

PENNSTATE



MatSE News

Materials Science and Engineering Summer 2008 www.matse.psu.edu

Research Spotlight:

Growing Tiny Wires for Nanoscale Devices

"Photovoltaic Forest" formed by a two-step silicon nanowire growth process



Dr. Gary L. Messing

**Distinguished Professor of
Materials Science and Engineering
Head, Department of
Materials Science and Engineering**

Dear Friends,

I hope you all are enjoying the summer. This edition of MatSE News celebrates the many accomplishments of our students and alums. The big news this past month was the announcement that Susan (below) was selected as a National Security Science and Engineering Fellow. As one of the select few (6 total), and the only materials scientist, chosen for this prestigious appointment, it is evident that Susan is one of the preeminent materials scientists in the U.S. The new group of promoted faculty on page 5 also underscores the excellence of Penn State's Department of Materials Science and Engineering. We hope you enjoy reading about Joan Redwing's nanowire research. Nanowires are becoming ever more established as a viable means to new device performance in a number of fields. Professor Redwing is a leader in nanowire synthesis and promises to be big news in the future as she and the team of faculty and students at Penn State push the frontiers

of nanowire synthesis, device assembly and new properties. With many exciting news items happening in the department each month, we are interested in getting more news out to you. We also would be very interested in knowing what is going on in your world. We currently have a news and notes page on the web, and job postings page for our students and alumni. We would be happy to post information to these sites for you. If you would like to become part of the Materials listserv, please send your email address to news@matse.psu.edu.

Finally, you have been generous in helping to establish the Newnham Distinguished Graduate Fellowship and the Tressler Career Professorship but we still need to raise a bit more to fully activate them. We hope you can help us make that happen.

Thanks.

Trolier-McKinstry Named to Inaugural Class of National Security Science and Engineering Fellows

Join us in congratulating Susan Trolier-McKinstry in being named to the DoD's Inaugural Class of National Security Science and Engineering Fellows. Susan was one of only six fellows selected nationwide and the only materials scientist. As a fellow she will study "High Strain Actuators for Miniaturized Actuators and Self-Powered Sensors".



The Department of Defense announced on June 2, 2008 the selection of six distinguished university faculty scientists and engineers forming the first class of its new National Security Science and Engineering Faculty Fellows (NSSEFF) Program. NSSEFF provides grants to top-tier researchers from U.S. universities to conduct long-term, unclassified, basic research of strategic importance to DoD. These grants engage the next generation of outstanding scientists and engineers in the most challenging technical issues facing DoD.

"Up to \$3 million of direct research support will be granted to each NSSEFF Fellow for up to five years," said William Rees, deputy under secretary of defense for laboratories and basic sciences. The fellows conduct basic research in core science and engineering disciplines that underpin future DoD technology development. This basic research is crucial to applications such as sensors, surveillance, information security, cyber and force protection, and power projection. In addition to conducting this unclassified research, Rees noted another important benefit of the NSSEFF Program, "Opportunities for fellows to participate fully in the DoD research enterprise and share their knowledge and insight with DoD military and civilian leaders, researchers in DoD laboratories, and the national security science and engineering community."

In response to the NSSEFF Broad Agency Announcement, nearly 150 academic institutions submitted more than 500 nomination letters. More than 350 technical white papers were received and, following a rigorous technical review, 20 semifinalists were invited to submit full

proposals outlining their research plans. Each of the semifinalists participated in a scientific interview before a distinguished panel of experts.



DEPARTMENT OF
**MATERIALS
SCIENCE AND
ENGINEERING**
COLLEGE OF EARTH AND
MINERAL SCIENCES

In this Issue:

Department News 3
Alumni News 6
Faculty News 7
Student News 8
Research Spotlight 10

Editor: Gary L. Messing
Writer/Editor: Katina L. Bartley-Posney
Design/Layout: Michael W. Fleck

MatSE News
Department of Materials Science and Engineering
The Pennsylvania State University
121 Steidle Building
University Park, PA 16802
(814) 865 0497

2008 Distinguished Lecture Series in Materials

The 2008 Distinguished Lecture Series in Materials Science and Engineering brought four distinguished faculty to Penn State. The first speaker of the year was Dr. Dawn Bonnell, Trustee Professor of Materials Science and Engineering and Director of the Nano/Bio Interface Center at the University of Pennsylvania. Dr. Bonnell's presentation was titled "Exploiting Molecular Interactions at Surfaces in Nano Device Function".

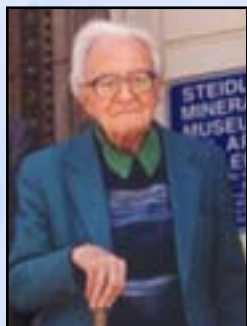
Dr. Ramamoorthy Ramesh, Professor of Materials Science and Engineering at the University of California Berkeley gave a talk on "Whither Oxide Electronics". Dr Ramesh was invited by Penn State's MRS (Materials Research Society) Student Chapter.

Dr. Zhong Lin Wang, Regent's Professor, CEO Distinguished Professor and Director of the Center for Nanostructure Characterization and Fabrication at Georgia Tech presentation was titled was "Nanotechnology for Energy Harvesting: From Nanogenerators to Nanopiezoelectronics".

Dr. Joseph DeSimone, William R. Kenan, Jr. Distinguished Professor of Chemistry and Chemical Engineering at the University of North Carolina at Chapel Hill and North Carolina State University presentation was titled "Complex Particles and Patterned Substrates: Opportunities in Material and Life Sciences".

The department would like to thank all of our distinguished speakers for taking the time to visit PSU.

William O. Williamson January 20, 1911 - January 4, 2008



Professor Williamson published extensively on petrology, microstructure and rheology of explosives, surface phenomena and various aspects of ceramic sciences. In 1959, Bill joined Penn State University as Associate Professor of Ceramic Technology and was promoted to Full Professor in 1964. In addition to his primary interests, he also pursued as a hobby a study of the material and literary heritage of ancient cultures. The fruits of this endeavor found their way into his creation of a social-humanistic course at Penn State called Materials in Ancient and Modern Cultures [MatSc 50]. The positive feedback he received for this course led to Bill being given the Wilson Distinguished Teaching Award from the College of Earth and Mineral Sciences in 1975. He traveled widely throughout the world. Upon retirement in 1976, he was made Professor Emeritus of Ceramic Science and Engineering. During retirement, Bill Williamson remained

active professionally with occasional consulting work, the editing of technical manuscripts, participation at seminars and attendance at classes in art history. He read broadly, especially in his favorite field of the ancient world. At social gatherings, he was known to sing and recite passages from his favorite operas, especially those of Handel. In the 1990's, he was the key person involved in establishing a strong research relationship between the departments of Art History and Geological Sciences at Penn State. One accomplishment of which he was particularly proud, and to which he referred frequently, was his role in launching the scientific career of Professor Richard E. Tressler. Bill was a mentor and co-author on Dick's first technical paper while Dick was still an undergraduate.

Professor Williamson was born in Luton, Bedfordshire, England. 1911. His early education was taken at the Hitching Grammar School. He received a B.Sc. and B.Sc. Hon. (Chemistry and Geology) in 1931 and 1932, respectively, and a PhD (Geology) in 1933 all from Queen Mary College of the University of London. Following graduation, he served as Chief Assistant, Department of Ceramics, at North Staffordshire Technical College from 1934-42. He joined the British Ministry of Supply as a physical chemist for work related to the Manhattan Project from 1942-45. Near the end of World War II, Bill emigrated to the Republic of South Africa and held the post of Professional Officer, Government Metallurgical Laboratory, from 1945-47. Later in 1947, he moved to Melbourne, Australia where from 1947-59, he held the positions of Senior, later Principal Research Officer, at the Commonwealth Scientific and Industrial Research Organization [CSIRO]. In 1958, Bill married the former Olive Zoe Burns. He was awarded the distinguished D. Sc. Degree in Geology and Industrial Chemistry from The University of London.

2008 Distinguished Lecture Speakers



Dawn Bonnell
Trustee Professor of Materials Science and Engineering and Director of the Nano/Bio Interface Center at the University of Pennsylvania



Ramamoorthy Ramesh
Professor of Materials Science and Engineering at the University of California Berkeley
Pictured with James Saal, Graduate Student and President of the Materials Research Society at PSU.



Zhong Lin Wang
Regent's Professor, CEO Distinguished Professor and Director of the Center for Nanostructure Characterization and Fabrication at Georgia Tech

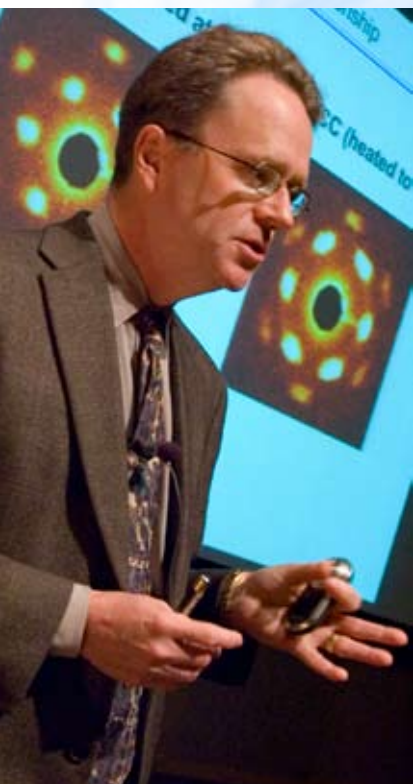


Joseph DeSimone
William R. Kenan, Jr. Distinguished Professor of Chemistry and Chemical Engineering at the University of North Carolina at Chapel Hill and North Carolina State University

Polymer Research is the Theme at the 2007 Nelson W. Taylor Lecture

The five talks at this year's Taylor Lecture, presented by the Penn State Department of Materials Science and Engineering in memory of Nelson W. Taylor, the former head of the Penn State Department of Ceramics, were tributes to the importance of polymers and polymer research.

The opening talks are traditionally given by Penn State faculty members, followed by the Taylor Lecture, presented by a distinguished invited guest. This year's faculty speakers were Ralph Colby and Qing Wang of Materials Science and Engineering, David Allara of Chemistry, and Scott Milner, an incoming member of the Chemical Engineering faculty recruited from ExxonMobil. The Taylor Lecture was delivered by Distinguished McKnight University Professor Timothy Lodge of the University of Minnesota.



Tim Lodge's 2007 Taylor Lecture was a short course on block copolymers – which in their simplest form are made of two normal polymers linked end to end. Block copolymers self-assemble in three shapes – spheres, tubes, and sheets. More complex block copolymers can be made with three or more different polymers.

The value of block copolymers lies in the ability to control their structure, length, and shape, their sensitivity to external stimuli, tolerance of component heterogeneity (which makes them commercially useful), the free-energy process of their self-assembly, and their easy scalability. Their potential uses are in nanoscale structures for computer memory and in their ability to precisely direct the assembly of nanostructures.

Block copolymers, Lodge said, have seen a tremendous broadening of their importance as shown by the recent increase of journal articles on the subject. This may be due to the much greater ability to control their structures over the past ten years, he hypothesized.

The Taylor Lectures have consistently attracted notable scientists, including Nobel Laureates, to speak at Penn State. Nelson W. Taylor, in whose honor the series was established in 1969, was the individual most responsible for establishing the College of Earth and Mineral Sciences as a major center for ceramic research.

Walt Mills, Writer/Editor, Materials Research Institute

2007 Taylor Lecturer, Dr. Timothy Lodge

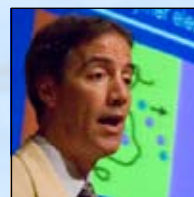
Photo: Mike Fleck, Materials Science and Engineering

2008 Taylor Lecture Opening Speakers



David L. Allara
Professor of Polymer Science and Chemistry

"Assembling, Characterizing and Utilizing Molecules in Confined Geometries"



Ralph Colby
Professor of Materials Science and Engineering

"Coercing Polymer Insulators to Transport Ions: New soft materials for actuators, batteries and fuel cells"



Scott T. Milner
Professor of Chemical Engineering

"Thin Glassy Polymer Films: When Soft Materials Get Hard"



Qing Wang
Assistant Professor of Materials Science and Engineering

"Tailoring Dielectric Properties of Polymers and Polymer Nanocomposites via Multi-scale Assembly"

2008 Nelson W. Taylor Lecture Announced

September 12, 2008, H.U.B. Auditorium, 8:30 a.m.



The theme of the 2008 Taylor Lecture for this year is Complex Oxides. The Taylor Lecture Selection Committee has selected Professor John B. Goodenough, Virginia H. Cockrell Centennial Chair Professor in Mechanical Engineering at the University of Texas, Austin as the 2008 Taylor Lecturer. Dr. Goodenough studies the relationships between the chemistry, structure and electrical properties of solids in order to design new or improved technical materials. He also explores the unusual physical properties encountered at the transition from magnetic to metallic behavior in transition-metal oxides. For example, he developed the cathode materials for lithium-ion batteries which have enabled the wireless revolution and will be used in tomorrow's electric vehicles, power tools and hybrid cars. He studied high pressure to understand the conditions for high-temperature superconductivity in copper oxides and the significant change in electrical resistance in manganese and cobalt oxides when a magnetic field is applied. Goodenough recently identified a ceramic anode material for a solid oxide fuel cell operating on natural gas.

For more information on the Taylor Lecture please contact Katina Bartley-Posney at 814-865-0497 or katina@matse.psu.edu.

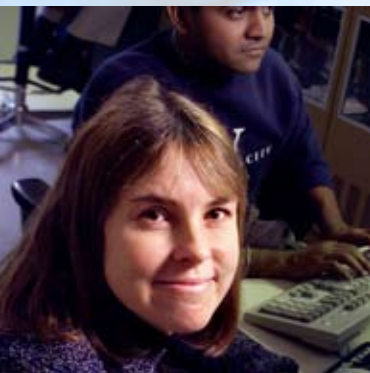
Professor Joan M. Redwing to Chair the Intercollege Graduate Degree Program in Materials Science and Engineering

The department is pleased to announce that Professor Joan Redwing has been appointed Chair of the iMatSE Graduate Program effective July 1, 2008. Dr. Redwing is Professor of Materials Science and Engineering and Electrical Engineering and has a courtesy appointment with Chemical Engineering.

Joan M. Redwing received her B.S. in Chemical Engineering from the University of Pittsburgh and her Ph.D. in Chemical Engineering from the University of Wisconsin-Madison. She was employed as a research engineer at Advanced Technology Materials, Inc. from 1994-1999 working on metalorganic chemical vapor deposition of group III-nitride materials. Dr. Redwing joined the faculty of the Department of Materials Science and Engineering in 1999. Dr. Redwing's research interests are in the general area of electronic materials synthesis and characterization with a

specific emphasis on semiconductor thin film and nanostructure fabrication by chemical vapor deposition. She currently serves as secretary of the American Association for Crystal Growth and is an associate editor for the *Journal of Crystal*

Growth. She is co-author of over 130 publications in refereed journals and holds 8 U.S. patents. Dr. Redwing received the Young Author Award of the American Associate of Crystal Growth, was recipient of an NSF Faculty Early Career Award, received the Wilson Teaching Award of EMS, and received the inaugural Faculty of Year Award in MatSE. Joan leads a research group focused on metalorganic chemical vapor deposition of wide bandgap semiconductors, semiconductor nanowires and superconducting thin films. Joan collaborates extensively with faculty in physics, chemical engineering, electrical engineering, chemistry and MatSE on applications related to hydrogen generation, solar energy conversion and nanoelectronics. With her extensive university interactions at Penn State and as a first rate scientist, Professor Redwing is ideally suited for this position. <http://www.matse.psu.edu/fac/profiles/redwing.htm>.



Professor Messing presenting a Nittany Lion to President Shin-ichi Hirano in appreciation for his 22 years co-organizing the International Conference on Ceramic Processing Science (ICCPs) with Professor Ludwig Gauckler (ETH-Zurich) and Gary Messing. The presentation was during ICCPS-10 May 27, 2008 in Inuyama, Japan, which was Hirano's last ICCPS meeting as a co-organizer. Professor Hirano is President of Nagoya University and an adjunct professor of materials science and engineering at Penn State. He will retire from Nagoya University March 2009.

Recent Promotions in MatSE



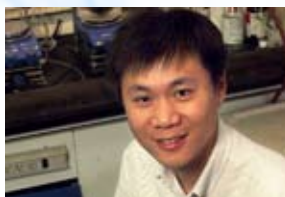
Elizabeth Dickey has been promoted to full professor in the department. Her primary academic and research interests include nanomaterials for electrical and sensing applications, interface materials science and composites, and the application of electron microscopy and spectroscopy techniques. Dr. Dickey also serves as the Associate Director of the Materials Research Institute and is in charge of the Materials Characterization Laboratory.



Venkatraman Gopalan has been promoted to full professor in the department. Dr. Gopalan's research expertise is light-matter interactions in complex oxides and metamaterials. Dr. Gopalan is currently the Associate Director for the Center for Optical Technologies and was named the Eshbach Faculty Fellow at Northwestern University in 2007 during his sabbatical.



Christopher Muhlstein, Corning Faculty Fellow has been promoted to associate professor in the department. Dr. Muhlstein's research group studies the deformation, degradation, and failure of materials. Their research programs explore the underlying mechanisms of mechanical behavior, and they enable the engineering of durable, reliable components and systems.



Qing Wang, Virginia S. and Philip L. Walker Faculty Fellow has been promoted to associate professor in the department. Dr. Wang's research group is centered on the development of novel functional polymers and polymer nanocomposites for energy harvesting and storage applications, including conducting polymers for organic solar cells, ferroelectric polymers for electrical energy storage, and polymer membranes for fuel cells.

Yonushonis '74, '76 receives Innovation Award



For the second time in 24 years with Cummins Inc., Thomas M. Yonushonis '74 BS, '76 MS, the firm's director of research and technology, has captured his employer's annual Julius P. Perr Innovation Award. First received by Yonushonis in 2003, the award honors employees whose inventions and work in structural ceram-

ics have significantly benefited the company, the industry and/or the environment.

The 2007 award recognizes Yonushonis' contributions to two advancements that Cummins deems "breakthrough" developments. The first, produced and patented as a joint venture with Toshiba, enables Cummins to use structural ceramic materials in fuel injectors and pumps and to produce these items at a competitive cost. The second entails developing a process that reduced costs and facilitated production of fuel injector plungers. In 2003, the award recognized Yonushonis' work in developing ceramic applications for engines.

A 34-year member of The American Ceramic Society, Yonushonis received his bachelor's and master's degrees in ceramic science from Pennsylvania State University. Congratulations Tom!

Robert Kumpf '84, '86, '88 receives PSU Alumni Fellow



The Alumni Fellow award is the most prestigious award given by the Penn State Alumni Association. Since 1973, the Alumni Fellow award has been given to select alumni who, as leaders in their professional fields, are nominated by an academic college and accept an invitation from the President of the University to return to campus to share their expertise with students, faculty, and administrators. The award is a cast bronze medallion and framed certificate. Bob received his award on October 10, 2007.

Bob Kumpf is Vice President, Chief Administrative Officer of Bayer MaterialScience LLC. In this role he leads the group responsible for developing the materials of the future by focusing on innovation-driven polymer products, next-generation application trends and new complex technologies. As a member of the global

Bayer MaterialScience Innovation Community Council, Bob's efforts will ensure the continuing growth of Bayer MaterialScience well into the 21st Century.

Bob has held research, product development and technical marketing positions in various Bayer Business Units and Central Research, including two ex-patriot assignments in Germany.

Newnham '56 receives 2008 MatSE Distinguished Alumni Award

Dr. Robert Newnham has been selected as the 2008 MatSE Distinguished Alumni recipient. Dr. Newnham has been an inspiration to colleagues and students during his 40 plus years. Congratulations Bob on all of your accomplishments.



Upcoming MatSE Events

July 9-13 - State College Arts Festival and EMS Reunion Weekend

September 12 - Annual Nelson W. Taylor Lecture, see page 4 for details

October 2 - Annual MatSE Picnic held in conjunction with the External Advisory Board Meeting

October 7 - MatSE Alumni Reception held in conjunction with MS&T in Pittsburgh, PA.

December 2 - MatSE Alumni Reception held in conjunction with MRS Meeting in Boston, MA.

January 20 - MatSE Alumni Reception held in conjunction with the ACerS Meeting in Daytona Beach, FL.

Roger Bagwell '96 and Maureen Mulvihill '89, '91, '96 voted Outstanding Technology Company of the Year

The Chamber of Business and Industry of Centre County (CBICC) membership voted Piezo Resonance Innovations, "2007 Outstanding Technology Company of the Year". PRII was selected based on its performance in developing innovative medical designs, and relationship with its customers and development partners. PRII owners Maureen L. Mulvihill and Roger B. Bagwell are graduates of the Penn State Materials Science Program. PRII incorporates precision motion and electronic control and sensing capabilities into highly-specialized medical devices, providing solutions to the device actuation challenges faced by medical product development teams. Offering original designs to a wide range of partners, PRII has gained expertise in creating innovative, smart-active tools for use in the fields of ophthalmology, vascular entry, and minimally invasive surgery. Incorporated in December of 2006, PRII has already delivered its first product, which is currently being evaluated in animal studies. PRII is located six miles from Penn State's University Park campus and has grown to 7 full time employees and one engineering intern. PRII is also pleased to have David E. Booth, formerly of Alcon Laboratories and Paul L. Frankhouser, former Executive Vice President of Arrow, as critical components of its development team.

Piezo Resonance Innovations, Inc.
Improving Patient Quality-of-life through Innovative Medical Device Technology

Newnham elected MRS Fellow

Robert E. Newnham, Professor Emeritus of Solid State Science in the Materials Research Laboratory, has been elected to the inaugural class of Fellows of the Materials Research Society. The title of MRS Fellow honors members who are notable for their distinguished research accomplishments and their outstanding contributions to the advancement of materials research, world-wide. The induction and recognition of the inaugural class of MRS Fellows will take place at the 2008 Spring Meeting to be held in San Francisco. Professor Newnham's citation reads, "For pioneering contributions to the design of smart materials and their use to benefit mankind, including the invention of composite piezoelectric transducers, sensors, and actuators; and for achievement as a superb educator". The transducers designed by Dr. Newnham are widely used in biomedical ultrasound, non-destructive testing, and underwater sonar systems.

Hickner receives Powe Award

Michael A. Hickner, Assistant Professor of Materials Science and Engineering received the Ralph E. Powe Junior Faculty Enhancement Award. The Ralph E. Powe Junior Faculty Enhancement Awards provide seed money for research by junior faculty at Oak Ridge Associated Universities (ORAU) member institutions. These awards are intended to enrich the research and professional growth of young faculty and result in new funding opportunities. In 2008, ORAU received 107 applications and awarded 30 grants. Well done Mike!

Pantano presents McLaren Distinguished Lecture

Carlo G. Pantano, Distinguished Professor of Materials Science and Engineering and Director of the Materials Research Institute was selected as the featured highlight of the 2008 McLaren Lecture Symposium on Friday April 11th, 2008 held at Rutgers University. Dr. Pantano's talk was titled "Glass Surfaces and Coatings for Biotechnology and Energy." Congratulations Carlo for this honor.

Liu named Chang Jiang Chair

Zi-Kui Liu, Professor of Materials Science and Engineering and Director of the Center for Computational Materials Design was recently appointed as a prestigious Chang Jiang Chair Professor in recognition of his contributions in the field of computational materials by China's Ministry of Education. The Chang Jiang Scholars Program was jointly established by China's Ministry of Education and the Li Ka-Shing Foundation in 1998. The main objective of the program is to further improve China's education and intellectual competitiveness by rapidly developing Chinese research institutions through the engagement of Chang Jiang Scholars. The program is to attract, select, and create a group of world leaders for advanced research in all areas of higher education. It is the highest recognition program from the Ministry of Education. The appointments are made based on international-wide competition among the nominees by Chinese universities. Professor Liu will have frequent visits to Central South University in China over the next three years.

Eklund named Distinguished Professor

We are pleased to announce the appointment of Peter Eklund to Distinguished Professor of Physics and Materials Science and Engineering.

Macdonald elected Trustee of ASM International

Digby D. Macdonald, director of the Center for Electrochemical Science and Technology and Professor of Materials Science and Engineering, has been elected to the Board of Trustees of ASM International, The Materials Information Society. Macdonald has written a book and more than 570 papers on thermodynamics, electrochemistry, corrosion science, chemistry and materials science. ASM International, The Materials Information Society, serves the materials science and engineering profession.

MatSE Faculty Receive Earth and Mineral Science Wilson Awards

Zi-Kui Liu, Professor of Materials Science and Engineering, and Director, Center for Computational Materials Design received the Wilson Award for Excellence in Research. Dr. Liu was recognized for his creative and scholarly contributions in the area of computational materials science and materials design.

Carlo G. Pantano, Distinguished Professor of Materials Science and Engineering, and Director of the Materials Research Institute received the Wilson Award for Outstanding Service. Dr. Pantano was recognized for his consistent and zealous dedication to the cause of interdisciplinary and multidisciplinary research at Penn State.

James P. Runt, Professor of Polymer Science and Chair, Intercollege Graduate Degree Program in Materials Science and Engineering received the Faculty Mentoring Award at the Annual Wilson Awards Banquet.

Liu elected TMS board of directors member

Zi-Kui Liu has become a board of directors member of The Minerals, Metals & Materials Society (TMS). In this role, Dr. Liu will chair the electronic, magnetic & photonic materials division of TMS.

Spriggs Phase Equilibria Award

Soonil Lee, postdoctoral scholar in Materials Science and Engineering, Clive A. Randall, Professor of Materials Science and Engineering and Director of the Center for Dielectric Studies, and Zi-Kui Liu, Professor of Materials Science and Engineering and Director of the Center for Computational Materials Design will receive the Spriggs Phase Equilibria Award at the MS&T fall meeting. This award is to honor the paper "Modified Phase Diagram for the Barium Oxide-Titanium Dioxide System for the Ferroelectric Barium Titanate" published in the Journal of The American Ceramic Society. Congratulations on receiving this important honor.

Congratulations Students on your recent awards !

GRADUATE STUDENTS

Samrat Choudhury (advisor, Long-Qing Chen) - received the American Ceramic Society Graduate Excellence in Materials Science Sapphire Award

Jason Claude (advisor, Qing Wang) - received 1st place at the Penn State Graduate Poster Exhibition

Amanda McDermott (advisor, Jim Runt) - awarded National Science Foundation Fellowship

Francelys Medina (advisor, Paul Howell) - awarded the 2008 WISE (Women in Science and Engineering) Recognition Award

Roi Meirum (advisor, Chris Muhlstein) - received 1st place at the university-wide Penn State Graduate Poster Exhibition

UNDERGRADUATE STUDENTS

Matthew Gross (advisor, Mike Hickner) - received 2nd place at the Penn State Undergraduate Exhibition in the Engineering Category

Elli Okkelberg (advisor, Gary Messing) - received 3rd place at the Penn State Undergraduate Exhibition in the Public Scholarship Category

Jessica Serra (advisor, David Green) - received the Sylvia Stein Memorial Space Grant Scholarship

Titi Shodya - received the Phi Kappa Phi Award for Excellence by a Junior at the University Undergraduate Exhibition



Photo: Mike Fleck, Materials Science and Engineering

EMEX is the College of Earth and Mineral Sciences Annual Open House. EMEX stands for Earth and Mineral Sciences EXposition. All high school students, current PSU students, and transfer students who are considering an EMS major are invited to attend. This year EMEX was held on February 16, 2008 with 181 prospective students attending.

In conjunction with EMEX our department offers exhibits to high school students and their families. This year we had seven exhibits set up in Steidle Building:

- **Advanced Materials, Every day, Every way:** explore ceramics, electronic and photonic materials, metals and polymers - from the commonplace to the far out.
- **Glass Science, Technology, and Art:** explore the melting, forming and blowing of glass with our resident glass scientists and artists.
- **Forensic Materials Science:** how materials science gives insight to why things fail; shipwrecks, aircraft, and buildings.
- **Electronic and Photonic Materials:** explore how these materials have revolutionized our lives.
- **Polymers and Nanocomposites for the 21st Century.**
- **Processing of Materials:** see processing in action.
- **Fuel Cell Technology:** tackle the subject of a future energy economy based on hydrogen technology.



Graduate student Bob Pavlacka demonstrates metal casting at EMEX 2008.



Undergraduate student Jess Serra rolls molten glass during a demonstration.

Mark your Calendars: EMEX 2009 will be held on February 28, 2009.

If you know of a high school student interested in Materials, please contact MatSE recruiter Jenneth Layaou at 814-865-5765 or layau@matse.psu.edu



Photo: Mike Fleck, Materials Science and Engineering

Photo: Mike Fleck, Materials Science and Engineering

Annual MatSE Awards Banquet Held on May 6, 2008

The MatSE Department annually celebrates the achievements of its students, staff, faculty and alumni at the annual Awards Banquet. More than 180 students, staff, faculty and alumni gathered for a reception and dinner followed by an awards program. After a warm welcome and remarks by Gary Messing, department head, the program was then handed over to the student emcees, Katie O'Brien and Nevin Sherlock.

Undergraduate Awards



MatSE Academic Excellence Award

William Woodford (left) and Alejandro Levander (right). William and Alejandro were Co-Marshalls for the College of Earth and Mineral Sciences graduation!



MatSE Service and Leadership Award

Jessica Serra



2008-2009 Undergraduate Research Fellows:

Front row: Daniel King, Yan Ling, Kathryn O'Brien, Titi Shodiya

Back row: Laura Jean Lucca, Patrick Mangiagli, Daniel Magagnosc, Jacob Kerr, Cory Bomberger



2008-2009 Kennametal Graduate Fellowship Awardees:

Hui Zhang, Omar Rosas Camacho, Roi Meiorom, Andrea Muller, Adam Stevenson

Congratulations Spring 2008 Graduates!

Spring - B.S.

Brian Booth
Michael Bresnehan
Nicholas Castro
Ratthaporn Chatchaidech
Andrea Fortunato
Ryan Fowler
Shawn Granoski
Samuel Kernion
Douglas Kushner
Melissa Lackey
Alejandro Levander
Zhifeng Li

Nicholas Lorenz
Julio Nunez
Roderick Reber
Richard Rump
Matthew Scates
Jonathan Shipper
Julie Sutsko
Loc Tran
Aaron Welsh
Danielle Williams
Katherine Williams
William Woodford
Ryan Wu

Spring - M.S.

Romesh Patel
James Saal
Michael Wallace

Spring - Ph.D.

Samrat Choudhury
Baojin Chu
William Fadgen
Theresa Foley
Mary Miller
Harshad Patil
Jingxian Zhang

Faculty & Staff Awards



Faculty of the Year Award

Mike Hickner



Staff Excellence Award

Scott Henninger

Graduate Awards

Graduate Award for Academic Excellence
Jingxian Zhang

Graduate Award for Service and Leadership
Rebecca Kirkpatrick and Ryan Koseski

Annual Poster Competition Winners

Graduate Individual Poster Awardees:

1st Place: Jason Claude advised by Qing Wang "*Electrical Breakdown in Polymers Based on Vinylidene Fluoride*"

2nd Place: Hideki Ogihara advised by Clive Randall and Susan Trolier-McKinstry "*Structural and Dielectric Characterization in BaTiO₃ System*"

3rd Place: Guang Sheng advised by Long-Qing Chen "*Domain stability of ferroelectric thin films under anisotropic strains: phase-field simulations*"

Undergraduate Individual Winners:

1st Place: Alejandro Levander advised by Joan Redwing: "*Growth and Characterization of High-Aspect Ratio Silicon Radial p-n Junctions Grown by Chemical Vapor Deposition*"

2nd Place: Jennifer Rygel advised by Carlo Pantano: "*Synthesis and Properties of Cerium Aluminosilicophosphate Glasses*"

3rd Place: Jacob Kerr advised by John Hellmann: "*Strengths of Portland Cements*"

Undergraduate Team Design Winner:

Brad Dinkfelt, Peter Gotthold, Matthew Gross, and Tamara Lubshva advised by Michael Hickner: "*Carbon Nanotube Polymer Matrix Composite*"

For a complete list of awardees please visit the MatSE website at www.matse.psu.edu.



“At Penn State we have a critical mass of faculty with expertise in creating the nanowires, characterizing them, and incorporating them into devices.”

Joan Redwing, Materials Science and Engineering

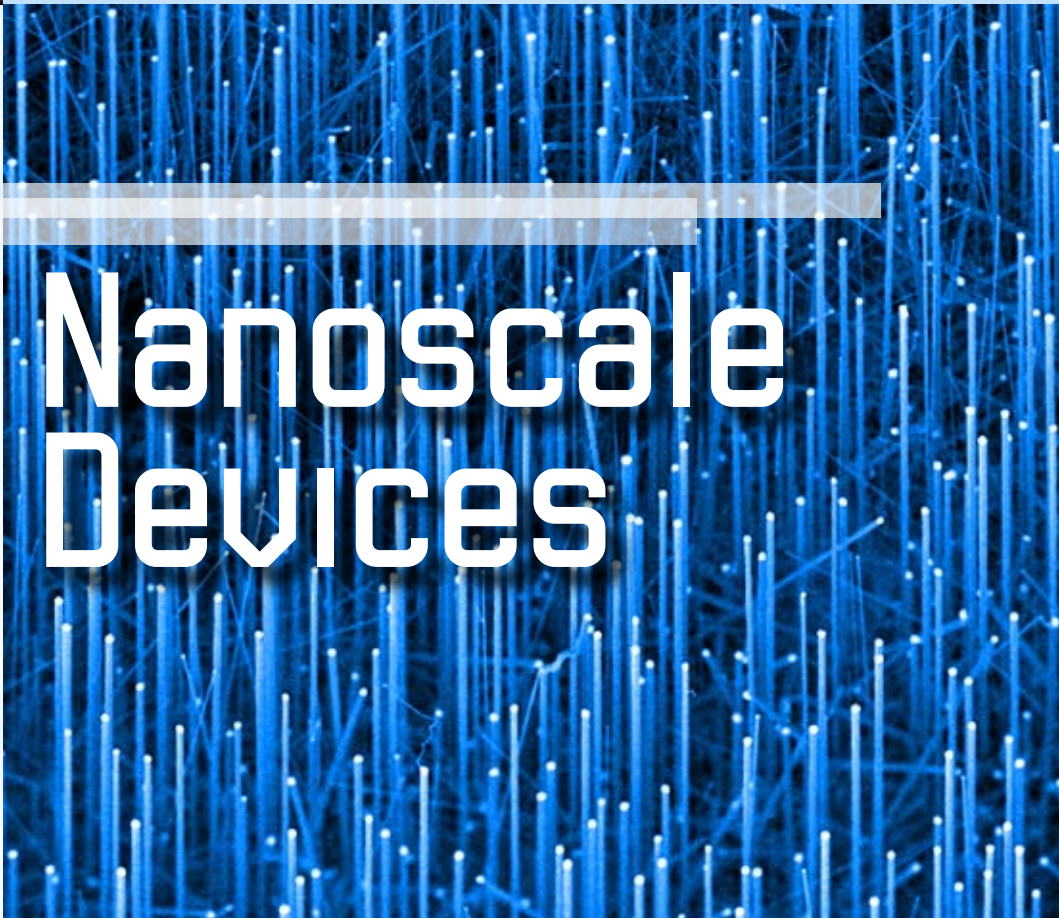
Growing Tiny Wires for

>>>> Shrinking the feature size

of electronic components and packing more circuits onto microchips have made possible the ongoing revolution summed up in Moore’s Law, the now famous prophecy by Intel co-founder Gordon Moore that the number of transistors for integrated circuits would double every two years. To continue this trend, device feature sizes will, in the next 5-10 years, need to be reduced to only a few nanometers, creating molecular size devices requiring new technologies to build and test.

Nanowires made of semiconducting materials such as single crystal silicon are a likely solution to the inherent physical limits of the current photolithography techniques used in microprocessing. Nanowires are one-dimensional, high aspect ratio structures with diameters of tens of nanometers or less and lengths that could be 100 microns or more. Nanowires can be used to make electronic devices such as field effect transistors, interconnects, biological and chemical sensors, and even third-generation solar cells.

Professor Joan Redwing, professor of materials science and engineering is an expert at fabricating these nanowires. She and her team of students and post-docs work to understand and control the synthesis of semiconductor nanowires, not only silicon, but also other semiconductors of interest such as germanium, gallium nitride, and gallium antimonide. In her lab, she and her group use vapor-liquid-solid (VLS) growth to form the nanowires. In this process, metal nanoparticles are either dispersed or patterned across a substrate. A gaseous source of a semiconductor such as silicon is introduced and the metal and semiconductor are heated to above 350°C, where they form



Nanoscale Devices

a liquid phase. Once enough silicon dissolves in the liquid phase, a silicon nanowire will crystallize out of the melt, pushed along by thermodynamics. The size of the nanowire can be controlled by the size of the metal nanoparticle.

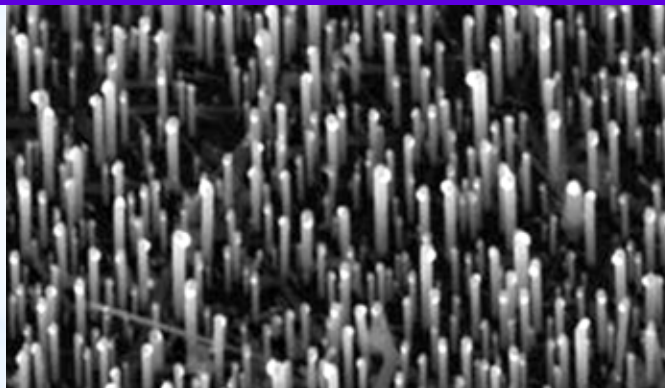
Redwing says, “Bulk crystals that are normally used by industry to fabricate integrated circuits are made by using a melt of silicon and crystallizing a solid out of the melt. What we do is similar, only our melt pool is really tiny, from 100 nm down to 10 nm in diameter.”

The vapor-liquid-solid growth technique was first recognized by scientists at Bell Labs in the sixties, she says, but they were working at a thousand

times larger scale than the technique in use at Penn State. In fact, the whole field is so new that when Redwing arrived at Penn State eight years ago, only a handful of papers had ever been published on the topic of nanowire fabrication. Since then, interest in nanotechnology has exploded, and along with it has come an exponential growth in nanowire research.

“At Penn State we have a critical mass of faculty with expertise in creating the nanowires, characterizing them, and incorporating them into devices. We’ve been able to bring together a group of faculty with complementary expertise to tackle some of the big problems in this area and move closer to making real devices,” Redwing explains.

Her frequent collaborators from materials science and engineering include Beth Dickey, an expert in materials characterization, and Suzanne Mohney, whose expertise is in processing and contacts. Theresa Mayer, a professor of electrical engineering and director of the Penn State Nanofabrication Facility, provides expertise in assembling nanowires on a substrate and incorporating them into devices. Mark Lundstrom at Purdue University collaborates on theory and device simulations.



Array of silicon nanowires

Nanowires as solar energy collectors

A race is on around the globe to find cheaper and more efficient ways to capture the energy of the sun, a fraction of which is enough to supply all of the energy needs that are now supplied by fossil fuels. Among the promising routes being explored to improve future solar cells is semiconducting single crystal nanowires. Though still in its infancy, the field is moving so quickly that someone will have a viable nanowire solar cell within three-to-five years, Redwing predicts.

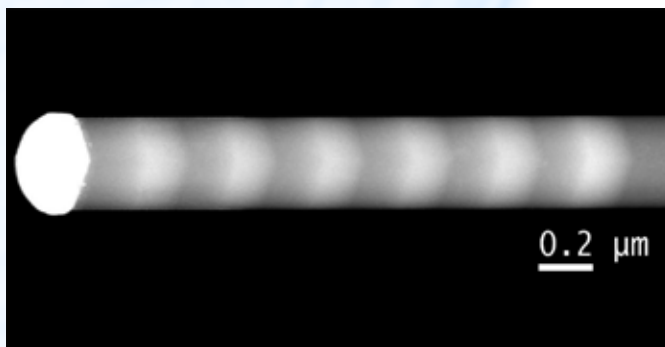
In today's solar cells, a slab of single crystal silicon about 100 microns thick is needed to efficiently absorb light. This material makes up a large fraction of the cost of manufactured solar panels. Defects in the silicon can reduce the efficiency of the cell, capturing the electron or the hole as they make the 100-micron journey to opposite sides of the crystal to be collected and form a current.

Using the same vapor-liquid-solid growth technique, the Redwing group can fabricate single crystal nanowires on a plain glass substrate. P-type silicon nanowires are grown upright on a glass slide to tens of microns lengths. Then the nanowires are coated with an n-layer to form the p-n junction. This geometry allows for a much larger surface area to capture the light, while the electrons and holes must travel only the diameter of the nanowire to reach the electrode.

"The idea is that this will be more efficient and cheaper than current solar cells and will use much less of the very expensive single crystal silicon, while offering at least as much efficiency," Redwing explains. Along with her frequent collaborators Mayer and Dickey, the solar cell group includes professor of chemistry Tom Mallouk and professor emeritus of electrical engineering Chris Wronski, both highly regarded solar cell researchers. Redwing is also working with a small nanotechnology company, Illuminex Corp., based in Lancaster, PA, to develop nanowire solar cells using their proprietary coating technology so the nanowires can be grown directly on glass substrates. Funding for the solar cell research comes from the Department of Energy.

Working at Penn State gives her a different perspective on her research, Redwing finds. She is not just making nanowires, she is solving problems that are important in building working devices. "I could be making nanowires, and then have nothing to use them for. These collaborations focus all of us on doing something useful with our research."

Their work, which is supported by the National Science Foundation through a Nanoscale Interdisciplinary Research Team grant, focuses on the development of high speed transistors for future nanoelectronic circuits. Their successes include fabricating stable and reproducible gate-all-around field effect transistors made of doped silicon nanowires. She is collaborating with chemistry professor Chris Keating on a new technique for building biological and chemical sensors on microchips using nanowires as cantilevers. This bottom-up process functionalizes the nanowires off-chip and then positions and anchors them precisely on the chip for sensing single molecules of, for instance, a targeted virus or cancer.



Alternating bands of silicon-germanium (bright) and silicon (dark) formed by controlled crystallization of the nanowire from a liquid alloy particle on the tip.



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Department of Materials Science and Engineering
The Pennsylvania State University
121 Steidle Building
University Park, PA 16802
Phone: (814) 865-0497

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