



Inside this Issue:

- Materials Science Program **2**
- Dept. Laboratory Facilities **3**
- Dept. Research Centers
and Institutes **5**

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A Message from the Interim Department Head

Prof. Chester van Tyne

Greetings from Golden, Colorado. Since Prof. Michael Kaufman is on sabbatical for the 2013/14 academic year, I have been asked to serve as the interim department head for MME during his time in Brazil; hence this department head update is coming from me.

The 2012/13 year was a busy year for the department. Among the highlights was the naming of Prof.

John Speer to the John Henry Moore Chair. He was selected after an international search for the position. We also had a search for a new assistant professor and have been fortunate to hire Dr. Zhenzhen Yu from Oak Ridge National Laboratory. Dr. Yu will join us in January and will work closely with the welding and non-ferrous centers. Another exciting event was the victory of the MME CSM team at the Materials Bowl competition which occurred in San Antonio during the TMS annual meeting. This was the fourth victory for our students out of the seven times the contest has been held. Greg Lehnhoff, Ellen Verkler, Liz Hunter, and Paul Wilson prepared well under the guidance of Prof. Jerry Bourne to secure the championship for CSM.

On the research front, the Kroll Institute for Extractive Metallurgy will be playing a vital role in the Critical Materials Institute (CMI) which is a large, multi-institutional program being sponsored by the DOE. This program will enable the purchase of about \$2M of new equipment and support a number of graduate stu-



Hill Hall, home of the MME Dept., on a beautiful fall day in Golden.

dents, postdocs, and projects over the next 5 years. [Editor's note: See pg. 6 for an article on the new CMI.]

Honors continue to be received by the faculty and students in the department. Prof. Ryan O'Hayre was named a visiting professor at the Chinese Academy of Sciences and spent a sabbatical year there. Prof. Brajendra Mishra was installed as an honorary professor at Kazakh National Technical University. Prof. Patrick Taylor was awarded the SME 2013 James Douglas Gold Metal. Profs. Emmanuel DeMoor, David Matlock, and John Speer received the SAE & AISI 2012 Sydney H. Melbourne Award for Excellence in the Advancement of Automotive Steel. In addition MME faculty have been issued patents, students have been recognized with awards, and the faculty continue to give keynote presentations around the world. In other words, Hill Hall continues to be a very active and productive place.

There have been three transitions this past year. Prof. David Olson has retired after 40 years of service to CSM and has

(Continued on page 2)

Graduate Program in Materials Science

A Message from the Interim Department Head

(Continued from page 1)

been named a University Emeritus Professor. He started a three-year transitional appointment in August 2012. Another long time contributor to research and education in MME, Prof. David Matlock, also retired, starting his three-year transitional appointment in August 2013. The Board of Trustees also recognized his long service by naming him a University Emeritus Trustee. He served 41 years at CSM and was director of the Advanced Steel Products and Processing Research Center for the past 20 years. He has passed the leadership of this important center to Prof. Speer. Finally, Elaine Wolfschlag, our departmental office manager, retired after 16 years of service to the department. The experience and wisdom of all three of these people will be missed greatly.

During the past year we have had four new research faculty join the department. Prof. Ivan Cornejo, who specializes in glass, will be working with the Colorado Center for Advanced Ceramics. He offered a section of MTGN419 – *Non-crystalline Materials* this fall, which was very popular and well received. Also, Profs. Terry Lowe, Steve Midson, and Bob Field, all with expertise in non-ferrous alloys (casting, nanostructuring, and characterization), will be working primarily with the Center for Advanced Non-Ferrous Structural Alloys. They will also each be teaching a class in the spring and our research programs and students will benefit from their expertise.

Finally, we continue to have over 120 undergraduate students and over 140 graduate students in the department. This along with over \$9M in research funding last year keeps the department faculty and staff very busy. If you ever pass through Golden please stop by and visit.

Chet Van Tyne, Interim MME Department Head

Materials Science Program

Prof. Brian Gorman, Director

<http://materials.mines.edu>

The Interdisciplinary Materials Science Program is a collaboration of the Departments of Chemical and Biochemical Engineering, Chemistry and Geochemistry, Metallurgical and Materials Engineering, Physics, Mechanical Engineering, and Electrical Engineering. It is a graduate-only academic program that prepares students for careers in interdisciplinary materials science.

The program was very fortunate to have many years of thoughtful directorship from Dr. David Olson, who is currently on transitional retirement. I took over the duties from him in 2011 and could only hope to give the program such excellent leadership.

Also in 2011, the Materials Science faculty elected to implement a variety of changes to the program. First, three new core courses were developed and implemented for incoming students: Bonding, Structure, and Crystallography (currently taught by Dr. Mark Eberhart, Chemistry), Advanced Materials Thermodynamics (currently taught by Dr. Jim Bernard, Physics), and Advanced Materials Kinetics (currently taught by Dr. Corinne Packard, MME). Additionally, the number of courses required for PhD and MS degrees were reduced in order to give students more laboratory experience. Lastly, the qualifying exam was standardized across the curriculum. The new written exam is given to first year students every spring and it covers the three core courses as well as Callister's Introduction to Materials textbook. Although we have only had these changes a short time, they seem to be serving the students well. Hopefully the students think so as well.

I am happy to report that the CSM administration approved a new faculty position specifically directed to support the new Materials Science curriculum. After an extensive search, we are excited to have Dr. Jeremy Zimmerman (B.S. MME, CSM 2004) join us in early 2014! Yes, his home department will be Physics, but having him back on campus and involved in Materials Science is a great boost for CSM.



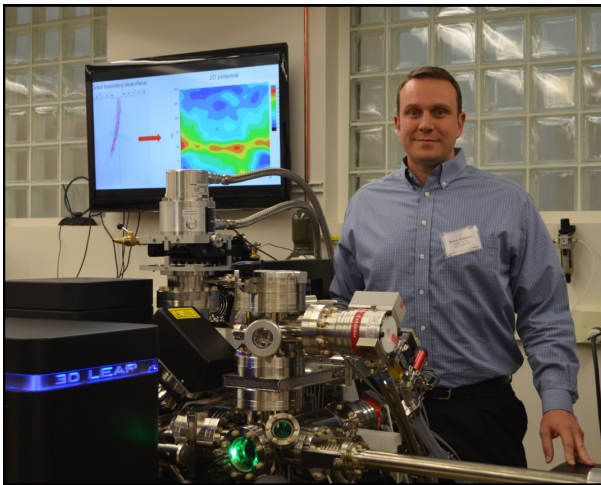
The 2013 winning team in the TMS Materials Bowl competition included l. to r. Greg Lehnhoff, Ellen Verkler, Liz Hunter, and Paul Wilson.

He will be taking over the teaching responsibilities for Bonding, Structure, and Crystallography in Fall 2014.

Atom Probe Laboratory

Prof. Brian Gorman, Director
<http://atomprobe.mines.edu/>

In 2010 Prof. Brian Gorman received a grant of approximately \$2.5M from NSF's Major Research Instrumentation program to develop a "Dynamic Atom Probe." Atom probe



Prof. Gorman with the new Local Electrode Atom Probe.

tomography (APT) pulls apart materials one atom at a time to make 3-D maps of local chemistry. Prof. Gorman proposed to add a high temporal resolution transmission electron microscope (TEM) to that. Ultimately, the APT Lab should be able to watch diffusion happen one atom at a time with ns temporal resolution!

To support this new lab, Dr. David Diercks joined the MME faculty in 2011. Prof. Gorman knew Dr. Diercks from the University of North Texas where they did TEM and APT together, so he was the perfect fit. They have had a lot of successes since he joined, despite moving the instruments twice already. Graduate student extraordinaire Rita Kirchhofer has also been of great assis-

tance. Rita has already won awards based on her APT analysis of oxides and is sure to have a very high profile career ahead of her.

The APT Lab has several programs funded from DOE looking at the atomic structure of interfaces, doping, and Cottrell atmospheres in solar cell materials. This fall they are kicking off a \$4.5M DOE FPACE-II program with NREL to look at epitaxial CdTe with the ultimate goal of increasing efficiency to 24% by 2017.

Currently, the Lab has eight students working on a variety of projects from grain boundary chemistries in oxides to solar cell semiconductor interfaces to NIST-grown GaN nanowires to drawn steel wire. They also are using the new FIB to its limits. Finally, congratulations to Dr. Melissa Teague (staff at INL) and Dr. Harvey Guthrey (staff at NREL) who recently graduated from the group!

Electron Microscopy Laboratory

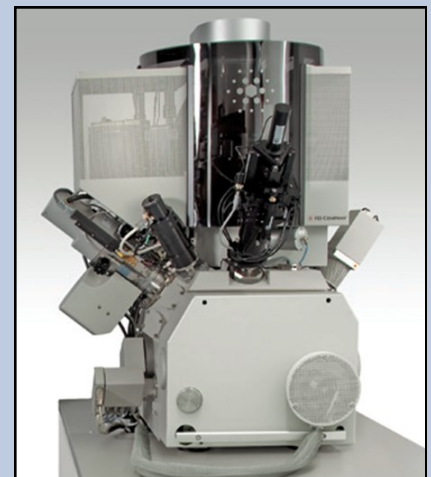
Prof. Michael Kaufman, Director
<http://inside.mines.edu/MME-Electron-Microscopy-Laboratory>

The Electron Microscopy Laboratory (EM Lab) continues to expand both its equipment and its user base. Most recently, three Mines faculty (Professors Kaufman, Gorman, and Kee) received a grant from the Office of Naval Research through the Defense University Research Instrumentation Program and acquired an FEI Helios NanoLab 600i Advanced Dual-Beam Instrument. This is a dual column instrument consisting of a Focused Ion Beam Column and a Field Emission Scanning Electron Microscope Column and is capable of ultra-high resolution imaging, analysis, and fabrication at the nanoscale. It is a

multi-purpose tool that will support the large research portfolio that exists both within and external to MME. This tool has been instrumented with an Omniprobe nanomanipulator, an x-ray energy dispersive silicon drift detector, an electron backscatter diffraction detector, and a STEM detector and is already being heavily used across campus and beyond. This combined with the new NSF-funded 3D atom probe acquired by Prof. Gorman has enabled MME and Mines faculty to be quite competitive in their research proposals. Faculty are working hard to upgrade the TEM facilities and are hopeful that this will happen in one of the upcoming equipment competitions.

In addition to the Helios, the EM Lab continues to train many users in

MME across campus. The total usage of the equipment has increased considerably and is commensurate with the growing research portfolio of the department and the institution.



FEI Helios NanoLab 600i instrument recently acquired in the EM Lab at Mines.

Departmental Research Centers & Institutions

Advanced Steel Processing and Products Research Center

Prof. John Speer, Director
<http://aspprc.mines.edu/>

The Advanced Steel Processing and Products Research Center (ASPPRC) conducts research on bar, plate, and sheet steels, with membership from 30 companies represent major steel producers and users from North America and overseas. The Center continues to be active, now in its 30th year. Along with many student graduations in the past year or so (and corresponding arrivals of new students), there have been some changes in the professional staff. Prof. David Matlock, after 41 years, was awarded the prestigious rank of University Emeritus Professor at the commencement ceremony in May. Consequently, Prof. John Speer became the third Director of the Center, following Profs. Krauss and Matlock who founded the Center in 1984. Research Prof. Robert Cryderman also joined the staff to contribute to student programs in the bar steel and other areas, after serving many years as a sponsor representative. Drs. Radhankanta Rana and Singon Kong have recently joined the center as post-doctoral researchers, and Jiyao Hong and Hidenori Nako are visiting researchers from Baosteel and Kobe Steel, respectively.

Some recent notable accomplishments include the AIST Jerry Silver Award for Dr. Courtney Nowill's paper "Effect of Austenitizing Conditions on Hardenability of Boron-Added Microalloyed Steel," originally presented at the International Symposium on the Recent Developments in Plate Steels and the SAE Syd Melbourne Award for Prof. Emmanuel De Moor's paper "Comparison of Hole Expansion Properties of Quench and Partitioned, Quench and Tempered, and Austempered Steels." ASPPRC Alumna Dr.

Amy Clarke also received the prestigious Presidential Early Career Award for Scientists and Engineers (PECASE) and enjoyed a trip to the White House to meet the President. Also notable are some recent proposal successes. The Center will be participating in a DOE-US Automotive Materials Partnership effort on Integrated Computational Materials Engineering for vehicle light-weighting with steel, quenching, and partitioning to replace hot-stamping (DOE Innovative Manufacturing program) and also received supporting sponsorship from Los Alamos National Laboratory on a DOE project related to nuclear steels.

Best wishes to the "extended ASPPRC family" from all of the faculty, staff, and students. For any further information, please contact Elaine Sutton at esutton@mines.edu.



Prof. David Matlock received a "steel sculpture" from Dr. Keith Taylor of SSAB NA on behalf of the sponsors in appreciation for his many years leading ASPPRC. The sculpture was created from a variety of steel test specimens used in student thesis projects.

Kroll Institute for Extractive Metallurgy

Prof. Patrick Taylor, Director
<http://kiem.mines.edu/>

The Kroll Institute for Extractive Metallurgy (KIEM) was established in 1974 as a Center for Excellence in extractive metallurgy. Since its inception, the Kroll Institute has provided financial support to both undergraduate and graduate students. KIEM strives



The spring 2013 senior design group working with Prof. Corby Anderson on pressure oxidation of molybdenite.

(Continued on page 5)

Departmental Research Centers & Institutions

Center for Welding, Joining, and Coatings Research

Prof. Stephen Liu, Director
<http://cwjcr.mines.edu/>

The Center for Welding, Joining, and Coatings Research (CWJCR) has been in existence since 1980 and has prepared generations of specialists for the welding and joining industries, government agencies, and academia. The Center counts on active participation of faculty members from several departments at Mines, namely, Metallurgical and Materials Engineering, Mechanical Engineering, Electrical Engineering, and Mining.

In addition to the core activities of CWJCR, it has two additional research thrusts. One is represented by the NSF sponsored Center for Integrative Materials Joining Science for Energy Applications (CIMJSEA) and the second is the Advanced Explosive Processing Research Group (AXPRO). While the NSF-CIMJSEA is a four university consortium with the Ohio State University, Lehigh University, and the University of Wisconsin-Madison, AXPRO is a



Prof. Stephen Liu with Dr. Hamad Almostaneer (Mines, 2011) at the First Saudi International Advanced Materials Technologies Conference in Riyadh, KSA sponsored by the King Abdulaziz City of Science and Technology.

Mines organization with expertise coming from the Mining Engineering and the MME Departments.

As usual, the CWJCR students and faculty had a very busy year with in-

ing of a new Critical Materials Institute (CMI) at CSM and have attracted research funding from the Office of Naval Research, Freeport MacMoran Copper and Gold, Newmont Mining, and several other mining companies. [See pg. 6 for an article on the new CMI.]

The KIEM faculty also teach several required courses for undergraduate students in MME (Thermodynamics, Chemical Processing and Lab, and Transport Phenomena and Reactor Design) and offer a full suite of graduate level courses in mineral processing, hydrometallurgy, pyrometallurgy, electrometallurgy, and iron and steelmaking.

volvements in several international and national conferences such as the International Institute of Welding Annual Assembly, the American Welding Society FabTech Program, MS&T, TMS, NACE, the Middle East Corrosion Conference, the International Brazing and Soldering Conference, the Microscopy and Microanalysis Conference, and the International Conference on Numerical Modeling of Welding.

The most exciting news is of course the addition of a new faculty member to CWJCR. Dr. Zhenzhen Yu from the Oak Ridge National Laboratory has accepted the position of Assistant Professor with the MME Department beginning January 2014. With expertise in joining and non-ferrous metallurgy, she will collaborate closely with CWJCR and CANFSA (Center for Advanced Nonferrous Structural Alloys). We welcome Zhenzhen to CWJCR and to the Department and look forward to a productive collaboration.

(Continued from page 4)

to provide: research expertise, well-trained engineers to industry, and research and educational opportunities to students in the areas of minerals processing, extractive metallurgy, recycling, and waste minimization.

In 2009 the faculty in KIEM (Profs. Patrick Taylor, Brajendra Mishra, and Corby Anderson) developed the highly successful NSF Industry University Consortia - Center for Resource Recovery and Recycling. This Center has funded several graduate students to develop new processing technology for recycling and waste minimization. In addition, the same faculty members were instrumental in the fund-

Departmental Research Centers & Institutions

Critical Materials Institute

Prof. Brajendra Mishra, Co-PI

<http://cmi.ameslab.gov/>

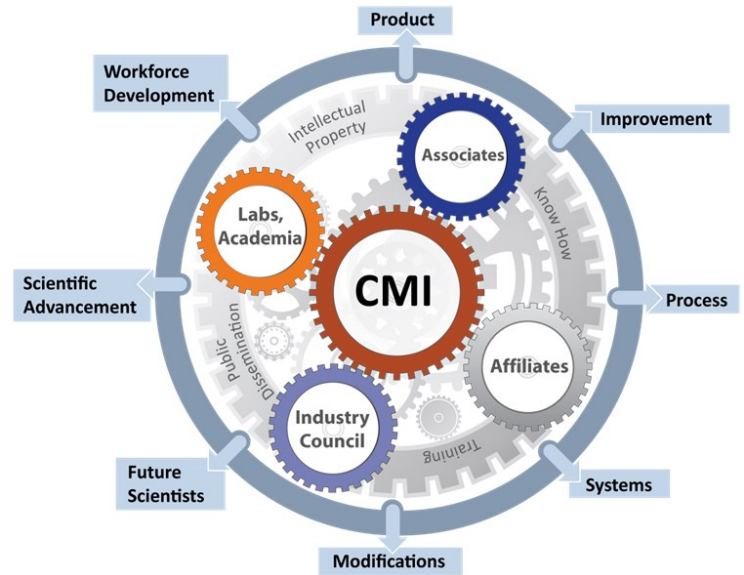
The multi-million dollar fifth and final energy hub of the US Department of Energy (DOE) was launched in June of this year with Ames Laboratory, Iowa, as the leading organization. This Critical Materials Institute (CMI) involves several other industrial partners, national laboratories, and academic institutions. A significant portion of the technical research activities are housed in the MME Department at CSM with Drs. Brajendra Mishra, Corby Anderson, and Patrick Taylor serving as principal investigators.

The CMI research activities at CSM fit into four focus areas of diversifying supplies, developing substitutes, improving reuse and recycle and cross-cutting research. The CSM MME facul-

ty and students are involved in developing elegant and smart processes for mineral beneficiation, metal production, and recycling and reuse of rare-earth containing permanent magnets and phosphor dust generated from fluorescent lights. The accomplishments of the institute will allow the US to develop indigenous resources for the select rare-earth elements and other strategic metals deemed critical by DOE.

MME faculty also work in collaboration with scientists from other or-

ganizations to provide technical support on other projects. For example, the CMI research activities that are embedded in the Kroll Institute for Extractive Metallurgy at CSM make use of the experience and extensive capabilities of the department.



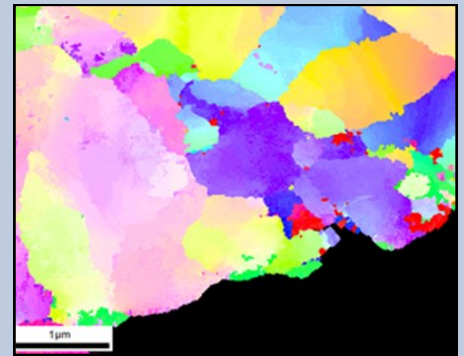
Center for Advanced Non-Ferrous Structural Alloys

Prof. Michael Kaufman, Director

<http://canfsa.unt.edu/>

The Center for Advanced Non-Ferrous Structural Alloys (CANFSA) is an Industry/University Cooperative

Research Center with an emphasis on conducting state-of-the-art research related to non-ferrous structural alloys. Established in 2011 by faculty at CSM and the University of North Texas, this Center is focused on combining computational modeling (various length and time scales) and experimental approaches (alloying, processing, and microstructure/property characterization) in order to advance industrially-relevant projects in an efficient and effective manner. The emphasis is on structural Al, Mg, Ti, and Ni-base alloys and their composites and on industries that develop, manufacture, and use these alloys.



TEM-based high-resolution orientation microscopy showing grain orientations and lattice rotation within each grain.

A primary goal of the center is to educate students in areas that have become increasingly rare in materials science and engineering departments around the country, namely, traditional physical metallurgy combined with computational modeling approaches.



Paul Rudnik from Plansee and MME graduate students Bo Wang and Logan Ward met during a CANFSA social in the Geology Museum.

Departmental Research Centers & Institutions

Renewable Energy Materials Research Science and Engineering Center

Prof. Craig Taylor, Director
<http://remrsec.mines.edu/>



A group of REMRSEC faculty and students along with Dr. John Poate, CSM vice-president for Research and Technology Transfer, attended the 2012 International School: Materials for Renewable Energy in Erice, Italy.

The Renewable Energy Materials Research Science and Engineering Center (REMRSEC) housed in the MME Department is an internationally visible and unique NSF supported MRSEC directed at fundamental materials research, education, and outreach efforts relating to renewable energy. The Center performs innovative and transformative research on materials for renewable energy applications, educates future workforce leaders in renewable energy sectors, and supports outreach efforts to the general public. The Center is committed to increasing the diversity of its students, staff, and faculty. The active participation of researchers from the National Renewable Energy Laboratory provides a strong and unique component that augments the Center's research efforts.

One of the REMRSEC research groups concentrates on materials of potential use in the next generation of photovoltaic devices. A second research group concentrates on advanced membranes for renewable energy applications.

Colorado Center for Advanced Ceramics

Prof. Ivar Reimanis, Director
<http://ceramics.mines.edu/>

The Colorado Center for Advanced Ceramics (CCAC) is a focal point for exciting technological developments in advanced ceramics. Ceramics are critical materials in a wide range of technologies in virtually all industrial sectors. The Center actively pursues ceramics research and education and serves as a national resource of expertise and facilities that industry can draw upon to make decisions on the synthesis, processing, and performance of advanced ceramics and composites. The Center educates materials scientists and engineers with the interdisciplinary skills necessary to design and manufacture the ceramic components and composites.

Current ceramics research includes membranes for gas separation, new fuel cell and battery materials, nanoionics, synthesis and properties of photovoltaic materials, atomic level manufacturing, transparent ceramic armor, fracture, and deformation of ceramics and composites. The Center recently hired Prof. Ivan Cornejo, a glass scientist from Corning, and he and his team have invented a new glass made entirely from food wastes.



Prof. Cornejo and Dr. Ramalingam pour glass made from organic food waste.



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SUPPORT MME

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

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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

