Carnegie Mellon Engineering

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MSE news

MATERIALS SCIENCE AND ENGINEERING

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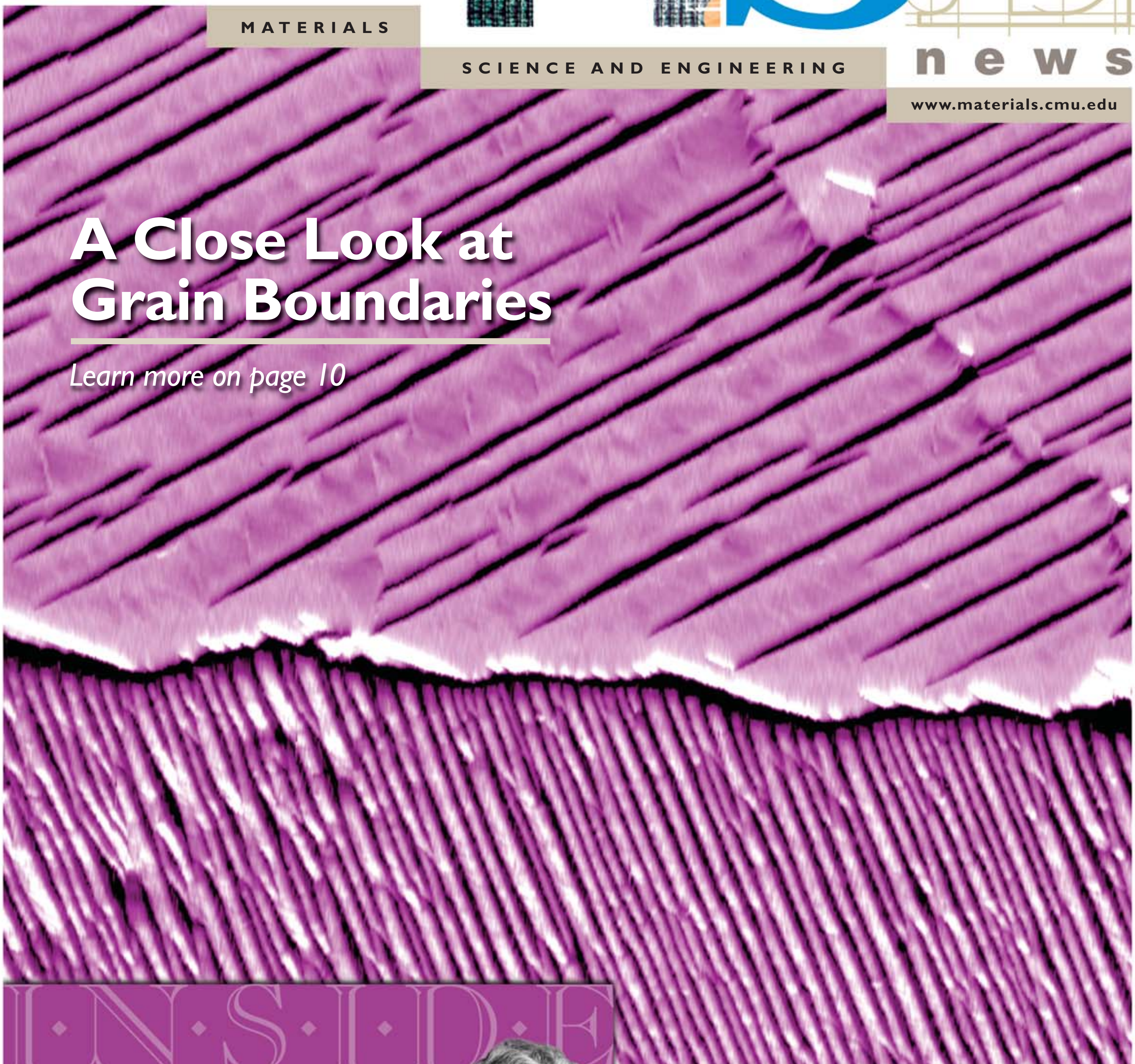
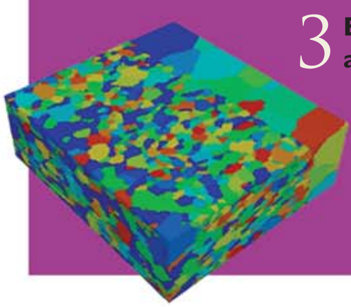
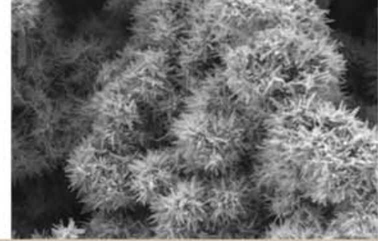


A Close Look at Grain Boundaries

Learn more on page 10

INSIDE





A Note From the Department Head

Gregory S. Rohrer, W.W. Mullins Professor

Dear MSE Graduates:

Over the past few years, one of the most exciting trends in the Department of Materials Science and Engineering has been the expansion of research into materials used for the production, storage, and utilization of energy. There are active projects on materials that can be used for the photolysis of water to produce hydrogen, materials for advanced batteries, materials for solid oxide fuel cells, and materials for reactors that can cleanly convert coal to gas. There are many other project directly related to energy efficiency—including materials processing strategies that use less energy and the development of alloys to reduce vehicle weight and energy consumption.

In this issue of *MSE News*, three ongoing research projects are briefly described in our feature story on pages 3–5. This article highlights research on coal gasification led by **Professor Sridhar Seetharaman**, research on materials for solid oxide fuel cells which is the focus of **Professor Paul Salvador**, and research on battery materials carried out by **Assistant Professor Jay Whitacre**. While these topics are new for MSE, this research builds upon the Department's existing strengths in materials processing and microstructural characterization. Furthermore, the interdisciplinary nature of these studies is a signature characteristic of research activities in our Department, as well as across the University.

Producing energy for a growing population, and doing so in a way that protects our environment, is a challenge that will occupy engineers for many years. We hope to contribute to innovative solutions not only through our research findings, but also by preparing our graduates to meet this challenge throughout their careers. Therefore, in parallel with this increased research activity, the Department has also begun formulating a Masters degree program in Energy Engineering—a one-year, interdisciplinary, course-based degree program. In addition to core courses, students will have the option of selecting a disciplinary concentration in Materials Science or one of the other engineering departments in the Carnegie Institute of Technology. We hope to begin accepting applications for this new degree program in Fall 2009. As part of this program, we have begun teaching new classes on topics related to materials for energy systems.

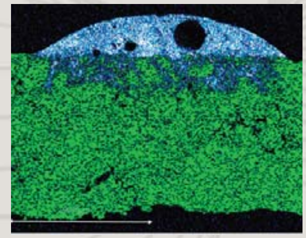
Let me close by reminding you to join us this October for the MSE Saltminers Dinner, which is held annually during the Materials Science and Technology (MS&T) Conference and Exhibition. The MS&T '09 event will be held in Downtown Pittsburgh at the David L. Lawrence Convention Center. Watch the mail for your dinner invitation, which should arrive in August. I look forward to seeing many of you in October!

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

FEATURE STORY

Applying New Energy

MSE Teams Tackle a Global Challenge



An MSE team is studying how coal ash (shown in blue) infiltrates into refractory materials (green). The depth of infiltration is being studied as a function of time, temperature, slag chemistry, refractory type, and thermal gradient—with the goal of minimizing materials erosion.

There are few issues that command the attention of the entire world. Today, energy has become a challenge that is shared across the globe—with widespread concerns about how it is made, consumed, and conserved, as well as its lasting impact on our environment. In every corner of the globe, people from all walks of life—from the average citizen to the highest-ranking government official—seem focused on the topic of energy.

As leading materials scientists and engineers, many MSE faculty members find that their research is increasingly focused on energy issues—and on helping to confront this growing global challenge.

From exploring alternative fuels to improving the efficiency of our current power sources, MSE research teams are making significant strides in ensuring a brighter energy future for the entire planet. This article describes the groundbreaking work of a handful of hard-working, innovative MSE teams.

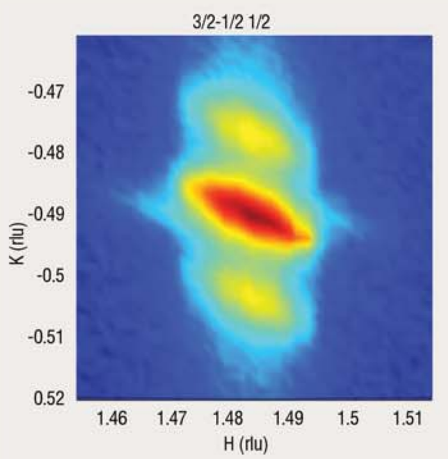
A New Generation of Coal Technologies

An MSE research effort headed by **Professor Sridhar Seetharaman**—the Department's POSCO Professor—is aimed at increasing the cleanliness, safety, longevity, and efficiency of coal technologies, so that this fossil fuel can support future power needs.

Focusing on integrated gasification combined cycle (IGCC) technologies that turn coal into gas, Seetharaman and his research group are seeking to reduce the environmental impacts of coal combustion, while also improving coal's energy outputs.

This MSE team is working to design and test new materials that help to convert, store, and deliver the energy that results from coal combustion. They are investigating new oxy-fuel systems that minimize the need for CO_2 separation, flexible feedstocks that offset CO_2 generation by using biomass waste, and downstream processing of the synthetic gases produced during IGCC processing.

Seetharaman and his team members are also studying how variations in slag chemistry—resulting from different ash mixtures—impact refractory efficiency and degradation. Coal and petcoke slag mixtures exhibit crystallization behaviors that have been shown to speed up the erosion of coal refractories. Seetharaman's team is focused on optimizing slag mixtures so that they remain fluid, with a low viscosity that helps to prevent or slow the erosion of refractory materials.



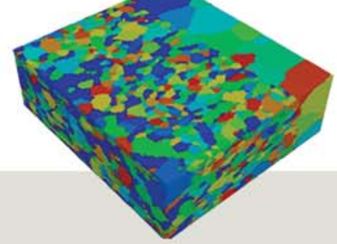
An MSE team prepares single crystal cathode films having targeted chemistries, orientations, strain states, and surface morphologies—and an ANL collaborative team characterizes their chemical and structural features in operational conditions at the Advanced Photon Source (APS). This image is the reciprocal space map (centered on the 3/2 -1/2 1/2 peak) of the (100) surface of a single crystal cathode film at 700°C in an oxygen environment. The central peak indicates the crystallographic nature of the film, and the satellites indicate a specific pattern of strain relaxation.

"While we must continue to explore alternative energy sources, coal is a cost-efficient fuel that is found in abundance here in the United States, as well as around the world," notes Seetharaman. "By creating cleaner, more environmentally responsible coal combustion materials, our research team hopes to ensure that coal remains a viable, long-term solution for our global energy demands."

Realizing the Potential of Fuel Cells

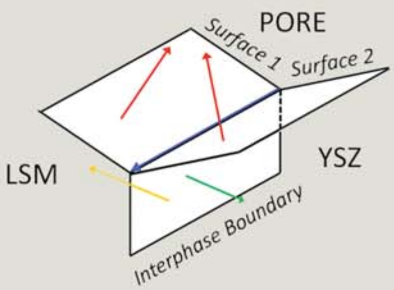
Among alternative energy solutions, fuel cells—which convert hydrocarbon or hydrogen fuels to electricity—have received a great deal of attention recently. But, while solid oxide fuel cells (SOFCs) have shown great promise for large-

Continued on page 4 ➢



FEATURE STORY

Applying New Energy *continued*



scale electrical energy production, current SOFC technologies are limited by a significant amount of energy loss during the reduction of oxygen in the cathode. In fact, this loss can reduce operational outputs of SOFCs by about one-half. Not only does this energy loss render SOFCs far less efficient, but it also greatly increases the cost of the electricity they produce.

An MSE research effort led by **Professor Paul Salvador** is aimed at addressing this energy loss, making SOFCs a realistic answer to the world's power-generation needs. In a project supported by the U.S. Department of Energy's Solid-State Energy Conversion Alliance (DOE-SECA), Salvador's research team is working to optimize the electrocatalytic activity of state-of-the-art SOFC cathode materials, in order to dramatically improve their energy yields.

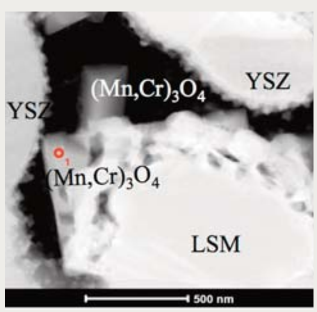
The team is generating well-defined epitaxial, textured, and polycrystalline films with controlled surface chemistries, as well as generating experimental data on surface properties that indicate how SOFC materials interact with oxygen gas in operational conditions. Electrical conductivity, Kelvin probe spectroscopy, and thermogravimetric techniques are used to generate a basic understanding of the surface properties of idealized thin film samples. In a collaborative effort, samples prepared by the Carnegie Mellon team are also being studied by research groups at Argonne National Laboratory (ANL), Massachusetts Institute of Technology, the National Energy Technology Laboratory (NETL), the University of Nevada, and Lawrence Berkeley National Laboratory.

In a related effort supported by the DOE-NETL, Salvador is partnering with NETL's Institute for Advanced Energy Solutions (IAES) and Assistant Professor of Chemical Engineering John Kitchin to identify surface chemical species and to optimize cathode materials, using nanoparticles of cathode materials having mesoscale porosity and ultra-high surface areas. Powders are prepared at Carnegie Mellon and various experiments—such as temperature-programmed desorption or reaction, and infrared or Raman spectroscopy—are carried out at NETL.

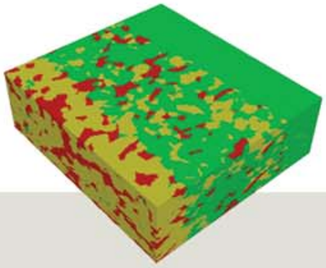
Another DOE-SECA project is aimed at understanding how degradation in SOFCs is related to local microstructural changes. Analytical transmission electron microscopy is used by researchers to identify the location and nature of microstructural changes after SOFCs are exposed to specific operational conditions.

Professors Salvador and Seetharaman are collaborating with the IAES in another DOE-NETL project to completely, quantitatively define the crystallographic complexity of the three-phase cathode used in many commercial fuel cells. SOFC button cells are operated under specific electrochemical loads at NETL and then characterized structurally at Carnegie Mellon. In collaboration with **Professor Gregory Rohrer**, this team is using automated oriental imaging microscopy to collect local crystallographic and phase information over a two-dimensional region, as well as using focused ion-beam milling to remove a thin layer. This process is repeated to collect a full 3D description of the SOFC microstructure, which includes not only traditional metrics concerning size and distribution of phases, but also connectivity and triple-phase boundary length, as well as the crystallographic nature of all features.

"Clearly, solid oxide fuel cells have demonstrated tremendous potential for efficient large-scale power generation—with little environmental impact," notes Professor Salvador. "If we can develop a better understanding of their surface properties and maximize their



A collaborative investigation between Carnegie Mellon and ANL demonstrates that cathodes exposed to aggressive electrochemical loads lead to large-scale microstructural degradation when chromia-forming stainless steel interconnects are used. $(Mn,Cr)_3O_4$ forms as nano-islands on YSZ (yttria stabilized zirconia) and as a decomposition product of LSM (lanthanum strontium manganate). The type and amount of degradation vary by location in the cathode. By varying the temperature, current, and voltage of operation, the researchers are investigating the nature of Cr-poisoning in SOFC cathodes to avoid large-scale performance degradation.



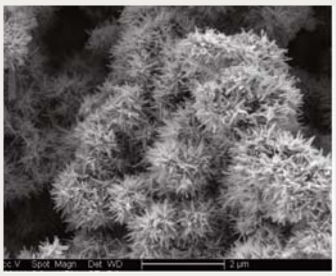
An MSE team characterizes the three-dimensional microstructural features of SOFCs. The colors on the left indicate the crystallographic orientation of all phases in the SOFC, while the colors on the right indicate the phases in the SOFC (green = YSZ, yellow = LSM, red = pore). Researchers are investigating the evolution of such features under varying processing and operational conditions.

electrocatalytic outputs, I'm confident they will emerge as an energy-efficient, cost-efficient alternative to more traditional power sources."

Harnessing the Power of Electrochemistry

Another MSE research team—led by **Assistant Professor Jay Whitacre**—is exploring the power generation capabilities of a wide range of electrochemically functional materials that may have applications in fuel cells, as well as a variety of other devices.

Whitacre's research group investigates materials that are either ionically or catalytically active, including metal-oxide and metal phosphate ceramics, carbons, noble metal catalysts, proton-conducting polymers, solid-state ion conductors, and liquid electrolytes. This team's work focuses on how these materials can contribute to the successful development of batteries for plug-in hybrid/full electric vehicles, stationary energy storage technologies, grid-level systems, materials commodity markets, and other applications.



Formed in an autoclave by an MSE research team, this nanostructured manganese oxide battery electrode material is literally "blooming" with additional surface area—which contributes to increased surface reaction rates and higher overall electrode performance.

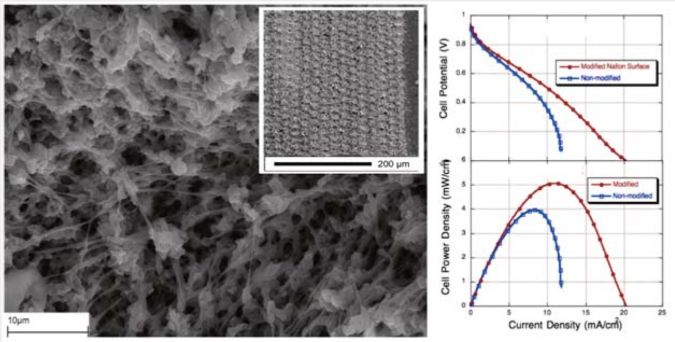
Professor Whitacre and his team are working on a spectrum of ongoing projects related to emerging energy technologies, including:

- A study of Li-ion ion diffusion mechanisms and the nature of phase changes in mixed transition metal phospho-olivine materials
- Investigations of Na-intercalation cathode materials
- Ultrafast laser modifications that enhance catalyst/membrane interfacial structures in fuel cell surfaces
- Hydrothermal synthesis routes for oxides and carbons
- Studies of solid-state thin film battery electrodes and structures
- Development of high surface area carbons for electrodes
- Creation of nanocomposites for ultra-high capacity anodes
- Studies of battery cell degradation when used in hybrid vehicles

While Whitacre's research efforts are varied, the ongoing efforts of his team focus on channeling electrochemical forces to generate power on a large scale. The group's efforts have the potential to impact a broad range of power-generation technologies and devices, making them both higher in output and lower in cost.

"While energy generation has typically been focused on familiar processes such as combustion, emerging technologies will harness more unexpected power sources—such as the electrochemical processes that take place at materials surfaces," says Whitacre, who holds a joint appointment in the Department of Engineering and Public Policy. "As materials scientists, we are in a unique position to help shape the future of energy, by applying our specialized expertise—and using our research efforts to continually push the boundaries of materials performance."

Adds Rohrer, who is MSE's Department Head, "Whether our teams are focusing on traditional or emerging power sources, the leading-edge energy research in our Department is truly revolutionary—because it has the power to change the way the entire world generates and uses energy, as well as the way we impact our environment. All of us should be excited about—and inspired by—the critically important energy research taking place within our Department today."



An MSE research group coated this specimen's surface with a platinum catalyst, then used an ultrafast laser to modify its proton-exchange membrane surface. When inserted into a fuel cell test environment, the result was a 300% increase in catalyst utilization.

DEPARTMENT NEWS

One Ångström and Beyond

The Department of Materials Science and Engineering has significantly expanded its microscopy capabilities with the recent addition of a spherical aberration-corrected ultra-high resolution transmission electron microscope (TEM), the FEI Titan 80-300.

This groundbreaking microscope is allowing MSE researchers to characterize materials more effectively than ever, with a resolution well below one Ångström. The performance of the Titan 80-300 enables corrected microscopy to be taken to the next level, where new discoveries of the structure-property relationships of materials become possible at ever-decreasing scales. These powerful capabilities are bringing electron microscopy into a new era, by expanding the boundaries and achieving unmatched results in nano-research.

MSE faculty and students can now embark on highly advanced research, obtaining incredibly detailed information on materials that was never possible before.

The addition of this microscope was the result of considerable effort from **Tom Nuhfer**, Director of Electron Microscopy and Materials Characterization, as well as **Professor Elias Towe**, Director of Nano-Enabled Device and Energy Technologies, who holds a joint appointment in MSE and the Department of Electrical and Computer Engineering. They were successful in obtaining funding from two sources—the PPG Foundation and the Gordon and Betty Moore Foundation—to support the purchase of advanced shared instrumentation for nano-materials. Important to these efforts are valuable contributions from Dr. Mary Grace Burke of Bettis Bechtel, and Dr. Rebecca Stiger of PPG.

Additional funds were required to purchase the correction optics for the Titan microscope. **Professors Marc De Graef** and **David Laughlin** submitted a joint proposal to the National Science Foundation's Major Research Instrumentation Program, and they were successful in obtaining the necessary funding. Their proposal was chosen for funding because it supports Cs-correction (Cs being the spherical aberration constant of the main imaging lens) at a resolution below 0.1 nm, as well as a focus aberration correction for Lorentz imaging of magnetic structures.

The Department's new Titan microscope has attracted considerable interest from the surrounding industrial community for its potential to perform sub-Ångström atomic scale research. This state-of-the-art instrumentation will play an important role as Carnegie Mellon develops research and development programs with the Western Pennsylvania industrial community.

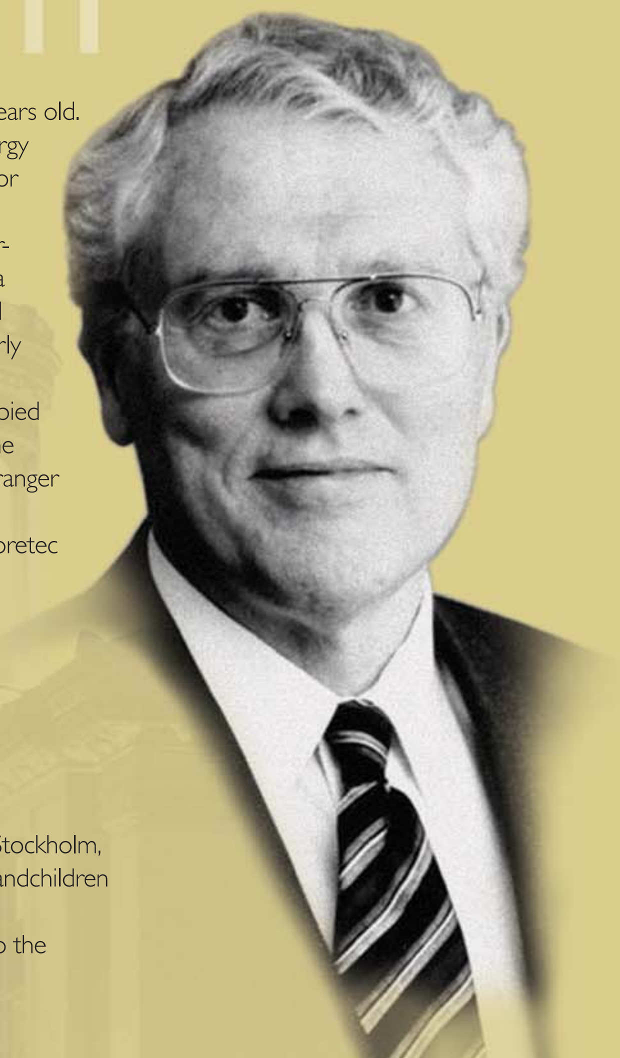
Shown here are major contributors to successfully bringing the Titan 80-300 microscope to MSE (left to right): Professor Marc De Graef, Professor David Laughlin, Dr. Mary Grace Burke of Bettis Bechtel, Dr. Rebecca Stiger of PPG, and Tom Nuhfer, Director of Electron Microscopy and Materials Characterization for MSE. Missing from the picture is Professor Elias Towe (see news story).

"It has been most rewarding to champion the addition of this aberration-corrected microscope to the Department's instrumentation resources, because it emphasizes MSE's leadership role in materials characterization," says Nuhfer. "I feel confident that it will have a major impact on the advanced materials research we can perform here in the Department, as well as the collaboration we can support with local industry. I am especially grateful for the continuing support of **MSE Department Head Gregory Rohrer** and **CIT Dean Pradeep Khosla**, who were instrumental in adding the Titan 80-300 to MSE's microscopy resources."

The History of Electron Microscopy in MSE

Carnegie Mellon's Department of Materials Science and Engineering began to explore electron microscopy in 1947, when **Professor Cyril Wells** purchased an RCA EMB transmission electron microscope with a resolution of 50 nm. **Professor William Robinson** reinforced MSE's commitment to electron microscopy with the purchase of a Philips EM100 (1955) and the purchase of a Philips EM 200 (1959). With their increased resolution, these early electron microscopes enabled MSE researchers to establish new techniques for characterizing metals and metal alloys, playing a key role in many research and development projects. Through the years, the Department has continuously invested in electron microscopy, acquiring a total of 14 transmission electron microscopes (TEMs) and eight scanning transmission electron microscopes (STEMs). With its resolution of 0.07 nm, the new Titan 80-300 aberration-corrected, ultra-high resolution TEM reinforces electron microscopy as the cornerstone of materials characterization in MSE.

In Memoriam



Former MSE Professor **Robert Dunlap** died on January 5 in Tucson, Arizona. He was 71 years old.

Dunlap began his 10-year career at Carnegie Mellon as an Assistant Professor of Metallurgy and Materials Science in 1967. His outstanding teaching won him the University's top prize for undergraduate teaching, the *Ryan Award*, in 1972.

With initial financial support from the Sloan Foundation, Dunlap introduced a joint undergraduate program offering a double major within a traditional engineering department and a second program—specializing in social science, economics, quantitative decision-making, and management. This program became the first new accredited engineering department in nearly 75 years. His work and teaching crossed departments and colleges—and his desire to hire, promote, and tenure faculty across department and college boundaries was realized and copied at major universities. "More than any other single person, Bob Dunlap was responsible for the creation of what is now the Department of Engineering and Public Policy," says Professor Granger Morgan, Head of EPP.

During Dunlap's prestigious career, he served as President, CEO, and Director of Thermoretec Corporation. He was also a Principal Consultant for Environmental and Financial Consulting Group, Inc., a New York-based firm supplying investment banking and consulting services to the engineering service industry.

Dunlap served as a member of Carnegie Mellon's Board of Trustees, as well as the Executive Committee, and was Chair of the Research and Technology Commercialization Committee. He was also a Co-Chair of the Advisory Boards for the Departments of Materials Science and Engineering, Civil and Environmental Engineering, and Engineering and Public Policy.

Dunlap is survived by his wife of 50 years, Ann Caris Dunlap, and three sons: Robert of Stockholm, Sweden; David of Tucson, Arizona; and Richard of Paris, France. He also leaves behind five grandchildren and a sister, Deane Krasow of Atlanta, Georgia.

The Department of Materials Science and Engineering extends its deepest sympathies to the Dunlap family.

ALUMNI NEWS

Alumni News Bits

Rodrigo Corbari *(Ph.D. '08)* will receive the tenth *Willy Korf Award for Young Excellence* at the Steel Success Strategies meeting in New York in June. Corbari is currently a Melt Shop Process Engineer with Vallourec & Mannesmann.

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Blake Darby *(B.S. '08)* is working toward his Ph.D. at the University of Florida in Gainesville. His current research focuses on structurally characterizing failure mechanisms in GaN devices using TEMs (transmission electron microscopes), STEMs (scanning transmission electron microscopes), and LEAPs (local electrode atom probes). Darby is also a member of the University of Florida crew team.

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Seth Eliot *(B.S. '88, M.E. '92)* recently left Amazon.com, where he was Manager of Quality Assurance for Amazon Digital Media—driving testing and quality support for Amazon Kindle, Amazon MP3, and Amazon Video on Demand. Eliot is now with Microsoft as Senior Test Manager for the Experimentation Platform, which enables Microsoft Web properties to make data-driven decisions about what works best for users.

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Gautham Ramachandran *(B.S. '97)* is living in Northern California and is currently employed by Lockheed Martin's Advanced Technology Center as a Researcher in the Materials & Structures Department. His field of work remains in high-temperature materials for rocket propulsion and thermal protection systems for re-entry/hypersonic vehicles. He has also recently joined a nanotechnology project involving composites. On a personal note, Ramachandran and his wife Stacie are expecting their first child.

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Roberto Rioja *(Ph.D. '79)* was recently promoted to the position of Technical Fellow in the Alloy Technology and Materials Research Division, Alcoa Technical Center. Rioja, who obtained his Ph.D. under the supervision of **Professor David Laughlin**, is recognized as a world expert in aluminum alloy metallurgy, as well as aluminum alloy development and commercialization. He has contributed to many of Alcoa's aerospace product introductions over the past 20 years and has led aluminum-lithium product development since the 1980s. Rioja is a two-time recipient of the *Alcoa Arthur Vining Davis Award* and a four-time recipient of the *R&D Magazine R&D 100 Award*, both recognizing outstanding achievements in aluminum alloy development.

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Rajasekaran Swaminathan *(Ph.D. '05)* is working as a Senior Materials Engineer at Intel Corporation in Chandler, Arizona. He is also a member of the IEEE Magnetics Society Technical Committee.

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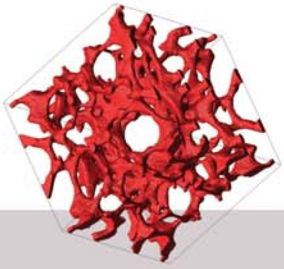
Alums Return for Spring Carnival

The Carnegie Mellon University Spring Carnival is the biggest annual event in the school year. Student organizations across campus, whether independent or Greek, work very hard to succeed in uniquely competitive events featured during the three-day period. This year, the MSE Department joined in the excitement and hosted our first annual "MSE Alumni Deck Party." The weather couldn't have been more cooperative, and it was great to see so many familiar faces that stopped by to join the celebration.

Mark your calendar for next year, as we will be hosting another alumni party on the deck on Friday, April 9, 2010!

Left to right are alums Carsen Kline *(B.S. '99)*, Mike Gingras *(B.S. '99)*, Joanna Meador *(M.S. '07)*, David Soltesz *(B.S. '07)*, Rebecca Wehrer *(B.S. '99)*, Matt Willard *(B.S. '95, M.S. '97, Ph.D. '00)*, and Autumn Wyda *(B.S. '04)*.



Shakul Tandon *(Ph.D. '04)* is working for Intel's Technology Development Group in Portland, Oregon. His current position involves helping Intel to keep pace with Moore's Law, in shrinking the size of chips by half every two years. His work at Intel focuses on lithography, and in the last four years he has been closely involved in a number of revolutionary technologies—from the hafnium-based 45 nm to 32 nm and beyond.

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Morgana (Martin) Trexler *(B.S. '03)* completed her Ph.D. in materials science and engineering at Georgia Tech in May 2008. Trexler is currently working in the Aerospace and Materials Science Group in the Research Department at the Johns Hopkins University Applied Physics Lab.

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Christine Tse *(M.S. '00)* joined the Gerson Lehrman Group in 2004, which was a start-up—but has now become the largest marketplace for expertise, connecting the world's leading institutions with leading experts (http://www.glgroup.com/). For the past three years, Tse was based in Hong Kong and built the Group's Energy & Industrials practice in Asia. More recently, she has been asked to take over the team in EMEA and has relocated to London.

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Roger Walburn *(B.S. '95)* was recently promoted to Manager—Applications and Routings at Duferco Farrell Corporation. His department is responsible for the process routings for all of the products that DFC and Sharon Coating (formerly Winner Steel) produce, as well as all technical inquiries.

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Amber Wheatley–Chastee *(B.S. '00)* is currently employed as the Quality/Technical Manager for Melting at Charter Steel in Cleveland, Ohio.

FACULTY NEWS

Faculty News Bits

Professor Robert Davis—who is the J. Bertucci Professor in MSE—has received the *John Bardeen Award* from The Mineral, Metals & Materials Society (TMS). This award recognizes an individual who has made outstanding contributions and is a leader in the field of electronic materials.

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Professor Marc De Graef was recently named a *Fellow of the Microscopy Society of America (MSA)*. MSA Fellowship is limited to a small fraction of the membership who have made significant contributions to the advancement of the science and practice of microscopy. De Graef has been elevated to the rank of Fellow for pioneering seminal research in the development and application of quantitative Lorentz methods for magnetic materials characterization, theoretical magnetostatics for nanoscale magnetism, and graduate and undergraduate microscopy education.

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Professor Richard Fruehan—MSE's U.S. Steel Professor—has received the *2009 Charles W. Briggs Award for Best Paper* for his work entitled "Decarburization and Slag Formation Model for Electric Arc Furnace," co-authored with Raimundo A.F.O. Fortes and Hiroyuki Matsuura. This award is presented to the authors of a paper selected by the AIST Steelmaking Technology Division, and judged by the Electric Steelmaking Technology Committee, to be the best technical paper submitted. As the recipient of this award, the paper will automatically be considered for the *AIST Hunt-Kelly Outstanding Paper Award* next year.

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Associate Teaching Professor Robert Heard was recently featured on the Web site CareersAndColleges.com for his expertise and experience in cooperative education. As a Faculty Advisor in Carnegie Mellon's cooperative education program, Heard was asked to give students advice on securing and maximizing co-op opportunities with prospective employers. Co-op positions—which represent a new "middle ground" between an internship and a salaried position—provide an opportunity for undergraduates to gain experience and try out an occupation before fully committing to it.

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Assistant Professor Mohammad Islam recently received CIT's *George Tallmann Ladd Research Award*, given annually in recognition of Carnegie Mellon faculty members who demonstrate outstanding research, professional accomplishments, and potential.

STUDENT NEWS

Recent Ph.D. Dissertations

Abhilasha Bhardwaj
"The Composition Dependence of the Photochemical Reactivity of $Sr_xBa_{1-x}TiO_3$"
ADVISOR: GREGORY ROHRER

Sukwon Choi
"Observations and Simulations of Resistance Switching Behavior"
ADVISORS: PAUL SALVADOR AND MAREK SKOWRONSKI

Rodrigo Corbari
"On a New Ironmaking Process to Produce Hydrogen and Reduce Energy Consumption"
ADVISOR: RICHARD FRUEHAN

Piyamanee Komolwit
"The Effect of Cobalt and Carbon on the Microstructure and Mechanical Properties of Martensitic Precipitation Strengthened Stainless Steels"
ADVISOR: WARREN M. GARRISON

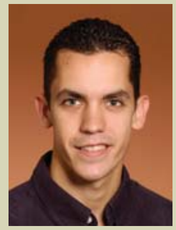
Sukbin Lee
"Microstructure-Property Relationships in Digitally Generated Three-Dimensional, Two-Phase, Liquid Phase Sintered Materials"
ADVISOR: ANTHONY ROLLETT

Samuel Lim
"Length Scale Effect on the Microstructural Evolution of Cu Layers in a Roll-Bonded CuNb Composite"
ADVISOR: ANTHONY ROLLETT

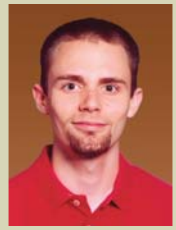
Jianguo Long
"FeCoB and FeZrSi-Based Nanocomposite Soft Magnetic Alloys and Application"
ADVISORS: MICHAEL MCHENRY AND DAVID LAUGHLIN

Jeremiah MacSleyne
"Moment Invariants for 2-D and 3-D Characterization of the Morphology of γ Precipitates in Nickel-Base Superalloys"
ADVISOR: MARC DE GRAEF

Herbert Miller
"Influences of Processing and Composition on the Grain Boundary Character Distribution"
ADVISOR: GREGORY ROHRER



Paul Ohodnicki
"Crystallization and Magnetic Field Processing of Co-Rich Co,Fe-Based Nanocrystalline and Amorphous Soft Magnetic Alloys"
ADVISORS: MICHAEL MCHENRY AND DAVID LAUGHLIN



Nicolaus Rock
"Synthesis and Characterization of Novel Electrocatalysts and Supports for Use in Polymer Electrolyte Membrane Fuel Cells"
ADVISOR: PRASHANT KUMTA

Bryan Webler
"A Study of the Processes During High Temperature Oxidation That Control Surface Hot Shortness in Copper-Containing Low-Carbon Steels"
ADVISOR: SRIDHAR SEETHARAMAN

COVER IMAGE

This is an atomic force microscopy image of the surface of a barium titanate surface. The sample was prepared by **Nina Burbure** for use by the sophomore Materials Characterization class. This is an "error" image showing the nanometer scale facets on two grains separated by a grain boundary.

MSE Student Shines in National R&D Competition

MSE senior **David Chan** was one of three Carnegie Mellon student engineers invited to participate in the L'Oreal USA R&D Innovation Lab 2009, held March 25-28 at the L'Oreal USA Research and Development facilities in Clark, New Jersey.

The three Carnegie Mellon students were among 20 participants from five leading universities invited to this unique competition, which gives students hands-on experience in developing product innovations as they work with L'Oreal's R&D Department.

Along with fellow seniors Sheun Ogunsunlade (Chemical/Biomedical Engineering) and Marianne Mota-Paulino (Chemical Engineering), Chan was assigned to an intercollegiate team that also included students from Cornell, Rutgers, the University of Pennsylvania, and New Jersey Institute of Technology. Each four-person team included two Ph.D. candidates, one graduate student, and one undergraduate, as well as a mentor from the L'Oreal Skin Care Labs.

The participants took on the role of development scientists, combining their creativity with their scientific knowledge to imagine a new men's skin care product of the future. The teams presented their product innovations to a panel of L'Oreal scientists and managers, with the goal of winning the *L'Oreal USA R&D Innovation Award & Prize*.

Chan's team tied for first place in total points awarded by the judges. However, in the "tie-breaker" deliberations that followed, the judges ultimately awarded Chan's team second place—which included a $250 prize for each participant.

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MSE Sweeps ASM Young Member Awards

MSE students won every major award at ASM International's Young Members Night, hosted on February 19 by the Pittsburgh Golden Triangle Chapter.

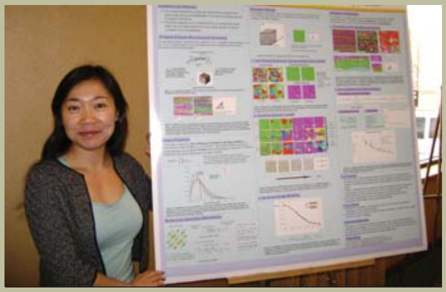
In the graduate student poster competition, doctoral student **Kelsey Miller** was awarded first place, while doctoral student **Shengyu Wang** received the second-place prize. Doctoral students **Lisa Chan** and **Kelvin Cheung** tied for third place.

In the undergraduate poster competition, MSE senior **Carolyn Sawyer** received the first-place prize.

Completing the MSE sweep, senior **Mitchell Kosowski** won the *Outstanding Senior Award*.

Carolyn Sawyer

Mitchell Kosowski



Doctoral student Shengyu Wang is shown with her winning poster.

Doctoral student Debashis Kar (right) discusses his work.

Shown left to right: Lisa Chan, Kelsey Miller, Shengyu Wang, and Kelvin Cheung

MSE news

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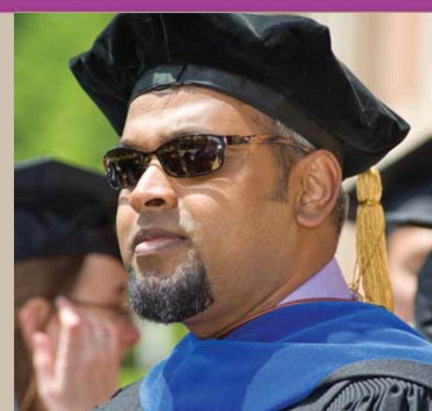

The Department of Materials Science and Engineering celebrated its annual Commencement Ceremony on May 17, 2009.

Watch for the Fall issue of *MSE News*, which will have more details!