will serve as an electrode in lithium ion batteries.

Editors: Sarah Ostman, Kathleen Stair
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