Carnegie Mellon Engineering

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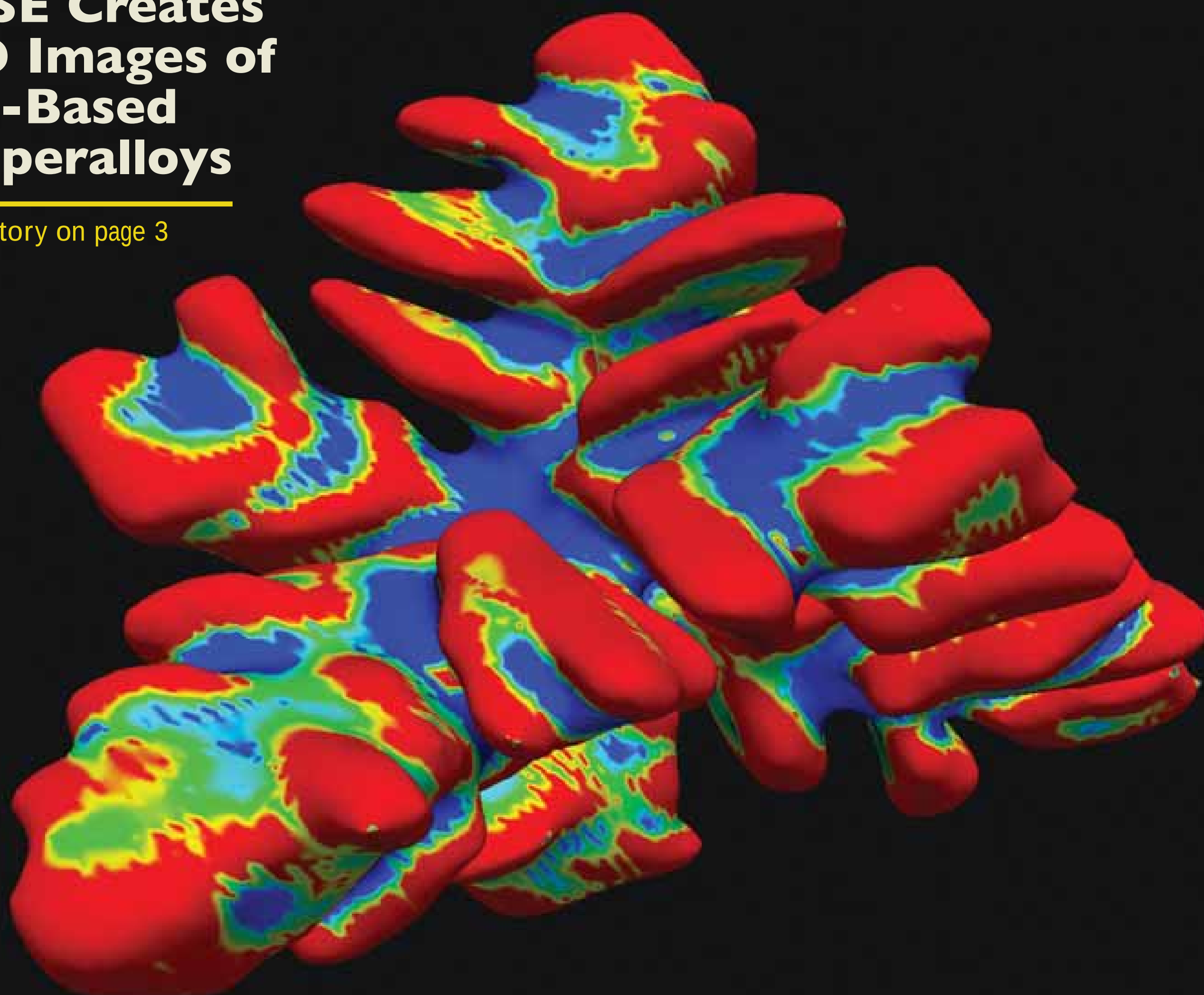
MSE news

MATERIALS SCIENCE AND ENGINEERING

MSE Creates 3D Images of Ni-Based Superalloys

See story on page 3



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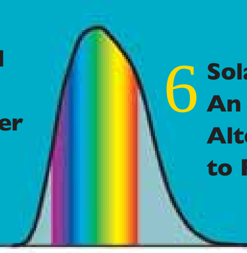
5 MSE's New Multifunctional Electronic Materials Center



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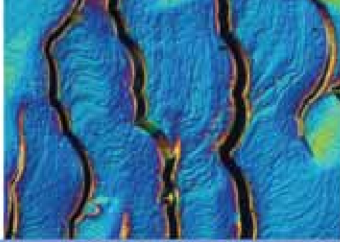


A Note From the Department Head

Gregory S. Rohrer, W.W. Mullins Professor

Dear MSE Graduates:

As another academic year comes to a close, I will take this opportunity to report on the excellent health of the Materials Science and Engineering Department. First and most important, our undergraduate program continues to expand and succeed in producing excellent students. In 2001, our total undergraduate enrollment (in the sophomore, junior, and senior classes) was 43. Counting the 39 students who have recently decided to join next year's sophomore class, our total enrollment for the 2007/2008 academic year will be 94. As you can see in the Student News section, our undergraduates continue to receive recognition for their work. The majority of this year's graduates plan to follow in the footsteps of their predecessors and pursue higher degrees at the best engineering colleges in the country.

Our graduate program also has good news. The College has made a major investment in graduate education by sponsoring the first year of tuition for all new doctoral students. The tuition fellowship includes an allowance so that each student can purchase a laptop computer for his or her thesis work. This investment has allowed us to expand our graduate enrollment; this Fall, 22 new doctoral students will join the Department, bringing the total number of doctoral students to more than 80.

The faculty and staff remain busy and productive. During 2006, each faculty member (on average) published eight papers, gave five invited lectures, and expended more than $400,000 in external funding, mostly to support graduate dissertation research. The faculty has also recently received external funding for large scale research instrumentation, including a dual-beam focused ion beam scanning electron microscope, a small-angle X-ray scattering system, a laser scanning multi-photon confocal microscope, and a robotized metallographic system with automated Laue pattern analysis for 3D microscopic studies. We will say more about each of these facilities in an upcoming issue of the newsletter.

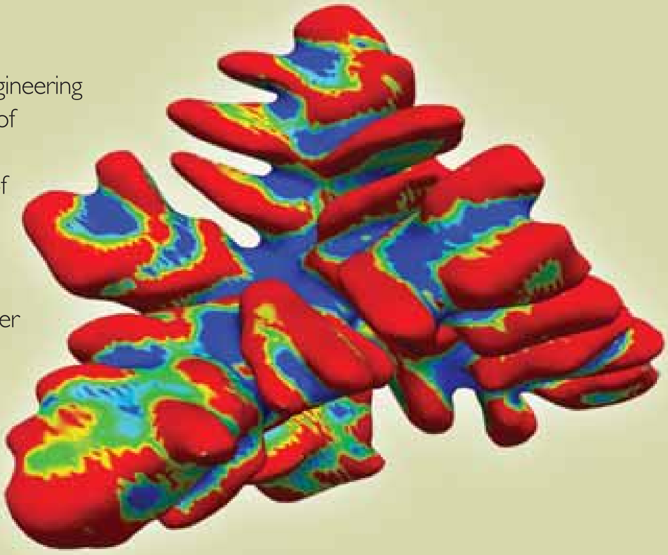
“The majority of this year's graduates plan to follow in the footsteps of their predecessors and pursue higher degrees at the best engineering colleges in the country.”

Finally, the Department recently resolved to work on two major initiatives for the future. The first is the renovation of the undergraduate facilities in Doherty Hall, including the teaching laboratories, the computer cluster, and student lounge area. We plan to modernize these facilities to accommodate both our evolving educational program and growing student body. The second is an expansion of our education and research programs in the area of materials for energy systems. This will include new course offerings and a Masters degree program. This effort will also involve research on materials that can operate in increasingly harsh conditions in conventional energy conversion systems, and materials with novel properties to be used in renewable energy conversion systems.

Gregory S. Rohrer
W.W. Mullins Professor and Department Head

cover story

MSE Creates 3-D Images of Ni-Based Superalloys



Quantitative analysis of three-dimensional microstructures in advanced engineering materials provides novel opportunities for the detailed characterization of individual precipitates and/or grains.

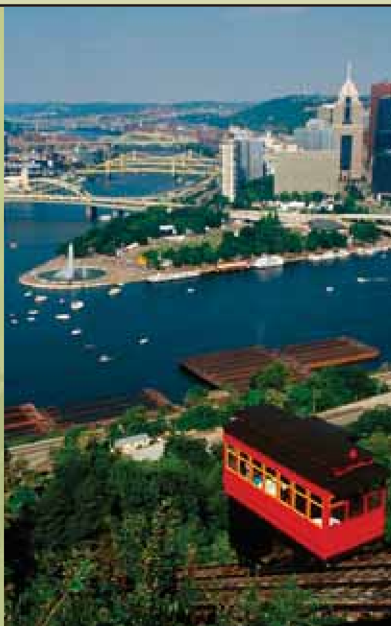
A collaborative research group, including representatives of the Department of Materials Science and Engineering, is currently using a variety of serial-sectioning techniques to obtain 3D data, which is then further analyzed by means of image processing methods and statistical approaches. The alloy systems being studied by this group include two-phase a-b Ti alloys, as well as Ni-based superalloys. The cover image shows a 3D rendering of a single three-micron-wide g' precipitate in a Rene88-DT (damage-tolerant) superalloy; the color indicates the local mean surface curvature, from red (convex) to blue (concave).

Professor Marc De Graef

The input data for this 3D reconstruction was obtained by serial sectioning in a focused ion beam instrument at Wright Patterson Air Force Base by MSE graduate student **Jeremiah MacSleyne**, working with Michael Uchic of the Air Force Research Laboratory. The superalloy sample was provided by Tresa Pollock at the University of Michigan via Peter Sarosi at Ohio State University. The 3D reconstructions and image renderings were created by **Professor Marc De Graef** of MSE.

Funding for this research was provided through the Office of Naval Research D3D project.

Pittsburgh and CIT: A Winning Combination



The city of Pittsburgh and Carnegie Institute of Technology (CIT) have recently won a long list of national awards and recognition—emphasizing what a unique combination of benefits are enjoyed by MSE faculty, staff, and students.

Once again, Pittsburgh has been named "America's Most Livable City" for 2007 by *Places Rated Almanac*, an honor the city last received in 1985. In addition, *American Style* magazine has named Pittsburgh its Best Arts Destination among mid-sized cities, and *Forbes* magazine recently recognized the region as among the top 10 "World's Cleanest Cities." An affiliate magazine of *Financial Times* named Pittsburgh one of North America's top three "Cities of the Future," and *Expansion Management* magazine ranked the city as one of America's 50 hottest for business relocation and expansion. *National Geographic Adventure* magazine placed Pittsburgh at the top of its "America's Best Urban Adventures" rankings.

In addition, *US News and World Report* recently ranked Carnegie Institute of Technology sixth among US engineering schools in its 2008 ratings. Each year, the magazine assesses graduate programs at more than 1200 major US universities, and ranks them according to their achievements in both research and education.

faculty news

Piehler Announces Retirement

Professor Henry R. Piehler

In June, after 40 years of dedicated teaching and research, **Professor Henry R. Piehler** will officially retire.

Piehler received his S.B. (1960), S.M. (1962), and Sc.D. (1967) degrees from Massachusetts Institute of Technology. He began his faculty career at Carnegie Mellon in 1967, and in 1974 he split his tenure between what were then known as the Metallurgy Department and the Engineering and Public Affairs Program—which later became the Department of Engineering and Public Policy.

Over the years, Professor Piehler's research interests have been very diverse, focused on the areas of deformation processing and the mechanical behavior of materials—with special interests in powder and composites processing, sheet-metal formability and the properties of formed sheets, orthopedic and cardiovascular biomaterials and implants, powder metallurgy products, and composite and clad materials. He has also studied such issues as the interaction of law and technology in product-liability litigation, standardization processes, risk management, technology transfer, networking among engineers, productivity, and innovation.

Piehler is a member of numerous societies and has served on many of their boards over the years. He has been the recipient of the *George Tallman Ladd Teaching Award*, the *Bradley Stoughton Award for Young Teachers of Metallurgy*, and the *Award of Merit and Fellow of the American Society for Testing and Materials*. He has authored or co-authored more than 95 publications.

While he will be retiring, Piehler plans to remain actively involved in the Department—where we hope he will remain a presence for years to come.

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MSE Research Associate Honored

MSE Research Associate **Dr. Michael Gao** has received the *APDIC Best Paper Award*—presented by the Alloy Phase Diagram International Commission—for the best published manuscript on alloy phase diagram data in the year 2005. His paper, entitled "Reassessment of Al-Ce and Al-Nd Binary Systems Supported by Critical Experiments and First-Principles Energy Calculations," was published in *Metall. Mater. Trans. A* (36A, 2005, pp. 3269-3279). Co-authors of the paper are N. Unlu, G.J. Shiflet, M. Mihalkovic, and M. Widom. This paper was completed with partial financial support from the Computational Materials Science Network, a program of the Office of Science, US Department of Energy.

FACULTY UPDATES

Professor Mohammad F. Islam has received the *CAREER Award* from the National Science Foundation (NSF)—which provides a five-year, $500,000 grant. Islam has also been named a recipient of the *Sloan Research Fellowship*. Both awards are intended to enhance the careers of the very best young faculty members in specified fields of science.

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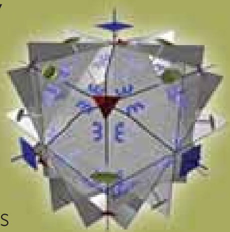
Professors Marc De Graef and **Michael McHenry** have authored a textbook entitled *The Structure of Materials—An Introduction to Crystallography Diffraction and Symmetry*. Publication by Cambridge is scheduled for July 2007. For details, visit http://som.web.cmu.edu.



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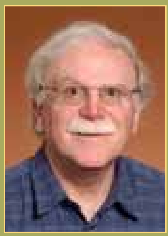
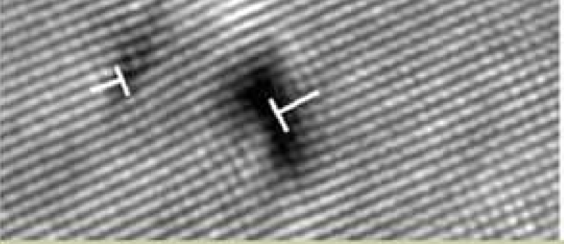


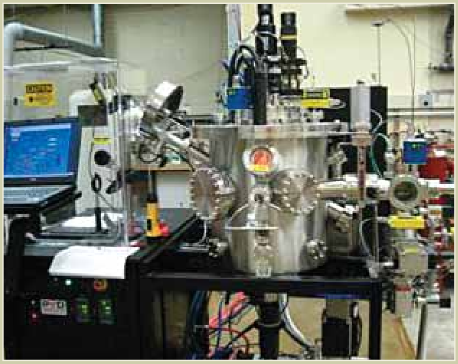
Professor David E. Laughlin has been selected as a *Fellow of TMS*. Only a handful of TMS members are elevated to the class of Fellow each year. TMS Fellows are recognized for their outstanding contributions to the practice of metallurgical science and technology.



Skowronski and Salvador Launch MEMC

Center Will Foster Materials Innovations Through Collaborative Efforts

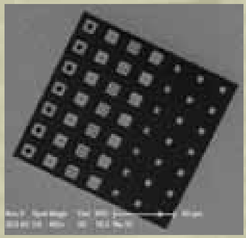
MSE's new Multifunctional Electronic Materials Center (MEMC)—led by **Professors Marek Skowronski** and **Paul A. Salvador**—is dedicated to developing new multifunctional electronic materials for use in data storage, electronics, communications, and energy technologies. MEMC's multidisciplinary research focuses on developing and optimizing the processing techniques required to create or integrate advanced materials for these applications. The Center was created to continuously improve materials for current and near-term technologies—as well as develop materials that enable revolutionary changes in the functionality of electronic devices and systems.



MEMC researchers are currently working to improve the storage density of memories, the reconfigurability of electronic processors, the tunability of high-frequency circuits in communications, and the electrocatalytic properties of cathodes in solid oxide fuel cells. This work is supported by collaborative research efforts with four well-established research centers:

- In cooperation with the Data Storage Systems Center (DSSC) at Carnegie Mellon, MEMC is working to create new nanoscale devices that improve storage capacity on computer hard drives. Researchers are investigating heterostructures of complex oxides—one class of the so-called resistance change materials—to generate ultra-high density storage devices using novel non-volatile electrically switchable domains controlled by arrays of miniature tips, called probes.

- Resistance change materials and probe-based controls are also being developed with the Center for Memory Intensive Self-Configuring Integrated Circuits (MISC-IC) at Carnegie Mellon, in order to revolutionize the design of reconfigurable integrated circuits such as field programmable gate arrays. By employing materials-based programmable inter-connects in integrated circuits and using unique system architectures, designs for new reconfigurable integrated circuits are being developed—with applications that range from consumer iPods to large data/communications systems in military ships and planes.



- In partnership with the Penn State Electro-Optics Center (EOC), MEMC is developing tunable high-frequency electronic circuits that will improve the performance of wireless communications systems—for example, making radar systems more agile with respect to their sweeping rate. To accomplish this, MEMC researchers are improving the quality of thin films of complex oxides, designing prototype devices, and measuring materials and device characteristics in the MHz-GHz frequency ranges.

- MEMC is collaborating with the Materials Research Science and Engineering Center (MRSEC) at Carnegie Mellon, as well as the National Energy Technology Laboratory (NETL), to improve the electrocatalytic performance of solid oxide fuel cells. Research is focused on understanding the surface activity of complex oxides, as well as preventing electrochemical degradation that arises from either long-term electrochemical poisoning or microstructural evolution.

MEMC is supported by the direct participation of five professors, three post-doctoral research associates, and seven graduate research assistants. The Center's research is also supported by more than $900,000 of annual funding provided by a range of sponsors that include the Semiconductor Research Corporation (SRC), Intel Corp., the National Science Foundation (NSF), the Air Force Office of Sponsored Research (AFOSR), the Office of Naval Research (ONR), and the US Department of Energy (DOE).

Solar Energy: An Ideal Alternative to Fossil Fuels

By Professor Elias Towe and Professor Lisa M. Porter

Energy has recently become a topic of public discussion. This is partly due to the rising cost of fossil fuels, but primarily due to concern about major global climate changes that are likely to occur if pollution from CO_2 from fossil fuels is not curbed.

It is the specter of these permanent negative consequences that is likely to force the world to abandon fossil fuels—or to find more efficient ways of using them, which generate much less pollution. According to the World Energy Council, there is an abundance of fossil fuel reserves (coal, oil, and natural gas) to satisfy demand in both the short and long terms [1]; scarcity is not an issue.

Earth's Atmosphere: A Delicate Balance

Planet Earth is habitable because it has the right temperature and atmosphere for sustaining life. Earth's atmosphere acts as an insulating blanket—of optimal thickness, and possessing the right mix and proportion of gases—for trapping solar energy. These insulating gases are called "greenhouse gases" because they keep heat on Earth, in a manner similar to a greenhouse.

The main greenhouse gases, which are infrared active, are water vapor (H_2O), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Visible light from the Sun—absorbed by landmasses, oceans, and vegetation—is re-emitted as heat, in the form of infrared photons. This heat is absorbed by the greenhouse gases. The gas molecules, in turn, re-emit the heat, warming the atmosphere and Earth's surface.

This natural balance keeps the temperature on Earth at levels that sustain life. Altering the proportions of the greenhouse gases affects the amount of heat retained by the atmosphere—leading to global climate changes. Because burning fossil fuels produces carbon dioxide, CO_2 levels have risen from about 280 ppm in the pre-industrial era to about 380 ppm today. This increase is largely attributed to the combustion of fossil fuels, and particularly to the emission of CO_2 [2]. Since the estimated residence time of CO_2 in the atmosphere is very long, identifying energy sources that do not produce CO_2 would help to preserve Earth's delicate balance.

Protecting the Balance: The Promise of Photovoltaic Energy

In the face of potential atmospheric and climate changes, increasing attention is being paid to the Sun—a non-carbon-producing energy source. There are two approaches to harnessing solar energy: one relies on the thermal, or heating, effects of energy absorbed from the Sun, while the other—the photovoltaic effect—relies on the electron-generating effect of photons from the Sun.

This article focuses on the potential of direct energy generation via the photovoltaic effect, recognized for more than 50 years. The basic concept of photovoltaic energy involves the generation of electrons—in a solid semiconductor material—due to the absorption of light (photon) of a particular energy (wavelength or color). Associated with the generation of an electron is a "hole" left behind when that electron no longer occupies its original location. In the presence of an internal electric field, the electron and hole are attracted to opposite sides of the electric field vector in the semiconductor. This is known as transport by "drift"—the predominant mode of charge carrier collection in inorganic devices.

Typically, the internal electric field is oriented perpendicular to the semiconductor surface, where, with appropriately placed metal electrodes, it enables the collection of the electron and hole as electric current. The internal electric field is usually designed into the semiconductor by special "dopants" in the material. This is the essence of the simple inorganic photovoltaic solar cell.

The Limitations of Silicon

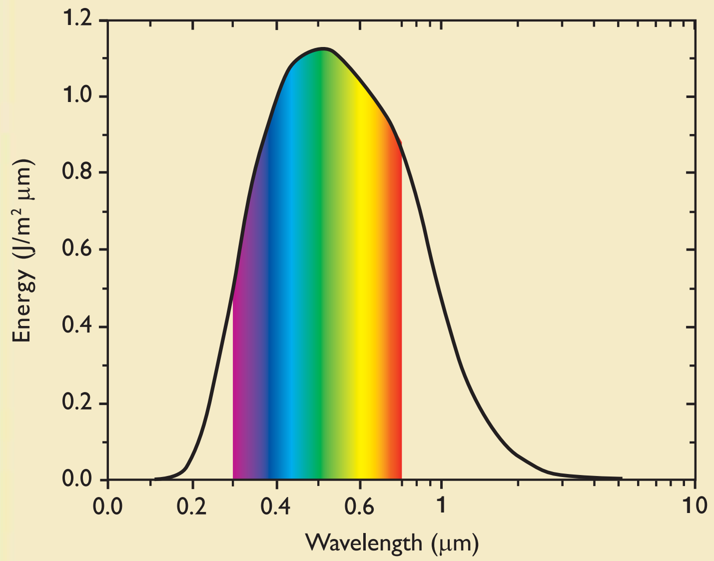
Silicon has been, and remains, the major semiconductor used in photovoltaic solar cell panels—due to its abundance, as well as the ability to leverage the infrastructure of the global silicon microelectronics industry. Silicon, however, is not an ideal material for generating electricity from the Sun.

The theoretical thermodynamic conversion efficiency limit for a simple silicon solar cell has been estimated to be about 30% [3], and the measured record (unconcentrated) efficiency for a single-crystalline cell is about 24.7% [4]. The optimum photon energy required to "kick" an electron into circulation—as current, if it is collected—is about 1.1 eV in silicon, corresponding to a light wavelength (color) of about 1 μm, which is in the infrared. This energy is known as the band gap energy. Photons with more energy than this waste the remainder as heat, once the minimum energy required for electron-hole pair generation has been absorbed—and those with less energy do not contribute to the electron-hole pair generation process at all.

> "Researchers at CNXT are working on several approaches for creating multi-color solar cells based on inorganic and organic materials."

Over 40% of solar energy is contained in the visible range of the electromagnetic spectrum; the majority of visible photons waste some energy as heat in silicon material. The figure at right illustrates the relative location of visible light in the solar energy spectrum, with the Sun considered as a blackbody source at 5800 K. Note that, beyond 700 μm, the scale of the horizontal axis of the spectrum is logarithmic. A significant portion of the solar spectrum—slightly over 50 percent—has photons with less energy than the band gap of silicon; most of this portion therefore does not contribute to the solar electric power generation process in silicon.

What is needed is a material whose energy structure allows the capture and conversion of a good fraction of the solar energy spectrum (rainbow). While no such materials exist in nature, the artificial structuring of some semiconductors through nanometer-scale engineering may allow their creation.



Solar spectrum, with the Sun modeled as a perfect blackbody at 5800 K

CNXT: Focused on Next-Generation Solutions

To overcome the limitations of silicon, researchers at the Carnegie Mellon Center for Nano-Enabled Device and Energy Technologies (CNXT) are working on several approaches for creating multi-color solar cells based on inorganic and organic materials.

With regard to inorganic materials, there are projects at CNXT exploring the use of engineered quantum nanostructures (quantum dots, quantum wires, and quantum wells) embedded in the active regions of compound semiconductor solar cell devices. There is particular interest in studying the use of epitaxially synthesized InGaAs quantum dots on GaAs substrates to create structures that allow absorption of solar energy at two or several distinct bands of the spectrum. Since the band gap of quantum dots can be modified by simply altering the size of the dots—or the composition of the dots and the matrix into which they are embedded—this approach could lead to higher conversion efficiencies.

The InGaAs/GaAs materials system allows the tailoring of the absorption spectrum of quantum structures in the infrared. For the visible portion of the spectrum, the CNXT researchers plan to transfer the lessons learned to the InGaN/GaN materials system, where wider band gap compositions can be created. CNXT research is also exploring more efficient light capturing and trapping methods, with the goal of enabling the manufacture of low-cost, high-efficiency solar cells.

Going Organic: Solar Energy From a Surprising Source

While much attention is focused on finding low-cost alternatives to silicon and other inorganic semiconductors, a major second-generation technology is based on a somewhat surprising material: polymers, or plastics. Although typically insulating, certain polymers can be made conductive through controlled synthesis and processing [5, 6]. Moreover, because polymers can be processed from solution rather than via the expensive deposition processes required to manufacture silicon and other inorganic semiconductors, organic solar cells could be made at a much lower cost than their inorganic counterparts. Furthermore, their flexibility would allow for roll-to-roll processing, much like photographic film. There is also the potential to easily incorporate them into structures such as clothing or buildings.

MSE faculty members are collaborating with colleagues in the Department of Chemistry to create solar cells that combine organic materials blended in composite form at the nanometer scale. In this application, nanotechnology is a critical development that enables the positive and negative charges to be separated and extracted as current. This team is working to optimize the nanometer-scale morphology of the materials, as well as developing novel processing methods that would lead to low-cost manufacturing.

Diverse Approaches—With a Shared Goal

Researchers elsewhere are pursuing different approaches to making solar cells through nanotechnology. For example, at the National Renewable Energy Laboratory, scientists are studying the use of colloidal quantum dots prepared inexpensively in solution. They have conducted experiments with the dots that demonstrate that a single photon could generate several electron-hole pairs, indicating potential conversion efficiencies well beyond 100% [7]. No solar cells with this characteristic have yet been demonstrated.

Story continued on page 10

References

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[2] S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, and H.L. Miller (eds.), "IPCC, 2007: Climate Change 2007: The Physical Science Basis—Contribution of the Working Group I to the Fourth Assessment Report on the Intergovernmental Panel on Climate Change," Cambridge University Press, New York, NY (2007).
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[4] M.A. Green, K. Emery, D.L. King, Y. Hishikawa, and W. Warta, *Progress in Photovoltaics: Research and Applications*, volume 14, pages 455-461 (2006).
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[7] R.D. Schaller, M. Sykora, J.M. Pietryga, V.I. Klimov, *Nano Letters*, volume 6, pages 424-429 (2006).
[8] S.A. McDonald, G. Konstantatos, S. Zhang, P.W. Cyr, E.D.J. Klem, L. Levina, and E. Sargent, *Nature Materials*, volume 4, pages 138-142 (2005).

student news


Lisa Chan

Doctoral student **Lisa Chan** won the Light Metals Division Graduate Student Poster Contest at the 2007 TMS Annual Meeting & Exhibition. The title of her poster was "The Effect of Grain Boundary Character Distribution on the Stress Corrosion Cracking Susceptibility of 2124 Aluminum Alloy."

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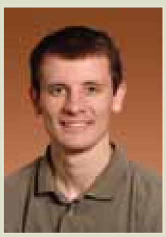
Stephen D. Sintay

Doctoral student **Stephen D. Sintay** (with R. Campman, G. Welsh, E.L. Anagnostou, J.M Papazian, and **A.D. Rollett**) was recognized with the *Best Poster of the Conference Award* for "Grain Orientation Influence on Matrix Crack Initiation in AA7075-T651," during the International Conference on Fatigue Damage of Structural Materials VI. The conference was sponsored by the *International Journal of Fatigue.*

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Doctoral student **Herbert M. Miller** won a National Science Foundation (NSF) supported *Travel Fellowship* to attend the European Ceramic Society meeting in Berlin, Germany, in June. He will present a paper titled "Time Evolution of the Grain Boundary Character Distribution During Grain Growth in Strontium Titanate."

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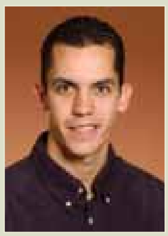
Paul Ohodnicki

A number of MSE students were honored this spring at the ASM International Young Members Night (Pittsburgh Golden Triangle Chapter). In the graduate student poster competition, doctoral student **Shengyu Wang** was awarded first place, and doctoral student **Paul Ohodnicki** was awarded third place. Seniors **Ruby Chen** and **Nicole Hayward** took third place in the undergraduate student poster competition. Sophomore **Steve Spurgeon** was awarded the *Past Chairman's Educational Assistance Award*, while **Nicole Cates** received the *Outstanding College Senior Award*.

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Sophia Woodley

Junior **Sophia Woodley** was the 2006 recipient of the *Boeing Scholarship for Academic Leadership.* She was selected because she possesses the characteristics that Boeing values in candidates: leadership, teamwork, and academic excellence.

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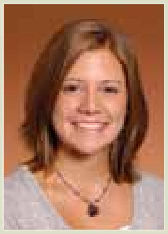
Senior **Eric Vanderson** received the *GE Co-Op/Intern Corporate Award*, which is given to approximately 3% of GE interns worldwide. The award was based on work Vanderson did as a co-op in summer 2006, which led to over $2.9 million in annual savings for GE.

Krzeminski Crowned National Champion

MSE senior **David Krzeminski** won the national championship in the 200-yard butterfly at the NCAA Division III National Swimming Championships in Houston, Texas, on March 17.

In the championship's final heat, Krzeminski topped his preliminary time—touching the wall with a time of 1:49.54—to set a new school record. He becomes Carnegie Mellon's sixth national champion in the last five years, as well as the first to win a national crown since Chris Pearson won the 200-yard freestyle and 200-yard butterfly in 2005. Krzeminski is a six-time All-American.



Rebecca Snyder

Junior **Rebecca Snyder** received a second-place prize for her poster titled "Use of Ferrogels to Improve Catheter Navigational Control: Neurointerventional Radiology-Based Applications." The poster session was part of the Carnegie Mellon course, Surgery for Engineering, and was attended by many local physicians and surgeons.

Nicole Cates

Esther Yu

MSE seniors **Nicole Cates** and **Esther Yu** have both been awarded prestigious *NSF Graduate Fellowships*. NSF awards approximately 1,000 graduate fellowships per year, in keeping with its mission to ensure the vitality of the human resource base of science, technology, engineering, and mathematics in the US—as well as to reinforce its diversity. These fellowships provide three years of support for graduate study leading to research-based masters or doctoral degrees. The Graduate Research Fellowship Program (GRFP) invests in graduate education for a range of diverse individuals who demonstrate their potential to successfully complete graduate degree programs. This fall, Yu will begin doctoral studies in the Bioengineering Department at the University of Pennsylvania, while Cates will pursue her doctoral degree in Materials Science and Engineering at Stanford University.

MSE Gets a Facelift

In the summer of 2006, the Department of Materials Science and Engineering gave its Wean Hall corridors a much-needed renovation. Gone are the dismal and depressing gray concrete walls and floors. Each hallway received a bright coat of paint, modern flooring, and new signage. The change is refreshing—and MSE is now the envy of Wean Hall!

Before

After

RECENT PH.D. THESES

Tricia Bennett
"Abnormal Grain Growth in Fe-1%Si"
ADVISOR: Anthony D. Rollett

Nan Boonyachut
"The Cellular Transformation in Cu-Ti Age-Hardening Alloys"
ADVISOR: David E. Laughlin

Daniel J. Ewing
"Inhomogeneities and Their Effect on the Electrical Characteristics of Schottky Contacts to n-Type 4H-SiC"
ADVISOR: Lisa M. Porter

Sungwook Huh
"Deep Level Defects in SiC Crystals Grown by Halide CVD Method"
ADVISOR: Marek Skowronski

Pallav Kaushik
"Mixed Burden Softening and Melting Phenomena"
ADVISOR: Richard J. Fruehan

Balasubramaniam R. Kavaipatti
"Phase Competition and Thin Film Growth of Layered Ferroelectrics and Related Perovskite Phases"
ADVISOR: Paul A. Salvador

Paolo Nolli
"Initial Solidification Phenomena: Factors Affecting Heat Transfer in Strip Casting"
ADVISOR: Alan W. Cramb

Changyong Um
"Fe-Based Amorphous and Nanocrystalline Nanocomposite Materials"
ADVISOR: Michael E. McHenry

Martín E. Valdez
"Controlled Undercooling of Liquid Iron: Effect of Substrate Composition and Undercooling"
ADVISORS: Sridhar Seetharaman and Alan W. Cramb

Sai Prasanth Venkateswaran
"Domain Structure Investigations in Multiferroic Heusler Ferromagnetic Shape Memory Alloy"
ADVISOR: Marc De Graef

Wanlin Wang
"The Heat Transfer Phenomenon Across Moldflux to Copper Mold in Continuous Casting"
ADVISOR: Alan W. Cramb

department news

New Multidisciplinary Course Makes Its Debut

Diverse Students Join to Assess Steel and Wood Construction

The Fall 2006 semester marked an exciting new addition to the MSE curriculum when **Associate Teaching Professor Robert Heard** joined with Research Associate Deanna H. Matthews (Civil and Environmental Engineering) to co-teach an innovative project course. "Environmental Life Cycle Assessment of Steel and Wood in Construction" brought together a diverse group of students from across the University—with the common goal of comparing the environmental impacts of these two building materials.

Professor Robert Heard

The new course—supported by a *FeMet Grant* from the Association for Iron and Steel Technology (AIST)—attracted students from MSE, as well as the School of Design and the Department of Civil and Environmental Engineering. Each student contributed his or her own academic experience and talents to the project work, while learning from those in other disciplines. This collaborative experience showed students how disciplines interact in real-world projects, as well as encouraging them to pursue their own interests within the topic area.

The collaborative student team performed a thorough assessment of steel products as either a direct replacement for wood products in construction applications, or as newly designed products. Their work included an environmental life cycle assessment (LCA) that focused on energy consumption and greenhouse gas emissions as metrics.

The life cycle assessment involved a hybrid approach of both process-based analysis of materials manufacturing and an economic input-output analysis (EIO-LCA) of the supply chain. Data was collected on specific processes within the products' life cycle, including the extraction of raw materials, the manufacturing of steel and wood semi-finished products, and the final finishing of these products.

"The results of this new project course provide an invaluable comparison of steel and wood construction products from an environmental perspective," notes Professor Heard. "We hope that this careful examination of the environmental life cycle impacts of steel and wood products will help to identify areas where steel is a viable alternative for wood—and merits inclusion in green building construction."

Solar Energy

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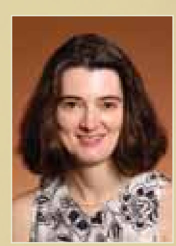
Other researchers have embedded the colloidal dots in organic semiconductor polymer materials. The basic idea is to sensitize a conjugated polymer, such as poly[2-methoxy-5-(2'-ethylhexyloxy-p-phenylenevinylene)] (MEH-PPV), by inserting colloidal dots of the right size for particular spectral absorption bands into the active region of the MEH-PPV-based device. Although solar cell devices manufactured using this approach still have a long way to go—with demonstrated efficiencies below 1%—their main attraction is the potential for low-cost manufacturing [8].

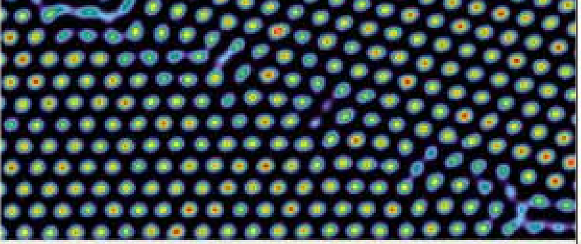
Looking beyond environmental impacts and climate change, the one overarching factor that would accelerate the adoption of photovoltaic technology is a lower cost per unit of energy. Two short-term scenarios are likely: either a low-cost technology with solar cell panels of moderate conversion efficiencies (10-15%) will lead to large-scale deployment, or a moderate-cost technology with solar cell panels of high conversion efficiencies (30-50%) will be deployed. These two approaches are considered second- and third-generation photovoltaics, respectively, as opposed to today's first-generation, silicon-based photovoltaics. In either case, the unit cost of energy should reach a threshold that is almost competitive with the unit cost of traditional energy sources. Thanks to nanotechnology, we believe the future looks bright for solar cells—as well as for the ongoing efforts to protect Planet Earth.

the authors

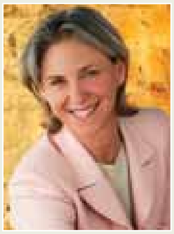
Professor Elias Towe



Professor Lisa M. Porter



alumni news


Diane Albert

Diane Albert *(M.S. '87, Ph.D. '91)*, a recent graduate of the University of New Mexico School of Law, has been honored as a pioneer of The Ohio State University's College of Engineering, where she earned her B.S in 1982. Albert was recognized this spring during Ohio State's first "Honoring Women in STEMS" event. The event acknowledges and honors the many women within the University who have obtained a Ph.D. in science, technology, engineering, or math (STEM). Albert received her J.D. degree this spring.

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Bassem El-Dasher

Bassem El-Dasher *(M.S. '98, Ph.D. '03)* recently accepted a Metallurgist position in the Materials Science and Engineering Division at Lawrence Livermore National Laboratory. This Division is part of the Chemistry, Materials, and Life Sciences Directorate.

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Thomas Gilbert *(B.S. '98)* recently completed his Ph.D. in Bioengineering at the University of Pittsburgh, and has accepted a Research Assistant Professor position there in the Department of Surgery. Gilbert has also been advising students in MSE's Capstone Design course on projects related to the use of materials in biomedical applications.

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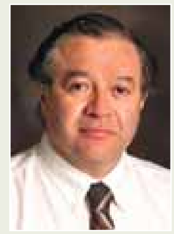
Roberto J. Rioja

Roberto J. Rioja *(M.S. '77, Ph.D. '79)* was elected a *Fellow of ASM's Class of 2006*. His citation reads, "For distinguished contributions to the development of new aluminum products to meet the increasingly demanding requirements of the aerospace and space industries." Rioja works at Alcoa as a Technical Manager.

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Tomoko Sano

Tomoko Sano *(M.S. '01, Ph.D. '05)* is currently a Materials Engineer in the Materials Division, Survivability Materials Branch, at the US Army Research Lab.

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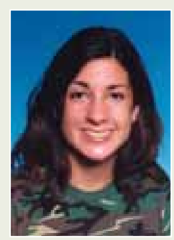
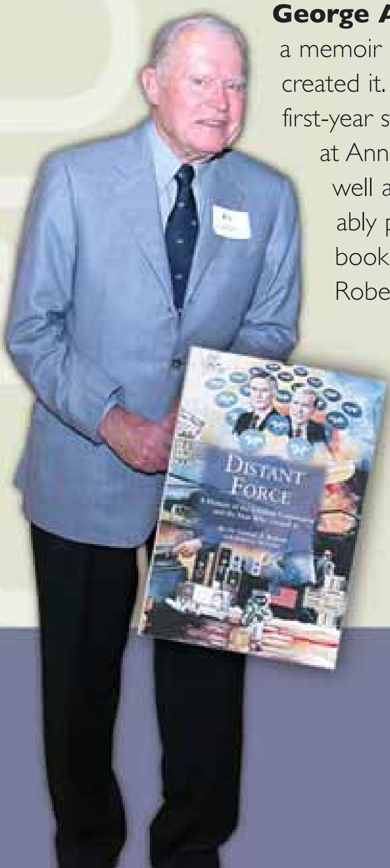

Mitra Taheri

Mitra Taheri *(B.S '01, M.S. '02, Ph.D. '05)* has been named the Hoeganeas Professor of Metallurgy at Drexel University.



George A. Roberts *(B.S. '39, M.S. '41, Ph.D. '42)* has penned a memoir of the Teledyne Corporation and the man who created it. Roberts met Henry Singleton when they were first-year students and roommates at the US Naval Academy at Annapolis in 1935—beginning a lifelong friendship, as well as more than three decades of a close and remarkably productive business association. *Distant Force*, a new book by Roberts (with former Carnegie Mellon president Robert Mehrabian) is his memoir of how they built the Teledyne Corporation into a $4 billion business that was, at times, controversial—but also unerringly successful in providing high financial returns to those shareholders who remained with them through their amazing journey. For more information on *Distant Force*, please visit http://www.distantforce.com.

We love hearing from our graduates! *If you would like to be included in the next issue of MSE News, simply send your update to* **sb3n@andrew.cmu.edu,** *or mail it directly to the Department c/o Alumni Updates.*

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