METALLURGICAL&MATERIALSENGINEERING
COLORADO SCHOOL OF MINES

Spring 2014

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A Message from the Interim Department Head

Prof. Chester van Tyne

Hello from Golden. I have the privilege of writing my final department head update while Prof. Kaufman is enjoying the last few months of his sabbatical in Brazil. The spring 2014 semester continues to be very busy for the MME Department.

The big news of the semester is that the American Bureau of Shipping (ABS) has agreed to endow a Chair in Metallurgical and Materials Engineering at CSM. This generous gift will allow us to maintain expertise in the metallurgical aspects of shipbuilding and offshore structures. We are also delighted that Prof. Stephen Liu has been named as the interim ABS chair. This appointment recognizes the major contributions of Prof. Liu in the field of welding and the critical nature of welding in producing ships and other ocean-based structures. Prof. Liu also has a long history of working directly with ABS on a number of projects that they have sponsored. A search for a permanent ABS chair will be initiated this coming fall semester.

In other news, the MME department is in the process of interviewing candidates for two new assistant professors to begin in the Fall of 2014. We will provide you with the results of this process in the fall newsletter.

MME faculty members have received several significant recognitions this spring. First, Assistant Prof. Corinne Packard has been selected as a recipient of a prestigious NSF Faculty Early Career Development award (see pg. 5). Second, Prof. David Matlock played a major role in landing the CSM partnership with the American Lightweight Materials Manufacturing Innovation Institute (ALMMII) that was just announced by President Obama. Finally, Prof. Stephen Liu has been named to receive a Fulbright Foreign Scholar Distinguished Chair for Oil and Gas and will spend the spring 2015 semester in Brazil. There have been a number of other faculty and student awards and recognitions (see pg. 8). Please visit the MME website to keep up with ongoing department activities.

There have also been some changes among the support staff since our last newsletter. Alice Jensen who worked for many years as an administrative assistant for the Colorado Center for Advanced Ceramics (CCAC) retired in January. She will be greatly missed. Elaine Wolfschlag was persuaded to come out of her retirement and provide support for CCAC on a half-time basis. In the main office, Kelly Hummel joined us about one year ago as our Graduate Educational Specialist. She not only handles the MME graduate program but also has the responsibility for the Materials Science Program and the Nuclear

(Continued on page 2)

Welcome to Our New Faculty

(Continued from page 1)

Science and Engineering Program. She has been able to balance these activities well, and we are pleased that she is part of our department. In November, Erin Stoll joined the MME department as a program assistant. She runs the main office, the departmental budgets, and keeps track of our undergraduates – a sometimes daunting task. She had big shoes to fill but is doing an admirable job.

In other news, Bob Cryderman (see pg. 3) joined the department as a Research Associate Prof. this fall. He had been associated with the Advanced Steel Processing and Products Research Center (ASPPRC) for four months during 2012 and by mutual agreement has returned on a more permanent footing. Bob has over 45 years of experience in steel production. He has created a one credit course in the area of Steel Bar Manufacturing, and his presence on campus has had a very positive impact.

Prof. Ivan Cornejo continues to develop processing methods for turning food waste into glass (see pg. 6). His innovative ideas and developments have received a great deal of press including a focus piece on national television. He has also been bringing grade school students into the lab to see the process and to get them excited about the good things materials engineering can do for people.

On a more somber note, we are saddened to report that Emeritus Prof. Rex Bull passed away in March. Prof. Bull has left a legacy of well-educated mineral processing engineers as well as some amazing black and white photographic art work some of which the MME department proudly displays in the main office.

We continue to appreciate the loyal support that is received from our alumni and friends. Your financial contributions allow us to educate our students better, but more importantly your technical contributions provide a standard that our graduates hope to emulate and maintain as they enter the work force and continue the traditions of our CSM MME graduates.

If you are passing through Golden, we would be pleased if you dropped in to see us.

Chet Van Tyne, Interim MME Department Head

Prof. Zhenzhen Yu

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Prof. Zhenzhen Yu has joined the Department of Metallurgical and Materials Engineering (MME) as an assistant professor since January 2014. She received her M.S. and Ph.D. degrees from the Department of Materials Science and Engineering at the University of Tennessee, Knoxville under the guidance of Prof. Hahn Choo and her B.S. degree from Mechanical Engineering at East China University of Science and Technology. She most recently was a post doctoral research associate with Oak Ridge National Laboratory (2010-2013) supervised by Dr. Zhili Feng where she worked on the development of experimental and numerical approaches to characterize transient material behavior during welding (e.g. texture, phase transformation, precipitation, stress, and defect transport), the optimization of welding techniques and parameters in the joining of lightweight metals/advanced high strength steels, and the application of synchrotron x-ray and neutron scattering for materials research in automotive and nuclear industries.

Prof. Yu will be working with the Center for Advanced Non-Ferrous Structural Alloys (CANFSA) and the Center for Welding, Joining and Coating Research (CWJCR) at CSM. Her research interests include:

- Development of advanced similar/dissimilar joining technologies for non-ferrous lightweight metals and advanced high strength steels
- Welding consumables development and weld-pool physics
- Application and development of advanced characterization tools such as micro X-ray diffraction, synchrotron and neutron scattering to in-situ monitor the transient material state during manufacturing and welding, e.g., phase transformation in ferrous alloys weld pool, strain distribution and evolution of precipitates/voids in various alloys
- Development of testing equipment to evaluate the thermo-mechanical properties of similar/dissimilar welds
- Experimental and numerical simulation of material joining behavior
- Additive manufacturing of composite materials

Welcome Prof. Yu!

Welcome to Our New Research Faculty

Mr. Bob Cryderman

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Mr. Bob (Robert L.) Cryderman was recently appointed as a Research Associate Professor at CSM in association with the Advanced Steel Products and Processing Research Center (ASPPRC). He has over 45 years of experience in the steel producing industry where he has been instrumental in developing and applying metallurgical principles to produce new and improved products. He received his B.S. (1967) and M.S. (1970) degrees from the University of Michigan. He has published over 16 technical papers and has been awarded 9 patents. While employed at Climax Molybdenum Company, he was a principle contributor to the initial development of acicular ferrite plate steels alloyed with Mn, Mo, and Nb that increased toughness and strength of large diameter pipelines. He was the first to publish a paper that identified and characterized the martensite-austenite constituent in low carbon sheet steels using transmission electron microscopy. During employment at Jones and Laughlin Steel, he was instrumental in the production of the first dual phase sheet steel for a production part at General Motors. Bob implemented conversion of railroad rail production from ingots to round continuous cast blooms and started up production of head hardened rails while at CF&I Steel. At North Star Steel (purchased by MACSTEEL and Gerdau), Bob was instrumental in developing a hot rolling mill for bars that is capable of thermomechanical (warm) rolling for grain size refinement. He contributed to improving the surface and internal quality of steel bars for automotive and truck applications, conducted fatigue characterizations, and developed micro-alloy steels for various applications.

Mr. Cryderman's current area of interest and research is in the effects of microstructure and grain boundary segregation on the performance of components manufactured from bar steels that perform at high hardness levels (>55 HRC) in highly stressed applications. He is looking for processing methods and chemistry modifications that will increase the fracture strength of low alloy steels as measured by fracture toughness, fatigue strength, and rolling-sliding contact fatigue life.

Welcome Mr. Cryderman!

Dr. Robert Field

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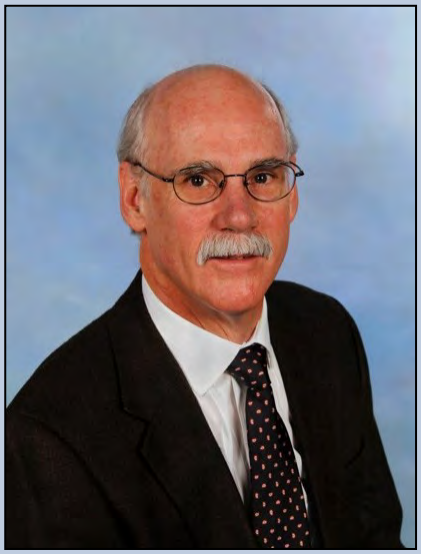
Dr. Robert Field received his B.S. in Mechanical Engineering from Union College in Schenectady, NY and his Ph.D. in Metallurgical Engineering from the University of Illinois at Urbana/Champaign specializing in the application of electron microscopy to address materials problems. He spent 11 years at General Electric Aircraft Engines (now GE Aviation) in Evendale, OH performing research on deformation behavior of Ni-base superalloys, Ti alloys, and intermetallics for high temperature applications as well as microstructure-property relationships in composite, coating, and bonding systems. Dr. Field recently came to CSM as a Research Professor after retiring from Los Alamos National Laboratory (LANL) where he spent 19 years performing research on numerous materials including Be and U alloys. He was the team leader for microstructural characterization in the Materials Science and Technology-Metallurgy group (MST-6) for 10 years and Deputy Leader of the LANL Materials Design Institute (MDI) for 7 years. He is a fellow of the American Society for Metals (FASM).



Dr. Field's current research interests are primarily in the area of deformation and phase transformations with emphasis on characterization using electron microscopy. He serves as the Assistant Managing Director of CANFSA in addition to teaching and performing funded research.

Welcome Dr. Field!

Welcome to Our New Research Faculty

Dr. Terry Lowe

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Dr. Terry Lowe's diverse career spans national laboratory research and management, executive leadership in the nanomaterials industry, and university research and teaching. In March 2011 he was recognized for his technical contributions in a report by Thomson Reuters as one of the Top 100 Materials Scientists in the world in the first decade of the 21st century.

After earning his Ph.D. in Materials Science and Engineering/Applied Mechanics from Stanford University, Dr. Lowe served as a Staff Scientist at Sandia National Laboratories from 1982-1990 developing multiple-scale computational models of polycrystal plasticity and metallurgical processes to simulate metal forging. Subsequently he served in technical leadership roles at Los Alamos National Laboratory (LANL) including Deputy Director of the Materials Science and Technology Division and Program Director for LANL's Science and Technology Base Programs, overseeing LANL's $125 million/year cutting edge research budget and managing LANL's relationships with universities worldwide.

Dr. Lowe shifted into the private sector in 2000 to serve as CEO of TECHNANOGY LLC, one of the world's first and largest nanotechnology incubator companies. He subsequently co-founded and served as CEO of the nanostructured metals company, METALLICUM INC.

In 2012 Dr. Lowe shifted to full time university research, teaching, and providing institutional-level service to higher education at New Mexico Tech. There he designed and launched the Biomaterials Engineering curriculum.

Recognizing the premiere status of CSM as a technical institution, Dr. Lowe joined the exceptional MME Department as a Research Professor in July 2013. He is currently building a Nanostructured Metals Research Group to conduct multi-disciplinary research to develop nanostructured non-ferrous and ferrous alloys.

Welcome Dr. Lowe!

Dr. Steve Midson

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Dr. Steve Midson earned his Ph.D. and B.S. degrees in metallurgy from the University of Sheffield (UK). He has over 30 years of casting and metallurgical experience and was appointed as a Research Professor in the MME Department in 2013, acting as co-managing director of the Center for Advanced Non-Ferrous Structural Alloys (CANFSA). He has also been an Adjunct Professor in the Department since 2012 and teaches the undergraduate Foundry Metallurgy course.

Dr. Midson previously served as Chief Operating Officer of a commercial casting company producing cast turbocharger impellers. He was also director of a development and prototyping company producing castings for a number of clients using several different processes. He has also worked in the R&D labs of two Fortune 500 companies (Olin Corp and AMAX).

Dr. Midson is currently president of The Midson Group, a Denver-based consulting company specializing in castings and materials. He is very active in the North American Die Casting Association, chairing the Die Materials Committee and serving as a member of the R&D Committee. He is also a member of the Semi-Solid International Scientific Committee and TMS. He has authored more than 50 technical papers and has received awards from the North American Die Casting Association, the Society of Automotive Engineers, the American Foundry Society, and Sheffield University.

Welcome Dr. Midson!

Packard Research Group receives several significant awards and honors

Prof. Corrine Packard
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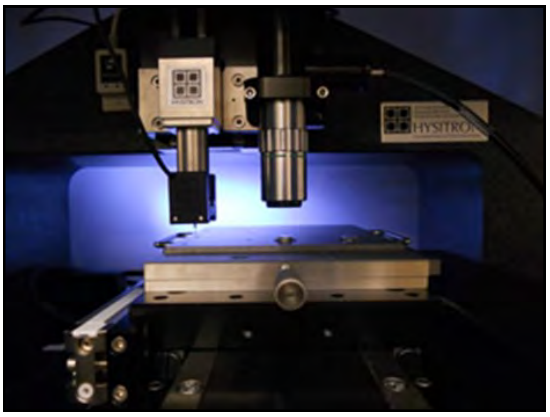
Prof. Corinne Packard recently received two prestigious awards in recognition of the quality research and achievements within the Packard Research Group. First, at the Annual Meeting of the Minerals, Metals & Materials Society (TMS), Prof. Packard received recognition for her research, leadership, and commitment to professional society service where she was honored with a 2014 TMS Young Leader Professional Development Award in the Structural Materials Division. This TMS-wide award program recognizes early-career individuals for their potential as future leaders within TMS and the materials and engineering community it serves and provides awardees with opportunities for involvement with society activities and networking.



The Packard Research Group includes expertise in probing the mechanical behavior of materials using this Hysitron TI 950 Nanoindenter.

In addition, early this spring, Prof. Packard was awarded a National Science Foundation Faculty Early Career Development (NSF CAREER) grant. This award is the most prestigious award in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations. Her proposed work, "Controlling Pressure-Induced Transformation in Rare Earth Orthophosphates," aims to discover the fundamental material science of deformation in materials for next-generation high temperature ceramic components.

Some unique ceramics undergo a change in their shape and volume to a new crystal structure when they are deformed, which can be harnessed to impart increased toughness in a material by absorbing energy caused by an impact or propagating crack. This project is determining how to use chemistry to control the point at which the change to a new crystal structure occurs and its speed of transformation. The information and new materials discovered in this research can be useful in designing ceramic matrix composites with better performance (superior mechanical properties) for high temperature aerospace applications.

Prof. Packard joined the MME Department as an Assistant Professor in 2010 and holds a joint appointment at the National Renewable Energy Laboratory in the National Center for Photovoltaics. She earned her Ph.D. in Materials Science & Engineering from MIT for her research in nanomechanics and the development of high temperature nanoindentation techniques. Her current research advances our understanding of the mechanical behavior of ceramics and the kinetic processes that control mechanical behavior in these materials in structural and renewable energy applications.

Undergraduate and graduate students studying materials science and engineering at Mines will be involved in the research. The project will also develop science-learning modules for local elementary school teachers and the Rocky Mountain Camp for the Dyslexic.

Students and trainees working under Prof. Packard have also received recognition for various recent milestones. Former post-doc, Dr. Mukesh Kumar, was recently placed as an Assistant Professor at the Indian Institute of Technology-Ropar in the Department of Physics. In November, Taylor Wilkinson successfully defended her M.S. thesis in Materials Science titled "High-Resolution, Mechanical Property Mapping in Oil Shales" and is remaining to continue her Ph.D. This spring and summer, Cassi Sweet will present her research on the production of thin film, single crystal GaAs by controlled spalling at the Spring Meeting of the Materials Research Society and at the 40th IEEE Photovoltaic Specialists Conference. This summer and coming school year promise to be exciting; be sure to follow the Packard Research Group's progress!

Trash-To-Glass: A sustainable process for glass making

Dr. Iván A. Cornejo
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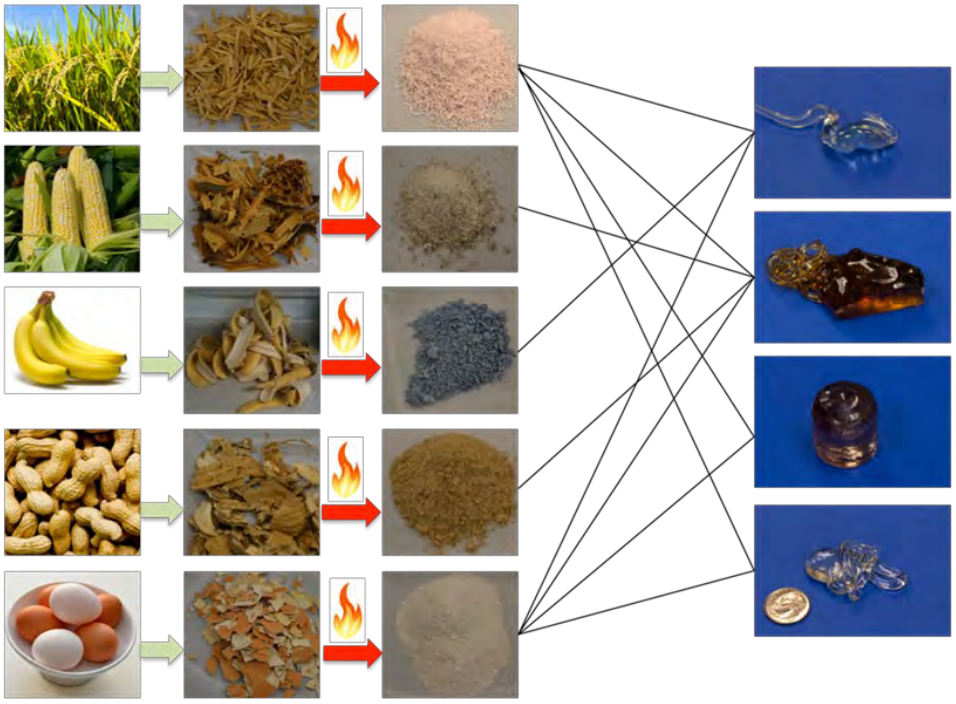
A recent discovery at the Colorado Center for Advanced Ceramics in the MME Department has demonstrated that commercial and/or new glass and glass-ceramics can be made entirely from foods or agricultural waste with unusual physical and chemical properties. This is the first demonstration of making glasses and glass-ceramics from unusual mineral sources.

A sustainable and environmentally attractive process, the trash-to-glass concept proposes harvesting the mineral portion needed to make glass from organic food waste, thus treating waste as a mineral source with which to make advanced materials.



Glasses made from food waste. Raw materials (left) are ground, dried, and then calcined to powders. The connector lines indicate which calcined food wastes were used to make the glass. The third glass photo from the top (cylindrical geometry) is a wollastonite glass -ceramic composition. The coin is shown for scale for the photographs of the glasses.

A recent report published by the Food and Agriculture Organization of the United Nations indicated that approximately one third of all food produced for human consumption in the world is lost or wasted. In the US alone, according to the US Environmental Protection Agency 2013 report, a total of 250 million tons of municipal solid waste was generated in 2011 and about 34.4% (86 million tons) is of an organic form (excluding paper and paperboard).

The global production of new flat glass in 2011 was ~55 million metric tons. Flat glass is typically ~70 wt% silica; therefore, ~36.4 million metric tons of silica is currently needed to satisfy the global demand for flat glass. The worldwide production of the main three grains consumed by humans in 2011 was 2,173 million tons worldwide. These grains of rice, wheat, and corn produce waste in the form of husks, stems, and cobs which account for about one fifth of the total production by weight. Given that these waste products contain on average ~15% silica, in 2011 65 million tons of silica could have been harvested from these three waste streams alone. This is more than was needed for the entire production of flat glass globally!

Research Prof. Iván Cornejo, postdoc Subramanian Ramalingam, and Prof. Ivar Reimanis (background) turn food waste into glass.

This work has the potential to have an enormous broad societal impact on pollution reduction via the reduction of landfill waste, to increase awareness on the utility of food waste, and stimulate, excite, and inspire students at all levels of our education system.

Dr. Iván Cornejo, Prof. Ivar Reimanis, and Dr. Subramanian Ramalingam have provisionally patented this sustainable method to turn organic food and agricultural waste into glass. Their findings have been featured by several news agencies including Ceramic Tech Today and the local ABC TV station.

Materials Research Society

Archana Subramaniyan, President
organizations.mines.edu/mrs/

The CSM Materials Research Society (MRS) student chapter is a professional organization established in 2012. The chapter aims to foster scientific discussion among students and faculty in the various materials disciplines, to generate student interest in materials science, and to promote the exchange and dissemination of information from the Society. To accomplish this, a variety of activities including research seminars, panel discussions, professional networking events, and social events are organized by the chapter executives. Highlight events from this last year included a guided tour of the CSM Geology Museum and a seminar on the novel synthesis of glasses from organic food waste by Prof. Ivan Cornejo. A series of workshops on materials characterization techniques is underway for the spring semester where students are invited to share knowledge of various structural, microstructural, electrical, and optical characterization techniques.

In collaboration with the national MRS, the CSM MRS chapter awards travel funds of up to $500 to chapter members attending Spring or Fall MRS meetings. More information about the chapter, upcoming events, and membership can be found online.

Dr. Bruce Geller discusses geological minerals from a materials perspective with MRS chapter members at the CSM Geology Museum.

Material Advantage Chapter

Madeline Hatlen, President, orgsync.com/38891/chapter

CSMMAC members and the Materials Bowl members and coach at TMS 2014 in San Diego, CA. The Materials Bowl team made it to the semi-finals.

The CSM Material Advantage Chapter (CSMMAC) was established in 2000. The student chapter is affiliated with four professional societies through Material Advantage: the American Ceramic Society; the Association of Iron and Steel Technology; ASM International; and The Minerals, Metals, and Materials Society. There are approximately 70 active student members within the chapter.

Throughout the year CSMMAC hosts social, outreach, and professional events for members. The chapter has several reoccurring events including weekly meetings featuring a professional speaker, monthly breakfast socials for members (deemed “Breakfast Club”), and monthly “Free Pour Fridays” where members engage students around campus in foundry activities. Beyond these regular events, during the 2013–2014 year, CSMMAC members toured the facilities of Advanced Forming Technologies, Evraz Steel, and Lockheed Martin. These tours enable students to interact with professionals and see industrial applications of concepts they have learned in the classroom. CSMMAC also assisted in judging local science fairs and organizing laboratory demonstrations to promote math and science related fields. Additionally, the group regularly promotes the MME Department to students at CSM by participating in major fairs and department tours.

CSMMAC sponsors outstanding members to attend the MS&T and TMS conferences. Eight students were sponsored to attend MS&T this past fall and ten students to attend TMS this spring. CSMMAC also helped fund the CSM Materials Bowl team.

CSMMAC is a Material Advantage “Chapter of Excellence” and was recently recognized for hosting the “Most Creative” recruitment events.

Departmental Honors and Awards

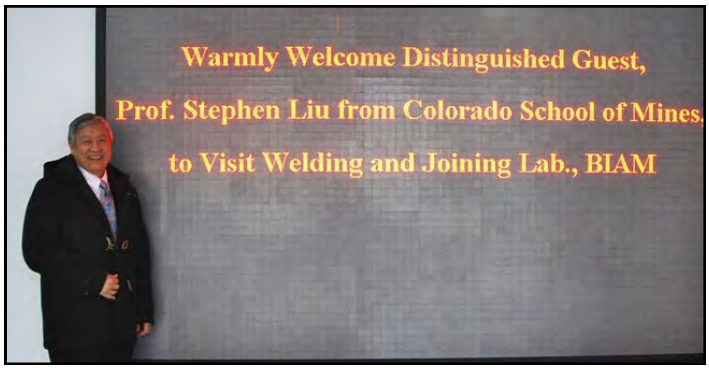
FEBRUARY 2014

Prof. Corinne Packard was awarded an National Science Foundation Faculty Early Career Development grant, the most prestigious award in support of junior faculty who exemplify outstanding research, excellent education, and the integration of education and research. See pg. 5 for a Featured Research article from Prof. Packard.

Graduate student Archana Subramaniyan received the Best Student Presentation Award for her talk at the Materials Research Society Fall Meeting. She spoke on non-equilibrium deposition that reduces the growth temperature of pure Cu_2O thin films.

JANUARY 2014

Prof. Corinne Packard was recognized with the 2014 Young Leader Professional Development Award from the Structural Materials Division of TMS. The award was created to enhance the professional development of dynamic young people from TMS.



Prof. Stephen Liu (above) was invited to visit the Beijing Institute of Aerospace Materials, the Beijing Institute of Petrochemical Technology, and the Chinese Pipeline Bureau to lecture and discuss potential collaborative research opportunities.

Research Prof. Ivan Cornejo (below) hosted a group of students from the Logan School for Creative Learning who learned about the Trash-to-Glass project (see pg. 6) from the news media and requested a visit.

DECEMBER 2013

Undergraduate Paul Wilson was named the Outstanding Graduating Senior from MME at the Dec. commencement ceremonies. Wilson will be continuing his studies as a graduate student in the Center for Advanced Nonferrous Structural Alloys at CSM.

Three graduate students Jordan Rutledge, Caelen Anderson (right), and Joseph Grogan (below from the Kroll Institute for Extractive Metallurgy received scholarships from the Mineral Processing Division of the Society for Mining, Metallurgy, and Exploration. Prof. Taylor is shown presenting the awards.

NOVEMBER 2013

The Center for Welding, Joining, and Coatings Research reaffirmed its prominent position amongst the top research universities in the field of welding and joining with eight oral presentations at the 2013 FabTech event. Profs. Stephen Liu and John Steele traveled to the meeting with graduate students Stephen Tate, Erik Pfeif, Ali Al-Shawaf, and Andrew Neill. Scott Nelson, a former graduate now with Rolls-Royce, was also present to deliver his M.S. research results.

OCTOBER 2013

MME senior and cross country runner Derek Alcorn (right) was named Mines Student Athlete of the Week. He is a two-time All-American.

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Departmental Honors and Awards

(Continued from page 8)

OCTOBER 2013

For the second time, the CSM Materials Advantage Chapter (see pg. 7) won the Chapter of Excellence Award under the leadership of Sarah Holmes as the 2012-13 president.

Research Prof. Richard Ahrenkiel gave invited talks at Purdue University and at the University of Toledo on current techniques for measuring carrier recombination lifetime.

Prof. Corinne Packard gave an invited seminar at the University of Colorado Boulder on residual stress and mechanical properties in transparent conducting oxide contacts.

SEPTEMBER 2013

Prof. Corby Anderson gave a plenary lecture at the 18th International Conference of Mineral Processing held in Lower Silesia, Poland. He spoke on new copper and silver production methods.

Research Prof. Richard Ahrenkiel presented an invited talk at the International Materials Congress in Cancun, Mexico. He spoke on resonant coupling of the contactless measurement of carrier lifetimes. The work was in collaboration with Dr. Steve Johnston of NREL.

Prof. Jeff King was interviewed on the local KDVR TV station about plutonium contamination from Rocky Flats in light of the recent flooding in Colorado.

Prof. Corby Anderson presented a lecture to the Colorado Section of the Mining and Metallurgical Society of America. He spoke on the challenges and opportunities of critical and strategic metals.

Graduate student Ana Luiza Araujo from the Advanced Steel Processing and Products Research Center received a Roberto Rocca Education Program Fellowship (supported by Ternium, Tenaris, and Techint companies). The fellowship will allow her to study the effects of niobium additions in C-Mn-Si quenched and partitioned steels.

AUGUST 2013

Through the generous support of ArcelorMittal, the MME senior class visited the ArcelorMittal steel making facilities in Chicago (left). This annual trip is a highlight and allows students to see steel making processes up close. Prof. Kip Findley serves as the prime lead for this trip.

As part of the annual Celebration of Mines the CSM Materials Advantage Chapter including Amanda Erskine, Will Ash, Tyrel Jacobsen, and Paul Wilson (below) ran demonstrations to get first year students interested in MME.

Prof. Chester Van Tyne was recognized for 25 years of excellence in research and education as the Forging Industry Education and Research Foundation Professor at CSM.

MME senior Evody Tshijik Karumb received a scholarship for the 2013-2014 academic year from the Woman's Auxiliary to the American Institute of Mining, Metallurgical, and Petroleum Engineers.

JULY 2013

Prof. John Speer was named the John Henry Moore Distinguished Professor of MME. He has been instrumental in helping the Advanced Steel Processing and Products Research Center develop into a world class research center focused on the physical metallurgy of steel. He and his students and colleagues invented the quenched and partitioning process which is currently used by several steel companies worldwide.

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SUPPORT MME

A gift to the Department of Metallurgical and Materials Engineering is an investment in the future.

Gifts can support scholarships, fellowships, professorships, academic programs, faculty research, and other initiatives that are not typically supported through state appropriations. Private philanthropy empowers the Department to achieve greater excellence in research and education.

To learn more about supporting the Department, contact the CSM Foundation.

http://giving.mines.edu/
303-273-3275

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Newsletter prepared by Ann Deml, Materials Science Ph.D. Candidate