

MATERIALS SCIENCE AND ENGINEERING

TWO MAJOR AWARDS FOR RONDINELLI

Rondinelli receives PECASE and Sloan Fellowship

February was a big month for Assistant Professor James Rondinelli.

He was honored with two prestigious awards: the Presidential Early Career Award for Scientists and Engineers (PECASE) and a Sloan Research Fellowship.

Selected by the Alfred P. Sloan Foundation, the Sloan Research Fellowships are awarded in eight scientific and technical fields: chemistry, computer science, economics, mathematics, computational and evolutionary molecular biology, neuroscience, ocean sciences, and physics. Each fellowship comes with a \$55,000 award.

Rondinelli was selected as a Sloan Research Fellow in Physics and recognized for his work to apply quantum mechanical and computational physics approaches to design new materials atom-by-atom. He manipulates materials at their fundamental electronic level, pushing electrons in inorganic compounds to do new things in dynamic environments.

The PECASE is the highest honor bestowed by the United States government on science and engineering professionals in the early stages of their independent



Rondinelli

RONDINELLI IS RECOGNIZED FOR HIS SEMINAL RESEARCH CONTRIBUTIONS IN COMPUTATIONAL PHYSICS AND NOVEL MATERIALS DESIGN APPROACHES.

research careers. A total of 105 researchers across the country were honored this year. Recipients were invited to the White House this spring to meet President Barack Obama and attend an awards ceremony.

"It's a great honor to receive such recognition at this stage of my scientific career, where I've focused on creating new knowledge and training a new generation of scientists and engineers to solve 21st-century problems," Rondinelli said. "The award is particularly gratifying because it recognizes the importance of fundamental theoretical and computational science research to the nation's priorities."

Rondinelli is recognized for his seminal research contributions in computational condensed matter physics and novel materials design approaches. He has transformed the scientific community's approach to designing materials using broken inversion symmetry at interfaces and provided the first-ever methodology for predicting the relationship between strain and octahedral rotations in complex oxides, paving the way for the design of many-body quantum properties in ways previously not considered possible.

FROM THE CHAIR

Dear Friends,

Much has happened since our last newsletter in October. Many alumni and friends of the department attended the tribute to **Morris Fine** on November 12, a moving memorial to Morrie and his impact both here and abroad. More recent highlights include the recognition of our faculty with very prestigious awards. These include two major awards for **James Rondinelli** (described on page 1) and the election of **Peter Voorhees** into the American Academy of Arts and Sciences. Our students are also garnering recognition: five graduate students and two alumni received National Science Foundation Fellowships and a number received honorable mention. Many alumni have also

received significant recognition for their professional achievements.

From my previous letters, you know that the department is growing. The addition of new faculty with relatively large research groups requires more space, and I am happy to report that the University is supporting us in this effort. Over the next few years, plans are in place for materials science and engineering research groups to occupy parts of two different additions to the Technological Institute. Two floors are being added to the Seeley G. Mudd Building, which will house additional lab and office space. The department will also have space on the downtown Chicago campus in the new Simpson Querrey Institute of BioNanotechnology. The NUANCE facility, which is directed by **Vinayak Dravid**, will also expand to make way for two state-of-the-art electron microscopes.

On Thursday May 19, we will hold our annual Hilliard Symposium, followed by our Alumni Celebration Banquet. We are pleased that **Carolyn Duran** will present the Hilliard keynote address. We will also celebrate the accomplishments of alumni **Andrea Hodge** and **Shih-Wei Sun**, who are profiled on page 5. I hope that many of you will join us. See below for details.

I want to express my gratitude to all of you who have supported the department so generously. The Weertman Graduate Fellowship endowment fund has grown, as has the support for the Fine Lecture series. These and other generous donations greatly enhance our educational mission as well as recognizing those giants in the field who laid the foundation for this department.

Finally, it is my pleasure to share the news that **Erik Luijten** will be assuming the role of department chair on September 1. Erik has been a key member of the faculty since he joined us from the University of Illinois at Urbana-Champaign in 2009. Most recently, he has directed our Applied Physics Graduate Program. I enjoyed the opportunity to lead our department over these past few years and learned a great deal in the process. I am confident that Erik will provide strong leadership for the future.



Mike Bedzyk
Department Chair

Upcoming Events

THURSDAY, MAY 19

The John E. Hilliard Symposium

Norris Center

8:30 a.m. to 4:40 pm

This day-long event highlights the original research of our senior graduate students.

Keynote Talk at 11a.m. "Redefining What We Mean by a Quality Product" featuring Carolyn Duran (PhD '98, Wessels), director of global supply management — supply chain corporate social responsibility and lithography commodity management, Intel Corporation.

THURSDAY, MAY 19

Annual Alumni Celebration Banquet

Hilton Orrington

1710 Orrington Avenue, Evanston

Reception: 5:30 pm

Dinner: 6:30 pm

Honoring Alumni Award recipients Shih-Wei Sun and Andrea Hodge (see profiles, page 5). For more information or to register, please contact Molli Connell at 847-491-3533 or mbconnell@northwestern.edu.

FRIDAY, JUNE 17

Graduation Reception

Cook Hall Atrium

2220 Campus Drive, Evanston

11:30 a.m. to 1 p.m.

Bachelor's, master's, and PhD graduates, family, and friends are invited to attend this department-hosted celebration.



Carolyn Duran

ALUMNUS STARTS NEW ADVENTURE

Charlie Kuehmann ('94) becomes vice president of materials engineering for SpaceX and Tesla

Charles Kuehmann was born into a family of entrepreneurs. His great grandfather owned Kuehmann Potato Chips, a late 1800s snack operation, and his father operated a marina along the Colorado River. To date, Kuehmann himself has founded three businesses, including QuesTek, a new-materials design firm.

In December, Kuehmann ('94) became the vice president of materials engineering at both Tesla Motors and SpaceX, working on the future of electric cars and inter-

"NOW WE'RE AT THE POINT WHERE I'VE BEEN AT THREE COMPANIES ESTABLISHING MATERIALS DESIGN TEAMS. THAT'S PROBABLY THE BIGGEST PART OF MY LEGACY."

CHARLES KUEHMANN

planetary travel, respectively. He is the only employee — besides CEO and South African entrepreneur Elon Musk — who splits his time between the two companies, a role he described as "crazy." Before joining the moonshot operation, Kuehmann led a product design team at Apple.

Kuehmann grew up in Bullhead City, Arizona, a small town located about 100 miles south of Las Vegas. A product of the Apollo era, when US astronauts landed on the moon, the budding engineer divided his time between imagining life in space and running an athletic medicine office at his local high school.

After high school, the young entrepreneur received a scholarship to attend Arizona State University, where he graduated summa cum laude with a degree in aerospace engineering. While at school, Kuehmann recalled building an advanced



Kuehmann

engine for American aerospace company AlliedSignal that exploded after only 20 hours. His team had made a miscalculation of the turbine temperature, which reduced the engine's life dramatically. The experience taught Kuehmann that in order to improve design, he had to first improve materials.

Gradually, Kuehmann's focus began to shift away from design and toward materials. After college, he received a prestigious NSF grant, and in 1988 he began to pursue his PhD in Northwestern's Department of Materials Science and Engineering.

At the same time, Professor Gregory Olson, who also had an interest in materials and design, was transitioning from MIT to Northwestern. Olson, named the "father of materials design" by the American Academy of Arts and Sciences, had an idea to utilize computing software to lower the cost of materials creation.

Kuehmann became one of Olson's first graduate students at Northwestern, where the two worked together to hone computer models they hoped would reduce the cost of developing new metals. In 1996, unable to elicit interest from any other engineering companies in the industry, the two co-founded their own company, QuesTek. Straightaway, they received contracts from major clients, such as Newman/Haas Racing and the US Navy, and later worked with SpaceX.

After a three-year stint at Apple, Kuehmann reignited his childhood passion for space travel last December when he took the job at Tesla and SpaceX. A far cry from grade school daydreams, today Kuehmann splits his time between combating the risk of human extinction and curbing fossil fuel emissions.

"If we can't move away from fossil fuels, we're going to destroy our environment," he said. "Long term, the risks are very high that either something natural or man-made is going to have a significant aversive effect on our planet. The capability to colonize and exist outside of (Earth) is probably the only weapon in the toolbox to address that risk."

Kuehmann said he would like to explore space, too, if ever given the chance. But for now, safely grounded on Earth, Kuehmann spends a lot of time with his family and rides bikes to stay in shape. "I'm bringing materials design and engineering into commercial spaces and starting to plant a seed," he said. "When I got out of graduate school, materials design was a stage zero company. Now we're at the point where I've been at three different commercial companies establishing materials design teams. That's probably the biggest part of my legacy."

Article used courtesy of David Fishman, Daily Northwestern

SCIENTISTS CREATE ATOMICALLY THIN METALLIC BORON

Synthesis of borophene expands family of two-dimensional materials beyond graphene

A team of scientists from Northwestern, Argonne National Laboratory, and Stony Brook University has, for the first time, created a two-dimensional sheet of boron — a material known as borophene. The study was published in the December 18 issue of the journal *Science*.

Scientists have been interested in two-dimensional materials for their unique characteristics, particularly involving their electronic properties. Borophene is an unusual material because it shows many metallic properties at the nanoscale even though three-dimensional, or bulk, boron is nonmetallic and semiconducting. Because borophene is both metallic and atomically thin, it holds promise for possible applications ranging from electronics to photovoltaics.

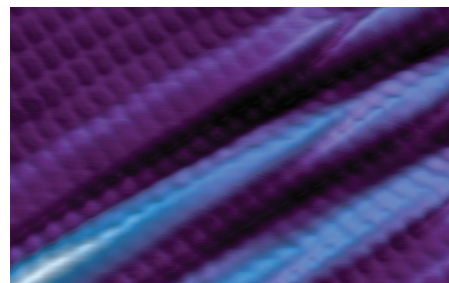
Like its periodic table neighbor carbon, which appears in nature in forms ranging from humble graphite to precious diamond, boron wears a number of different faces,

called allotropes. But that's where the similarities end. While graphite is composed of stacks of two-dimensional sheets that can be peeled off one at a time, there is no such analogous process for making two-dimensional boron.

Although at least 16 bulk allotropes of boron are known, scientists had never before been able to make a whole sheet, or monolayer, of borophene.

One of boron's most unusual features consists of its atomic configuration at the nanoscale. While other two-dimensional materials look more or less like perfectly smooth and even planes at the nanoscale, borophene looks like corrugated cardboard, buckling up and down depending on how the boron atoms bind to one another.

The "ridges" of this cardboard-like structure result in a material phenomenon known as anisotropy, in which a material's mechanical or electronic properties — like its electrical conductivity — become directionally dependent. "This extreme



An atomic-resolution topographic rendering of the borophene surface.

anisotropy is rare in two-dimensional materials and has not been seen before in a two-dimensional metal," said Andrew Mannix, Professor Mark Hersam's graduate student and first author of the study.

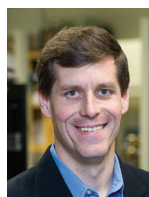
"Boron has a rich and storied history and a very complicated chemistry," said Hersam. "This is something that could have easily not worked, but Andy had the courage and persistence to make it happen."

HERSAM NAMED US SCIENCE ENVOY

He will focus on emerging technologies in Eastern Europe

Professor Mark Hersam has been selected as a US Science Envoy by the US Department of State. He began his yearlong service in February. As a US Science Envoy, Hersam will travel to Eastern Europe to stimulate cooperation in the area of emerging technologies.

"It is a great honor to be selected as a US Science Envoy for 2016," said Hersam, Walter P. Murphy Professor of Materials Science and Engineering. "I



Hersam

anticipate opportunities to exchange ideas on how to accelerate the transition of fundamental scientific research to economic prosperity through education, entrepreneurship, and commercialization."

President Barack Obama launched the US Science Envoy program in 2009

to demonstrate the United States' commitment to science, technology, and innovation as tools of diplomacy and economic growth. After traveling abroad, science envoys advise the White House, Department of State, and scientific community about potential opportunities for collaboration.

MATERIALS SCIENCE ALUMNI HONORED

Shih-Wei Sun and Andrea Hodge to receive awards at annual banquet

Two outstanding alumni will be honored at the 2016 Annual Alumni Celebration Banquet on Thursday, May 19. Shih-Wei Sun will receive the Distinguished Career Achievement Award for Alumni of Materials Science and Engineering at Northwestern University, and Andrea Hodge will receive the Early Career Achievement Award. They will speak at the banquet about their McCormick experiences and discuss how their time at Northwestern shaped their careers.

SHIH-WEI SUN (PHD '86, WESSELS)

Former vice chairman, CEO, and COO of the United Microelectronics Corporation; senior adviser at McKinsey & Company

Sun worked for Motorola's semiconductor product sector for 10 years before joining United Microelectronics Corporation, a global semiconductor foundry that provides advanced technology and manufacturing for applications spanning every major sector of the integrated circuit industry. He has more than 50 granted patents and publications. He served as chairman of the International Electronic Device Meeting and currently serves on the boards of the McCormick Advisory Committee, A*STAR in Singapore, Brewer Science, D-SIMLAB, and Kingyup Optonics.

What were some of your most memorable, proudest, or challenging moments as a student in the Department of Materials Science and Engineering?

As the only first-year graduate student from Taiwan in 1981, I initially had a difficult time with the English language while taking the undergraduate thermodynamics course taught by Professor Jerome B. Cohen. To help me on this regard, Professor Cohen intentionally asked me to present one homework problem-solution in front of the class every session. In the beginning, this was a lot of pressure. As the course wound down toward the end of the fall quarter, however, I was at ease and even started to enjoy going to the blackboard.

How did your experience in Northwestern's Department of Materials Science and Engineering shape or affect your career?

After working hard on my thesis proposal, I finally had a chance to discuss it with Professor Bruce Wessels. Professor Wessels said that he was not sure what I was trying to do. I told him that may have been due to my poor English. Professor Wessels then asked me if my Chinese was OK. It was the "problem definition, logic development, and story line" that were missing in my original thesis proposal. This invaluable guidance from Professor Wessels and the department at Northwestern helped me tremendously in my later career in the industry.



Sun



Hodge

ANDREA HODGE (PHD '02, DUNAND)

Arthur B. Freeman Professor of Chemical Engineering and Materials Science and of Aerospace and Mechanical Engineering at the University of Southern California

Hodge's research interests range from the processing of nanocrystalline and nanoporous materials to the nanomechanics of metals and biomaterials. She has co-authored more than 70 peer-reviewed papers and two book chapters and recently served on the Materials Research Society's Board of Directors. She received an NSF BRIDGE Award in 2008, a 2010 NSF CAREER Award, a 2011 Alexander von Humboldt Senior Research Fellowship, 2012 Young Investigator Program Award, 2012 DARPA young Faculty Award, and 2013 National Diverse Education Emerging Scholar Honor.

How did your experience in Northwestern's Department of Materials Science and Engineering shape or affect your career?

Being at Northwestern's Department of Materials Science and Engineering shaped my career in a multitude of ways. First, at a personal level I have had priceless mentorship and support from my adviser Professor David Dunand and from Professors Julia and Hans Weertman. At an academic level, I learned to expect and deliver the highest quality research and teach my students to do the same. In general, I think this Department of Materials Science and Engineering is always looking for ways to engage and recognize current and former students. As the recipient of the Early Career Achievement Award, I am honored to have been selected among so many outstanding materials science and engineering graduates.

What advice would you give to current materials science and engineering students about to begin their careers?

I think my advice is to cultivate personal relationships with your peers. Some day they will be your best friends and supporters.

FACULTY NEWS



Zdenek Bazant received the 2015 Raymond Mindlin Medal from the ASCE and was elected honorary member of the International

Society for Research in Materials and Structures. He will also receive the Austrian Cross of Honor for Science and Art of the First Class.

Jiaxing Huang, Yonggang Huang, Tobin Marks, and Chad Mirkin were named to the 2015 list of highly cited researchers by Thomson Reuters.

Mark Hersam was named fellow of the Institute of Electrical and Electronics Engineers for his contributions to carbon nanomaterial processing methods and devices.

Research associate professor **Dieter Isheim** received the AIME Champion H. Mathewson Medal Award for the paper "An Atom Probe Study of Kappa Carbide Precipitation and the Effect of Silicon Addition."



Chad Mirkin received the International Dan David Prize in the Future Time Dimension, the Sackler Prize in Convergence

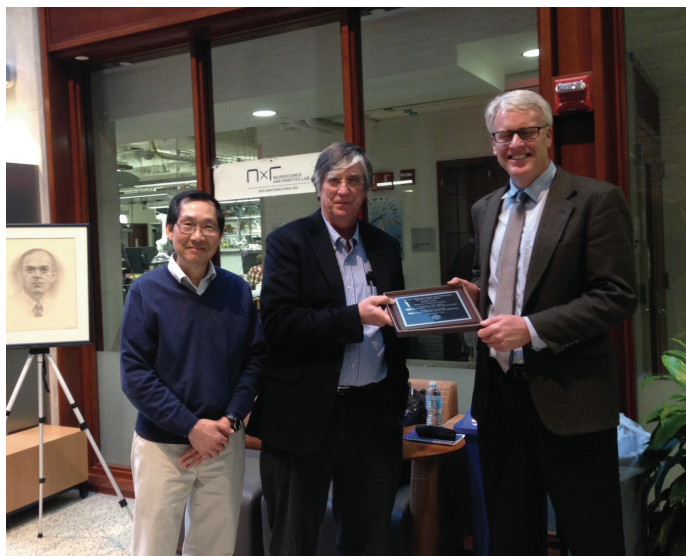
Research from National Academy of Sciences, and the 2016 American Institute of Chemists Gold Medal.



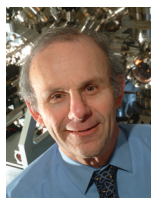
Chad Mirkin and Samuel I. Stupp were elected to the American Institute for Medical and Biological Engineering

College of Fellows.

Teri Odom was elected fellow of the Materials Research Society.



Professors **Yip-Wah Chung** and **Michael Bedzyk** present Mark Asta with an honorary plaque. The Arthur C. and Phyllis G. Oppenheimer Professor in Advanced Materials Analysis at the University of California at Berkeley, Asta delivered this year's Fine Lecture, titled "Twinning in HCP Metals: Anomalous Energetics and How They Might Be Useful."



David Seidman was elected as inaugural fellow of the International Field-Emission Society for his impact on the world of atom

probe and contributions to the Field Emission Society.

Ken Shull received the Award for Excellence in Adhesion Science from the Adhesion Society.



Bruce Wessels (right) receives an award from TMS

Bruce Wessels received the prestigious 2016 fellow award from The Minerals, Metals, and Materials Society (TMS). It is the society's highest award.

STUDENT NEWS

Graduate students **Hadallia Bergeron, Nathan Bradshaw, David Lam, Fernando Reyes-Tirado,** and **Jann Grovogui** and alumni **Andrew Rowberg** (BS '15) and **Edward Pang** (BS '15), received NSF Graduate Research Fellowships. Graduate students **David Delgado, Danielle Duggins, Riley Hanus, Kazi Sadman,** seniors **Theo Gao** and **Kelly Hyland** and alumna **Emily Levin** (BS '15) received honorable mention.

Logan Ward (Wolverton group) received the 2015 Weertman Doctoral Fellowship, an achievement-based award to recognize a PhD candidate in materials science and engineering for her or his outstanding scholarly achievements and promise.

Three materials science and engineering students received Graduate Student Awards at the fall 2015 Materials Research Society meeting. **Che-Ning Yeh** (Huang group) won the Gold Award and **Youngeun Kim** (Mirkin group) and **Ankun Yang** (Odom group) won Silver Awards. Alumni **Scott Grindy** ('12) and **Kelsey Stoerzinger** ('10), both students at MIT, also received Silver Awards.

ALUMNI NEWS

Carelyn Campbell (BS '92, PhD '97, Olson) received the 2016 TMS Brimacombe Medal for her notable contributions in the assessment of diffusion data for multicomponent systems and their application to materials design and process improvement.

Jim Ciston (PhD '09, L. Marks), staff scientist at the National Center for Electron Microscopy at Lawrence Berkeley National Lab, has been awarded a DOE Early Career Research Award.

Zayna Connor (PhD, '00, Fine) was named vice president of the American Foundry Society.

Jon Emery (PhD '13, Bedzyk) has joined Northwestern's Department of Materials Science and Engineering as a lecturer.

Jeff Gotro (PhD '83, Graessley) received the 2014 John A. Wagnon, Jr. Technical Achievement Award from the International Microelectronics and Packaging Society (IMAPS) for his contributions to the area of polymers used in the microelectronics industry. He was also elected as a fellow of the Society.

Mike Hilton (BS '82, MS '84) received the 2014 Trustees' Distinguished Achievement Award from The Aerospace Corporation.

Michele Manuel (PhD '07, Olson) received a Presidential Early Career Award for Scientists and Engineers.

Steve May (PhD '07, Wessels) was promoted to associate professor of materials science and engineering at Drexel University.

Koichi Tsuchiya (PhD '91, J.R. Weertman) is now managing director of the Research Center for Structural Materials at the National Institute for Materials Science in Japan.

CONTRIBUTIONS

MATERIALS SCIENCE AND ENGINEERING

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 Fidelity Investments Charitable Gift Fund
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 Prof. Bruce Wessels and Beverly
 Tiedemann Wessels

JEROME B. COHEN PROFESSORSHIP

Elissa Cohen Halpern and Jeffery Halpern

MORRIS E. FINE LECTURE

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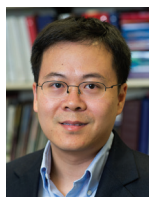
Donations made between October 5, 2015 and April 27, 2016. If you would like to contribute to MSE funds, please contact Patrick Hankey at patrick.hankey@northwestern.edu.

INCREASING OIL'S PERFORMANCE WITH CRUMPLED GRAPHENE BALLS

Additive reduces friction and protects engines better than commercial lubricants

When an automobile's engine is improperly lubricated, it can be a major hit to the pocketbook and the environment. For the average car, 15 percent of the fuel consumption is spent overcoming friction in the engine and transmission. While oil helps reduce this friction, people have long searched for additives that enhance oil's performance.

Professors Jiaxing Huang and Yip-Wah Chung discovered that crumpled graphene balls are an extremely promising lubricant additive. In a series of tests, oil modified with crumpled graphene balls outperformed some commercial lubricants



Huang

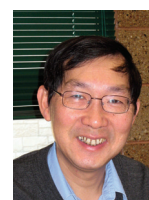
by 15 percent, both in terms of reducing friction and the degree of wear on steel surfaces.

Supported by the Office of Naval Research, the team's research is described in an article published online on January 25 in the *Proceedings of the National Academy of Sciences*.

Nanoparticles, particularly carbon nanoparticles, previously have been studied to help increase the lubrication of oil. The particles, however, do not disperse well

in oil and instead tend to clump together, which makes them less effective for lubrication.

Because of their unique shape, crumpled graphene balls self-disperse. With their



Chung

pointy surfaces, they are unable to make close contact with the other graphene balls. Even when they are squeezed together, they easily separate again when disturbed.

BACK PAGE

Nobel Laureate Shuji Nakamura Visits Campus

Shuji Nakamura visited Northwestern on Thursday, April 12 to deliver the annual Jerome B. Cohen Distinguished Lecture. A recipient of the 2014 Nobel Prize in Physics, Nakamura is the Cree Professor of Solid State Lighting and Display at the University of California, Santa Barbara. During his talk, Nakamura discussed his invention of efficient blue light-emitting diodes, which have enabled production of bright and energy-saving white light sources.



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