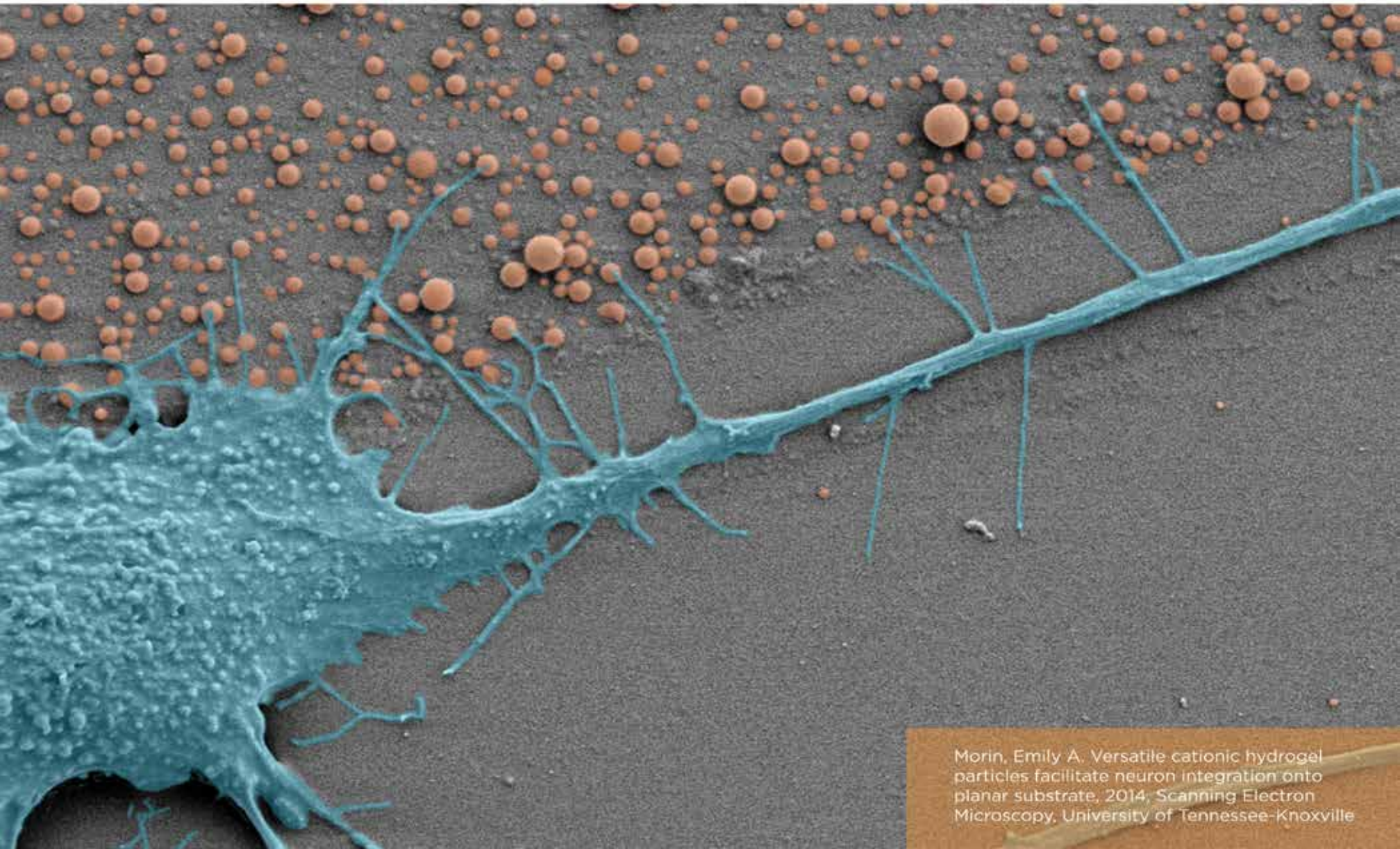
MATERIALS PROCESSING

2016 Annual Report



Morin, Emily A. Versatile cationic hydrogel particles facilitate neuron integration onto planar substrate, 2014, Scanning Electron Microscopy, University of Tennessee-Knoxville

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Center for Materials Processing
Annual Report 2016

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Chris Moore
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Special Thanks to
Michael Koehler, Ph.D.
CMP Undergraduate Reseach Coordinator

The information in this report reflects the time period from July 1, 2015 through June 30, 2016

Mission Statement

The Center for Materials Processing supports teaching and conducting basic and applied research emphasizing relationships between processing, structure on various scales, and properties of all classes of materials. This support improves existing processing and synthesis techniques, develops new materials and technologies, transfers improvements to the applied sector, and equips students to thrive in the broad field of materials science and engineering. The Center fosters interdisciplinary activities and establishes partnerships with industries and other institutions as appropriate.

THE UNIVERSITY OF TENNESSEE KNOXVILLE

CENTER FOR MATERIALS PROCESSING

Welcome from the CMP Director

Thank you for your interest and welcome to the Center for Materials Processing (CMP) Annual Report covering the period from July 1, 2015, to June 30, 2016. This year a second CMP Advisory Committee, made up entirely of industrial members, was formed to compliment the existing Advisory Committee. Along with the new Industrial Advisory Committee, the CMP Administration is working to establish various membership levels targeted to work with smaller, local companies. We are continuing our focus on funding graduate students and their research as well as building a strong and enthusiastic undergraduate research community. These activities relate directly to recruiting and retaining new talent in areas pertinent to materials processing. The annual report focuses on the students that are fully or partially funded by the CMP as well as the faculty that mentor these students. Other features in the CMP annual report include various partnerships with industrial members and updates on campus facilities that the CMP is helping to equip with state-of-art instrumentation.

Claudia J. Rawn

2016 General Center Operations

FY16 Expenditures

The Center for Materials Processing (CMP) is housed in the College of Engineering at the University of Tennessee and was established in 1985 as a "Center of Excellence" by the Tennessee Higher Education Commission (THEC). Its mission includes elements of fostering faculty research, educating students, and supporting the economic development of Tennessee, especially by helping to produce a highly competent and motivated STEM workforce for the state of Tennessee. Faculty mentoring of graduate and undergraduate students performing materials related research is the core of center activities and directly supports the CMP mission.

Studies in materials science establish the interrelationships among processing, structure, and properties of all classes of materials (ceramics, metals, and polymers). An understanding of these interrelationships guides the discovery and development of new materials that are the cornerstone of technological breakthroughs and improves the performance of existing materials. The CMP supports research in materials across the University of Tennessee, Knoxville campus. The CMP also supports both graduate and undergraduate students performing research within many of the College of Engineering (COE) departments as well as in the Scintillation Materials Research Center (SMRC) and the Manufacturing Demonstration Facility (MDF). The CMP has continued to support the continued efforts of the Tennessee Crystal Center (TennXC) for growing and providing crystals to a variety of researchers. The CMP also supports the recently-awarded NSF Industry/University Cooperative Research Center (I/UCRC) where the University of Tennessee has joined the Ohio State University, Lehigh University, and Colorado School of Mines as partners in the Manufacturing and Materials Joining Innovation Center (Ma^{2}JIC). The state-appropriated funds from THEC are matched by support from the Materials Science and Engineering Department as well as individual faculty from various industry and governmental agencies through industrial memberships, grants, and research contracts. An important feature of the matching funds is the cost sharing of facilities and administrative costs (indirect costs) by the University. The state-appropriated funds are used for the administrative costs of the CMP, "seed money" to initiate studies in new areas that have high potential for attracting external support, to assist new faculty members, and as matching funds for external support and equipment. Funding for faculty is often in the form of support for undergraduate and graduate research assistants.

A pie chart illustrating an approximate expenditure of funds, mostly supplied by THEC, confirms that graduate student support is the largest single expenditure (25%), reflecting the commitment of the CMP to supporting graduate students. The graduate student expenditures include salary, benefits, tuition, and some moderate supply support for the graduate students. Commitment to undergraduates performing research in materials processing related areas is shown by the research expenditures supporting 48 undergraduate research assistants and supporting the purchase of state-of- the-art instrumentation for the MSE undergraduate laboratories. Combining these expenditures with the graduate student support shows that almost half of the funds support students. In FY16, the CMP continued to support the Joint Institute for Advanced Materials (JIAM) X-ray Diffraction Core Facility through support for Dr. Maulik Patel and several undergraduates along with minor supplies including hardware and software for the X-ray diffraction instruments. No single person under the categories of CMP Administration and MSE Support Staff is supported more than 40% by the CMP. For these two categories, 95% and 100%, respectively, of the expenditures directly support salaries and corresponding benefits. Dr. Michael Koehler continues to be partially supported by the CMP for a variety of roles including coordinating the undergraduate research activities and the TennXC efforts. Expenditures (1%) supporting the new COE Innovation Collaboration Studio (ICS) appear for the first time this FY. Matching expenditures include support for various faculty activities and Scholarly and Research Incentive Funds (SARIF) for purchasing equipment. The Other category of expenditures includes support for student travel, poster printing, and instrumentation charges incurred by students using various facilities. One area of expenditures absent this year is the funding of Dr. Christopher Stephens and the Institute of Biomedical Engineering (iBME). Dr. Stephens left the University of Tennessee after accepting employment as a Medical Systems Engineer at TechMahl, LLC. Details of many of the expenditures outlined above are provided in the Technical Activities section of the CMP Annual Report.

Claudia J. Rawn

CMP Director

Dr. Claudia Rawn joined the Center for Materials Processing (CMP) in early January 2012 as the associate director and replaced Dr. Carl McHargue as the director in July of 2012 upon his retirement. This is Dr. Rawn's fourth year with the CMP and third CMP annual report.

Claudia Rawn received her B.Sc. in Materials Engineering from Virginia Polytechnic Institute and State University (Virginia Tech), her M.Sc. in Chemistry from George Mason University, and her Ph.D. in Materials Science and Engineering from the University of Arizona. Prior to starting her graduate studies, she worked as a materials engineer in the Ceramics Division of the National Institute of Standards and Technology (NIST) doing experimental phase equilibria studies. After obtaining her Ph.D., she moved to Ljubljana, Slovenia, and became a postdoctoral research associate in the Ceramics Department at the "Jožef Stefan" Institute where she used both solid-state techniques and single crystal growth to synthesize a variety of oxide materials as candidate materials for wireless communications applications. In addition to synthesizing the materials, she used X-ray and neutron powder diffraction data to determine details of the atomic structure and correlate those details with improvements of key physical properties. Dr. Rawn returned to the United States and joined the Materials Science and Technology Division (MSTD) at Oak Ridge National Laboratory (ORNL) as a postdoctoral fellow of the Oak Ridge Associated Universities (ORAU). She was promoted to a research staff member and senior research staff member during her years at ORNL. In 2001, she became a joint faculty member with the Department of Materials Science and Engineering (MSE) at the University of Tennessee, Knoxville. In December of 2013, Dr. Rawn retired from Oak Ridge National Laboratory and began concentrating all of her efforts at the University of Tennessee as an associate professor in the Materials Science and Engineering Department and director of the Center for Materials Processing.

Since joining the MSE Department, she has taught Introduction to Materials Science and Engineering, X-ray Diffraction and Structural Characterization of Materials, Principles of Ceramics, and is one of the original faculty associated with the Materials Processing course that was first introduced to the MSE Department in 2005. For the last four years, she has been an instructor for Tennesssee's Governor's School for Engineering. She is the Chair of the Undergraduate Affairs Committee in the MSE Department and is on the University of Tennessee's Undergraduate Research Advisory Committee. Dr. Rawn's research interests include investigations of crystal structures, phase transitions, and thermophysical properties of a variety of materials using in-situ X-ray and neutron scattering methods. She has co-authored over 90 technical publications. Dr. Rawn is a fellow of ASM International and served on the United States National Committee for Crystallography from January 2009 to December 2015, serving as secretary for the last three years. She is a member of several professional societies including ASM International, the American Crystallographic Association, the Neutron Scattering Society of America, and the American Ceramic Society. She has also held several positions in the Executive Committee of the Oak Ridge Chapter of ASM (ORCASM), including chairperson. Under her direction, ORCASM started hosting their local Materials Camps. In 2010, ORCASM started hosting Teacher Materials Camps, and she has served as co-chair for both the student and teacher materials camps since they began. Dr. Rawn is the director of the Research and Instructional Strategies for Engineering Retention (RISER) at the University of Tennessee that focuses on engineering retention through offering research opportunities and emphasizing engineering applications or mathematics. She is also the PI and site director of the UTK site of the Manufacturing and Materials Joining Innovation Center (Ma²JIC) funded by the National Science Foundation (NSF) and industrial memberships. In April 2016, Dr. Rawn was honored with the Nancy and Leon Cole Outstanding Teacher Award, an annual teaching award presented to an outstanding engineering faculty member in the UTK College of Engineering. The award has been awarded annually for over 20 years with the intent to reward outstanding teaching in engineering and to encourage teaching at a high level of excellence so future engineers have the necessary skills to solve the world's major problems.

CMP Supporting Staff

Karen Boyce is the financial specialist for the CMP as well as the Scintillation Materials Research Center (SMRC), the Reliability and Maintainability Center (RMC), the Center for Intelligent Systems and Machine Learning (CISML), and the Manufacturing and Materials Joining Innovation Center (Ma2JIC) University of Tennessee, Knoxville site. Ms. Boyce has been working within various university systems since 1995 and joined the University of Tennessee, Knoxville in June 2011.

Brandi Hayes was the administrative specialist for the CMP as well as the RMC starting in September 2013. In April 2016, Ms. Hayes left her CMP/RMC position to join the University of Tennessee Office of the Treasurer in the Accounts Payable Office as an accounts payable specialist specializing in the area of travel audits and direct billing.

Chris Moore is the communications specialist for the CMP and the RMC. Mr. Moore attended Middle Tennessee State University (MTSU) and joined the University of Tennessee, Knoxville in September of 2013.

Cory Simpson was the student assistant for the CMP from April 2012 to December 2015, at which point Mr. Simpson graduated from the University of Tennessee's College of Business with a degree in business administration.

2015 – 2016 CMP Advisory Committee Members

Established in early 2014, the CMP Advisory Committee works with the CMP Director to identify various areas of research that the CMP can advocate for and invest in for the future. In early 2016, a second CMP Advisory Committee, smaller in size and made up entirely of industrial members, was established. Both CMP Advisory Committees and the CMP Director work together with the goal of bringing positive recognition to the CMP, the College of Engineering, and the University of Tennessee in areas related to materials processing.

Dr. Khalid Alshibli
Professor – Civil and Environmental Engineering
College of Engineering
University of Tennessee, Knoxville

Dr. Sudarsanam Suresh Babu
UT/ORNL Governor,s Chair of Advanced Manufacturing
Professor – Mechanical, Aerospace, and Biomedical Engineering
College of Engineering
University of Tennessee, Knoxville

Dr. David Dietrich
Industrial Committee
Material, Process and Physics Engineering
Boeing Research and Technology

Dr. William Dunne
Associate Dean – Research and Technology
College of Engineering
University of Tennessee, Knoxville

Dr. Roger England
Industrial Committee
Director – Advanced Manufacturing Technology and Materials Engineering
Cummins, Inc.

Dr. Neal Evans
Industrial Committee
Senior Materials Scientist
Proton Power, Inc.

Dr. Charles Melcher
Director – Scintillation Materials Research Center
College of Engineering
University of Tennessee, Knoxville

Dr. Andrew Payzant
Engineering Materials Group Leader
Chemical and Engineering Materials Division
Neutron Sciences Directorate
Oak Ridge National Laboratory

Dr. George Pharr
Director – Joint Institute for Advanced Materials
Professor – Materials Science and Engineering
College of Engineering
University of Tennessee, Knoxville

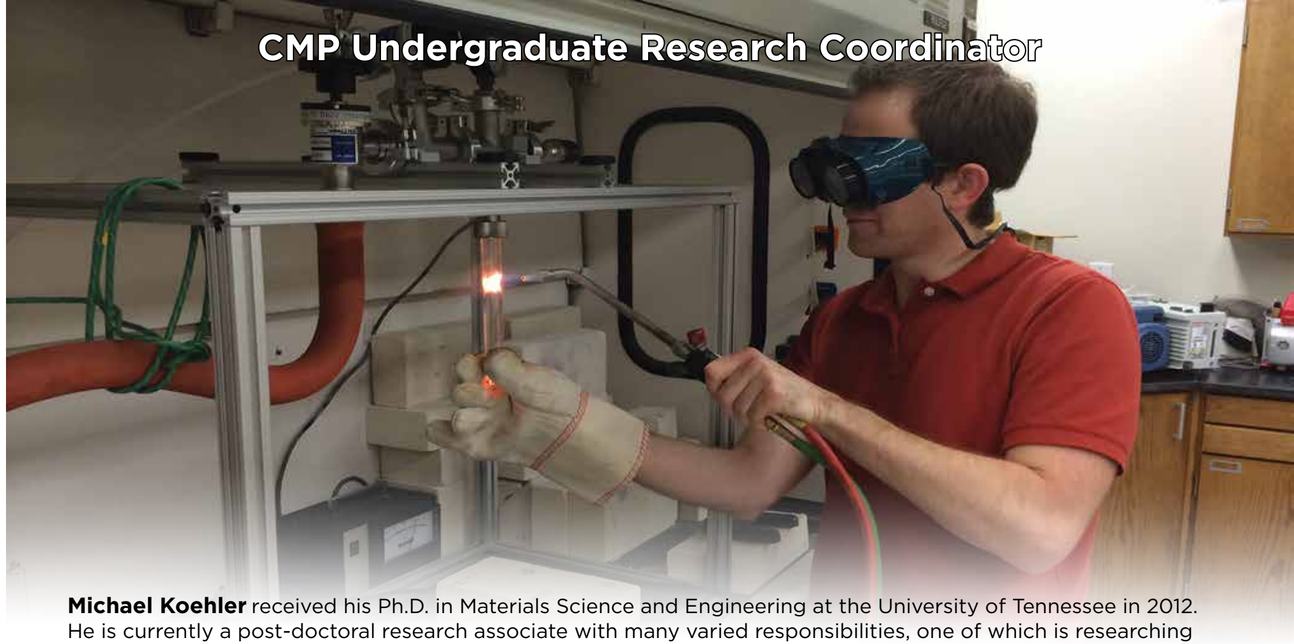
Dr. Kurt Sickafus
Professor – Materials Science and Engineering
College of Engineering
University of Tennessee, Knoxville

Mr. Trevor Toll
Industrial Committee
Research Engineering Analysis and Measurement Services (AMS) Corporation

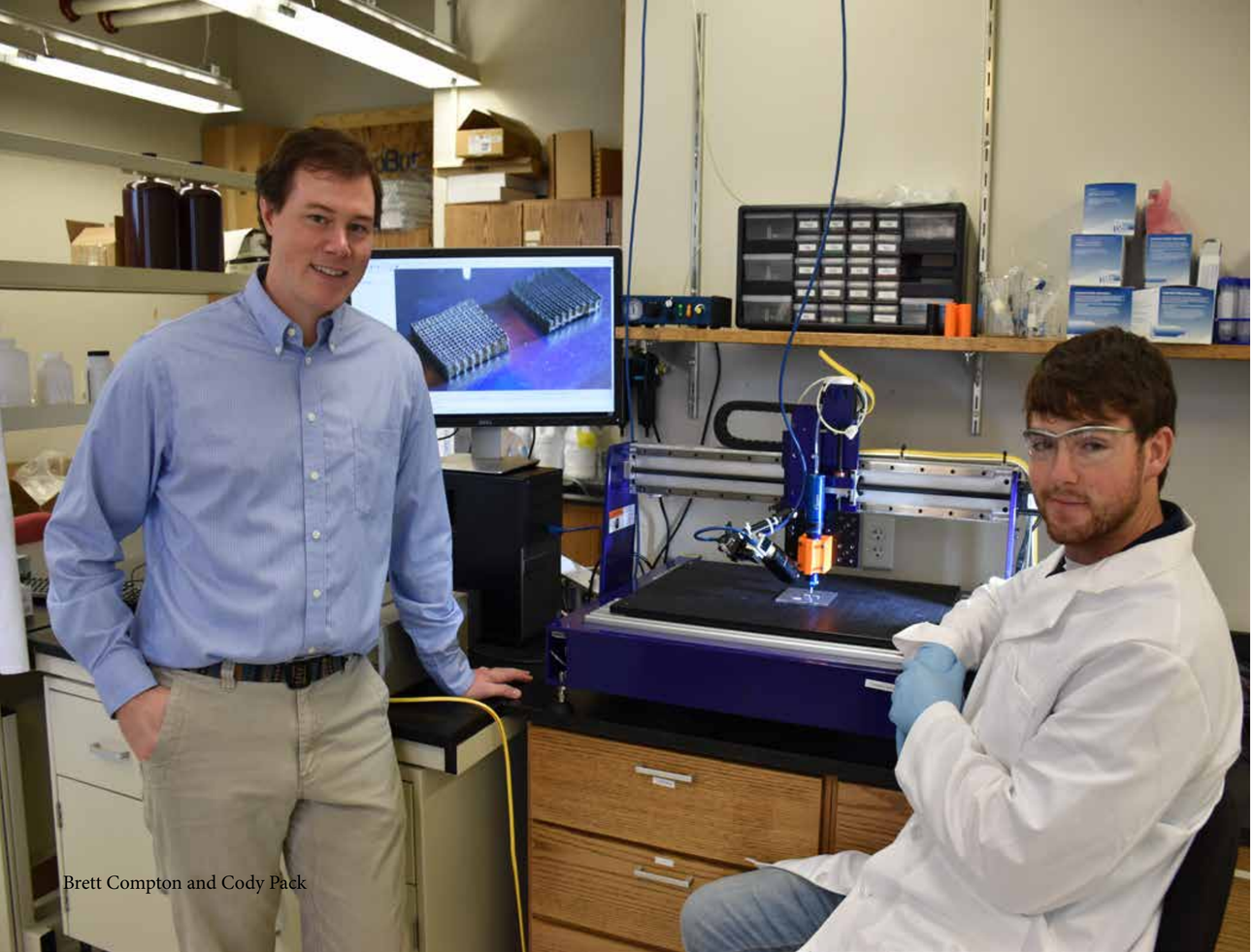
Dr. Peter Tortorelli
Acting Director – Materials Science and Technology Division
Physical Sciences Directorate
Oak Ridge National Laboratory

Dr. Steven Zinkle
Governor's Chair for Nuclear Materials
Professor – Nuclear Engineering
College of Engineering
University of Tennessee, Knoxville

CMP Undergraduate Research Coordinator



Michael Koehler received his Ph.D. in Materials Science and Engineering at the University of Tennessee in 2012. He is currently a post-doctoral research associate with many varied responsibilities, one of which is researching crystal growth with Dr. David Mandrus and the Tennessee Crystal Center (TennXC), an organization that grows crystals and licenses them to universities around the world. In addition to crystal synthesis, Dr. Koehler's work at TennXC includes customer support and sales. Dr. Koehler also serves as Undergraduate Research Coordinator for the CMP. In this capacity, he works to match undergraduates interested in performing research relating to materials processing with faculty with similar interests and capabilities. During the summer, Dr. Koehler organized the annual end-of-summer poster competition hosted by the CMP. Following the poster competition, he coordinated and accompanied the four winners on a CMP-funded trip to the National Conference on Undergraduate Research (NCUR) at the University of North Carolina at Asheville in April. He is frequently asked to present his seminar on "Creating Publication Quality Graphics and Tables," drawing off of his previous experience as the GTA for the MSE writing communication course for many years. Dr. Koehler also offers his excellent communication skills by helping to edit the CMP Annual Report.



Brett Compton and Cody Pack

Faculty Spotlight

Prof. Brett Compton

When you look very closely at natural materials, you'll see complex material architectures that simultaneously perform multiple functions necessary to the life of the organism. For example, the porous, cellular structure of wood enables the efficient transport of nutrients between the roots and the leaves, while the spatially-graded and highly directional organization of the cells provides mechanical integrity where it is needed most and with minimal weight penalties to the growing tree. Similarly, the complex, multi-layered, multi-component, porous architecture of skin enables it to act as a protective barrier to the harsh elements of the outside world, a temperature regulator to keep the body functioning properly, and an active sensing and damage detection system. Such integrated multi-functionality is highly desirable in engineering materials and structures but has largely been impossible with today's processing and fabrication technologies. Dr. Brett Compton, an assistant professor in the Mechanical, Aerospace, and Biomedical Engineering (MABE) Department at UTK, is working to make such multifunctional hybrid materials a reality through additive manufacturing (AM).

Additive manufacturing is the incremental deposition of feedstock materials to building components from the ground up. This incremental build process enables components to be built with unprecedented geometric complexity and function. Although several different AM technologies exist, Prof. Compton primarily uses material extrusion AM, also known as robocasting or direct ink writing, to build and characterize multifunctional hybrid materials and composites inspired by natural materials. Material extrusion AM affords the greatest flexibility in material feedstocks – from ceramic and metal particle-based inks, to compliant rubbers and gels, to high-strength fiber-reinforced polymer composites – but requires sophisticated processing techniques to transform a desired material into a viscoelastic, shear thinning fluid with the proper rheological characteristics for deposition.

With the support of the CMP, Prof. Compton is pursuing this research through several graduate and undergraduate projects in his laboratory. Students get hands-on experience with cutting edge additive manufacturing and material processing equipment while they learn about colloidal science, mechanical design, material characterization, and multifunctional composite materials. Specific areas of activity include novel bio-inspired ceramic-metal composites for stronger, more robust bone implants, longer lasting cutting tools and brake rotors, and more effective armors; graded lattice materials with tailored vibration damping and vibration sensing for lightweight, smart structures such as high efficiency wind turbine blades, aerospace structures, and vehicle armors; and the development of preceramic polymer feedstocks to enable near net shape additive manufacturing of high temperature ceramic composites for use in aerospace propulsion applications.

Center for Materials Processing Partnerships

Oak Ridge National Laboratory (ORNL) is managed by UT-Battelle, LLC, a limited partnership between the University of Tennessee and Battelle Memorial Institute. Within the College of Engineering and especially within the Department of Materials Science and Engineering (MSE), many of the faculty members either have joint appointments between the two institutions or have strong research collaborations with ORNL. ORNL is home to several Department of Energy (DOE) Office of Science national scientific user facilities where UT faculty and their students conduct research, including the Spallation Neutron Source (SNS), the Center for Nanophase Materials Science (CNMS), and the High Flux Isotope Reactor (HFIR). In addition, contracts between ORNL and the CMP support several research faculty. Drs. Peter Tortorelli and E. Andrew Payzant from ORNL both serve on the CMP Advisory Committee.

The TennXC moved into its third year of growing crystals that can then be licensed to the scientific community. The majority of crystals are two-dimensional semiconductor crystals that have applications in areas of dry lubrication, energy storage, nitrogen monoxide sensors, and flexible electronics. An important aspect driving the interest in these crystals is the fact that they can be reduced down to incredibly thin layers of atoms and used to build nanoelectronic devices. This year has seen the addition of three new two-dimensional crystals added to the previous four crystals available for licensure, and eight additional crystals are currently under development. Dr. Michael Koehler handles the TennXC daily activities including marketing efforts, growing crystals, and interacting with customers.

The Materials Properties Council (MPC) and the Welding Research Council (WRC) are not-for-profit technical organizations that have provided long-term, ongoing support to CMP. MPC and WRC are each composed of technical committees whose members support a variety of research and development activities essential to writing technically based codes and standards concerning design, life assessment, safety, and reliability of pressure equipment. Essential to the respective activities of MPC and WRC is gathering technical data relevant to the performance of welded equipment in adverse environments and advancing welding and joining technology of new materials. The membership fees of MPC and WRC have for many years supported graduate and undergraduate research assistants in the Materials Joining Group (MJG) headed by Dr. Carl Lundin at the University of Tennessee.

Over the years, the MJG has provided MPC and WRC with information essential to alloy development and metallurgical failure assessments, especially in regard to the behavior of welds under adverse conditions and for the development of new alloys. Specifically, the goals of the many studies conducted have been to aid the petroleum, chemical and electric power industries in fabrication of welds and prevention of failures of pressure vessels and piping in high-temperature, high-pressure and hydrogen services. The metallographic procedures developed and studies conducted by the MJG enable better understanding of the factors that govern the mechanical properties, design and safety of high-pressure components used in power and process plants world-wide. Dr. Martin Prager, Executive Director of MPC and WRC, often visits the University of Tennessee, Knoxville campus to discuss the progress of the MJG research with Professor Lundin and the MJG graduate students.

Techmer Polymer Modifiers has continued into its second consecutive year as a CMP industrial member working with Dr. Gajanan Bhat at the Nonwoven Research Laboratory (UTNRL). Techmer PM is a leader in producing value-added masterbatch and engineered compounds for the plastics and fiber industries and works with consumers and industrial product manufacturers on achieving the finest color, texture, appearance, and functional enhancements for a variety of product applications. Their advanced additives improve products in areas such as antistatic materials, flame retardants, UV stabilizers, and color-matching. The company operates its largest production facility in Clinton, TN.

The Scintillation Materials Research Center (SMRC), located in the College of Engineering, is a unique facility dedicated to the research and development of new and innovative scintillator materials for radiation detection. The SMRC is one of the most active crystal growth groups located in a US university and synthesizes and characterizes a wide variety of scintillators, from high-density materials that are well-suited for application in the area of medical imaging to low-density materials well-suited for neutron detection. The SMRC is engaged in a wide range of research activities and boasts many capabilities, including materials purification, handling and processing hygroscopic materials, crystal growth, and a wide range of scintillation and physical characterization techniques. Dr. Chuck Melcher, Director of the SMRC, serves on the CMP Advisory Committee.

The Joint Institute for Advanced Materials (JIAM) joins the Joint Institute of Biological Sciences (JIBS), the Joint Institute for Heavy Ion Research (JIHIR), the Joint Institute for Neutron Sciences (JINS), and the Joint Institute for Computation Sciences (JICS) as the fifth UT-ORNL joint institute; however, the JIAM holds the distinction of being the only joint institute not housed on the ORNL campus but rather on UT's Cherokee Farm campus. The construction of the $30 million facility is nearing completion, and instrumentation and researchers began to occupy the building in phases beginning in December of 2015. As research activities begin in the JIAM facilities, the CMP will provide support through supporting graduate students performing their research at the JIAM as well as supporting staff to help run and maintain the state-of-the-art instruments that will be housed at the JIAM. The CMP supports the maintenance of the X-ray powder diffractometers that are currently housed in the Science and Engineering Research Facility (SERF) and will be moved to their new home in the JIAM in the near future. Research activities will focus on a variety of materials synthesis techniques and advanced characterization methods often requiring sensitive instrumentation and highly qualified personnel. Dr. Veerle Keppens became the JIAM Director earlier this year and has agreed to serve on the CMP Advisory Committee next year.

The CMP is located within the College of Engineering (COE) and endeavors to collaborate with all departments within the COE that undertake materials research. However, the mission of the CMP is closely aligned with activities pursued by the COE Department of Materials Science and Engineering (MSE), and many of the undergraduate and graduate research assistants supported by the CMP are MSE students. Additionally, the CMP partially supports several strategic technical staff members that assist many of the MSE faculty and students in the areas of safety, information technology, microscopy, electronics and machining. This support makes the partnership between the CMP and the MSE Department strong and productive for both parties. Dr. Veerle Keppens is the MSE Department Head in addition to being the JIAM Director.

Center for Materials Processing Partnerships

Will Hoskins

Will Hoskins, a senior at the University of Tennessee, chose the field of Materials Science and Engineering as a result of two characteristics that developed at an early age: a fascination with chemistry and the desire to answer the questions of "How?" and "Why?" materials and devices behave in the manner they do. Growing up in New Tazewell, Tennessee (a small, rural town in Northeast Tennessee), he has extensive hands-on experience with common materials problems. Questions such as "Why do certain metals oxidize while others do not?", "Why do many plastics become embrittled after long term environmental exposure?", "What, in some cases, causes only the welds to be corroded in welded structures?", and "What determines when a crankshaft will fail by fatigue?" were met with great fascination. When selecting a career, Mr. Hoskins wanted an education that would resolve these types of fundamental inquiries due to his realization that material processing, properties, principles, and problems are often key in engineering design. A design may be remarkable, but it may also be both impossible to realize and

likely to fail without the proper materials.

Mr. Hoskins is pursuing an honors degree in Materials Science and Engineering and is also in the Chancellor's Honors Program. From June 2014 until June 2016, he worked as an undergraduate research assistant in the Materials Joining Group (MJG) under the guidance of Dr. Carl D. Lundin. During his time working with Dr. Lundin, Mr. Hoskins' undergraduate research experience has been jointly funded by the Center for Materials Processing (CMP) and CMP Memberships (the Materials Properties Council and the Welding Research Council).

During his time in the MJG at the University of Tennessee, Mr. Hoskins has developed a vast knowledge of metallurgy and a diverse skillset pertaining to metallurgical investigations. His gained understanding is largely a result of the counsel and mentorship of Dr. Lundin, who is a renowned expert in the field of welding and physical metallurgy. Mr. Hoskins' research focused on metallurgical issues typically encountered in the petrochemical and steam power industries, primarily with regard to steel weldments. He has contributed to projects on high temperature hydrogen attack (HTHA) in low alloy steels, creep behavior of graphitized components, friction repair welding of graphitized components, and the creep behavior of the Type IV (fine-grained heat affected zone) region in Grade 91 steel (modified 9 Cr-1 Mo) weldments. While involved with these projects, Mr. Hoskins has become experienced in metallographic examination, including sample preparation, microscopy techniques (optical light microscopy, scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS)), microstructural interpretation, and mechanical testing.

During the summer of 2016, Mr. Hoskins participated in an internship with the Materials Joining Group at Oak Ridge National Laboratory (ORNL). His primary research focus during this time was ceramic brazing. He investigated the development of a brazing procedure to fabricate alumina-to-alumina brazements that can withstand high temperature service (≥800 °C) in a corrosive environment for periods in excess of a year. Mr. Hoskins is involved in a variety of activities, including the Materials Advantage Student Program managed jointly by ASM International; the American Ceramic Society (ACerS); The Association of Iron and Steel Technology (AIST); and the Minerals, Metals, and Materials Society (TMS). He is also active in the American Welding Society where he serves as the publicity Chair for the Northeast Tennessee Section. He has presented three technical talks and seven research posters. Notable awards include 1st place in the Structural Materials Division at the 2016 TMS Annual Meeting and Exhibition poster competition (travel supported by the CMP), 2nd place at the 2016 Exhibition of Undergraduate Research and Creative Achievement poster session, the Outstanding Junior Award for the Materials Science and Engineering Department at the University of Tennessee, and the Materials Technology Institute (MTI) Bert Krisher Memorial Scholarship.

This fall, Mr. Hoskins will continue to participate in undergraduate research with Dr. Lundin and the MJG at the University of Tennessee. He plans on graduating with his bachelor's degree in May of 2017 and is enrolled in the 5 year B.S./M.S. program in Materials Science and Engineering, which will be completed under Dr. Carl Lundin's guidance. Throughout his time at the University of Tennessee, he has received a thorough education balanced with invaluable experience through undergraduate research. Hoskins partially attributes his growth as an engineer to the hands-on experiential learning he has been participating in as an undergraduate researcher, which began as a summer intern funded by the CMP.

Theses and Dissertations

Eli Barlow
M.S., MSE

Computational and Experimental Studies of $Ca_{12}Al_{14}O_{33}$, Mayenite

In this study $Ca_{12}Al_{14}O_{33}$ [mayenite] is computationally modeled, synthesized, and compared to literature in order to build a knowledge base for the further study of this compound. It is hoped that this study of mayenite will lead to the development of a new transparent conductive oxide that uses earth abundant elements instead of rare earth elements. For this study, polycrystalline mayenite was synthesized using traditional solid-state synthesis techniques, and growth of a single crystal was then attempted. The VASP software package was then used to simulate the compound, both physically and electronically. The results of the simulation were then compared to various literature sources and were found to be in good agreement. This body of work will form the basis for another researcher to modify the chemistry in a virtual environment before synthesis.

Jeremy Tisdale
M.S., MSE

Study of Magneto-Optical Behaviors at a Ferromagnetic/Organic Semiconductor Interface

Organic materials have been widely studied for the last 20 years for in use photovoltaic applications. Organic photovoltaic materials have shown promising properties for solar cells, such as very low cost, flexibility, easy fabrication methods, etc. Although power conversion efficiencies for organic-based solar cells have exponentially grown in the last decade, up to about 13% in early 2016, it is still optimal to increase these efficiencies. In order to raise efficiencies, it is important to study the fundamental mechanisms inside organic materials that lead to photovoltaic properties. This thesis reports the magneto-optical effects on the p-type organic semiconductor, tetracene, from a ferromagnetic/semiconductor interface between thin films of cobalt and tetracene. Magnetic field effect measurements were used to study singlet fission inside tetracene and effects from cobalt on singlet fission in tetracene. When a thin layer of cobalt was added, two main effects were determined. Magnetophotoluminescence results gave evidence of spin interactions at the interface causing spin polarization at the surface of tetracene, reducing hyperfine interactions and increasing the density of inter-triplet states, resulting in net increases in singlet fission. Photoluminescence and absorption results gave evidence of electrical interactions at the interface causing electrical polarization at the surface of tetracene, increasing the electron phonon coupling of tetracene as well as quenching photoluminescence. It is proposed that these changes from the ferromagnetic/organic semiconducting interface can be furthered utilized in photovoltaic and transistor applications based on singlet fission materials and possibly other similar types of organic material-based devices.

Funded Graduate Students Center for Materials Processing

Bernadette Cladek is a new Ph.D. candidate working with Dr. Claudia Rawn in the department of Materials Science and Engineering at the University of Tennessee, Knoxville (UTK). Ms. Cladek is jointly supported by the Center for Materials Processing and the University of Tennessee's Chancellor's Fellowship. Prior to entering UTK, she received a B.F.A. in Crafts from the University of the Arts in 2011 and a B.S. in Ceramic Engineering with a minor in Chemistry from the New York State College of Ceramics at Alfred University in 2015. During Ms. Cladek's time at Alfred University, she participated in undergraduate research projects involving atomistic computer simulation, ceramic powder processing and characterization, and X-ray diffraction and scattering. While at Alfred University, she also participated in a co-op at Kohler Co. Ms. Cladek's research interests include crystallography and diffraction (both X-ray and neutron) techniques, and her graduate research is focused on using in situ neutron diffraction to investigate the decomposition of mixed-gas hydrates. She is interested in the effects of mixing gases, such as carbon dioxide with methane, on the temperature and pressure of decomposition. Natural hydrates are a potential source for methane and CO_2 sequestration. Ms. Cladek is currently assembling a hydrate-synthesis lab, which will be included in the new Joint Institute for Advanced Materials (JIAM) ceramics processing laboratory.

Maneel Bharadwaj is a Ph.D. candidate in the Department of Materials Science and Engineering at the University of Tennessee, Knoxville, with a concentration in Welding and Physical Metallurgy. Mr. Bharadwaj is currently working as a graduate research assistant/teaching assistant in the Materials Joining Group (MJG) under the guidance of Professor Carl D. Lundin. Mr. Bharadwaj moved to the United States from Nepal in pursuit of a higher education and received his bachelor's degree in Extractive Metallurgy from the University of Idaho in 2008. After exploring various employment opportunities, Mr. Bharadwaj joined the University of Tennessee, Knoxville, in 2011 to pursue his graduate research in Welding and Physical Metallurgy.

Mr. Bharadwaj received his master's degree in 2015 studying high temperature hydrogen related damage in carbon steel components to assist the American Petroleum Institute (API) and various petrochemical industries to establish safe design criteria for high pressure hydrogen atmospheres at elevated temperature. His committee members were Drs. Carl D. Lundin, Carl McHargue, and Hahn Choo. Prior to defending his master's thesis, Mr. Bharadwaj began his research on this Ph.D. research topic of graphitization in carbon steel, a common industry problem at elevated temperatures. This research will assist in providing remaining life service assessments of graphitized and repair-welded components. His research will provide information on the kinetics of graphitization for carbon and C-½ Mo steels for graphitization prediction. Mr. Bharadwaj intends to defend his Ph.D. during fall 2016.

Funded Graduate Students

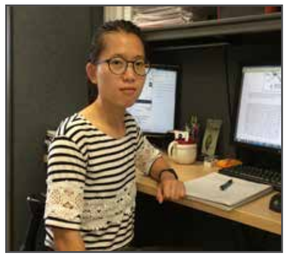
Mr. Bharadwaj, during his tenure at the Materials Joining Group (MJG), has been fortunate to work on multiple projects involving both ferrous and non-ferrous alloys. Additionally, he has worked on the development of toughness prediction factors, which correlate microstructure, mechanical properties, and chemical composition with toughness. The toughness prediction factors are of significant importance for engineers, manufacturers, and operators in making important decisions to repair, replace, or retire a vessel. This work was published in the Welding Research Council Bulletin (WRC 548). Simultaneously, he worked on HTHA damage examination in C-½ Mo steels and presented both studies in multiple conferences including WRC, the annual meetings of the Metals, Minerals, and Materials Society (TMS), the Association of Iron and Steel Technology (AIST), and ASM (MS&T'15). Mr. Bharadwaj was awarded third place in the annual poster competition cohosted by the Oak Ridge chapter of ASM and the Center for Materials Processing. In the future, he will be presenting his work on C-½ Mo steel at an International Hydrogen Conference in Moran, Wyoming, in September 2016. In past years, Mr. Bharadwaj also contributed to multiple projects involving Grade P91, CT15C (20Cr 32Ni 1Nb), and 6061-T6 aluminum alloy.

Mr. Bharadwaj has also worked as a teaching assistant for various courses including Introduction to Materials Science and Engineering, Materials Processing, Welding Metallurgy, Materials Selection and Design, and Materials Design. Last year, Mr. Bharadwaj worked as a teaching assistant for junior level MSE laboratories. Mr. Bharadwaj received a graduate student award at the 2016 annual MSE banquet recognizing his excellence in teaching. Apart from his class and research assignments, Mr. Bharadwaj has been actively involved with the local northeast Tennessee chapter of the American Welding Society (AWS). He served as an education committee chairman for the past three years, 2013-2016. Mr. Bharadwaj received an international scholarship award for 2015-2016 from AWS, and he will also be attending a leadership symposium in August 2016, hosted by the AWS.

John Bohling is a master's candidate in the Materials Science and Engineering program (metallurgy concentration) working with the Materials Joining Group (MJG) under the direction of Dr. Carl Lundin. Prior to receiving his B.S. degree in Materials Science and Engineering from the University of Tennessee in December 2010, Mr. Bohling worked in the MJG for several semesters as an undergraduate research assistant, culminating in an undergraduate thesis with Dr. Lundin entitled "Development of Optimum Welding Procedures for In Situ Weld Replacement for Main-Steam Piping."

While working in the MJG, Mr. Bohling has assisted with several undergraduate classes taught by Dr. Lundin, including Welding Metallurgy, Materials Processing, and the two-semester MSE senior course sequence Materials Selection in Design (required for obtaining a minor in MSE) and Materials Selection (the MSE Capstone course). Mr. Bohling's duties have included course organization and planning, proctoring and grading exams and reports, setting up laboratory sessions, and assisting the students with their group projects in areas including the planning of experiments, sample preparation, and microstructure analysis. In 2013, he received the MSE Departmental Student Award for Excellence in Service in recognition of his efforts. Mr. Bohling's research in the Materials Joining Group has centered on the investigation of cracking issues in a 20Cr-32Ni-1Nb heat-resistant austenitic stainless steel casting alloy (ASTM A351 Grade CT15C). This alloy is used for large-section (2-3" wall thickness) gas transfer line components in hydrogen reformers, operating at temperatures up to 1600 °F. Weldability problems with this alloy have been reported during repair welding of service-exposed material, principally as the occurrence of cracking in the base metal heat-affected zone (HAZ). Weld deposit cracking in previously trouble-free weldments after extended time in service has also been reported. Investigation of the cracking mechanism using material provided by an industry sponsor is ongoing. Microstructural evaluation of the as-received material has been performed, and the hot cracking susceptibility of the as-received material has also been evaluated using hot ductility testing. This test method utilizes the MJG's Gleeble 1500D, a high temperature/high strain rate thermal-mechanical simulator capable of reproducing the time-temperature profile of a welding thermal cycle. Current research is focused on completing microstructural characterization of the hot ductility samples to investigate the metallurgical basis for the observed trends in the hot ductility behavior. Mr. Bohling gave a presentation on his CT15C research at the April 2015 meeting of the Welding Research Council High Alloys Committee held in Knoxville, TN, and hosted by the MJG. Mr. Bohling passed his Ph.D. qualifying exams in the summer of 2014. He plans to defend for his master's degree later in the summer of 2016, after which he intends to continue research on 20Cr 32Ni 1Nb for his Ph.D. degree.

Center for Materials Processing



Shuying Chen is a third year graduate student in the Materials Science and Engineering (MSE) Department at the University of Tennessee, Knoxville (UTK). Prior to joining UTK, Ms. Chen studied the mechanical properties of the refractory high entropy alloy (HEA) AlxNbTiMoV at the University of Science and Technology in Beijing, China, receiving her Master of Science degree in 2014. Ms. Chen's research is mainly focused on the serrated flow mechanism and fatigue behavior in $Al_{0.5}$CoCrCuFeNi and TaNbHfZrTi HEAs under the direction of Prof. Peter Liaw. The temperature and strain rate effects on the compression, tension, fracture stress, and creep-life experiments are currently being investigated to establish statistical models for serration behaviors in $Al_{0.5}$CoCrCuFeNi HEAs. Excellent fatigue properties of the refractory TaNbHfZrTi HEA have been observed during cyclic loading experiments. Characterization tools, including scanning electron microscopy (SEM) with electron backscatter diffraction (EBSD), transmission electron microscopy (TEM), atom probe topography (APT), and high-energy synchrotron X-ray diffraction and neutron diffraction, are being employed for studying phase transformations and determining details including nano-particles, twinning, and interactions of dislocations within the HEAs. These characterization studies combined with computer modeling could potentially ascertain in-depth mechanisms for plastic deformation and precursors to fracture of serrations within these application-attractive materials. Ms. Chen presented some of her recent research results at the TMS 145th annual meeting and exhibition held in Nashville,

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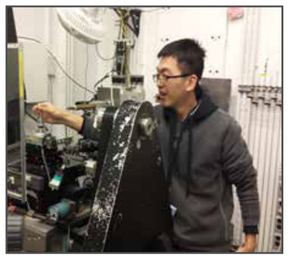
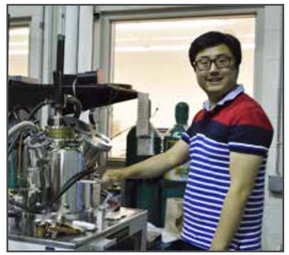
TN, in February 2016. She also shared her research during one of the UTK MSE departmental seminars.



Peijun Hou joined Dr. Hahn Choo's research group as a Ph.D. candidate in the Department of Materials Science & Engineering at the University of Tennessee, Knoxville (UTK), in August 2014. Prior to coming to UTK, Mr. Hou received his Bachelor of Engineering in civil engineering in 2009 and his Master of Science in engineering mechanics in 2014 from Dalian University of Technology, China.

At UTK, Mr. Hou's research is focused on fluid dynamics modeling of the dynamic recrystallization processes in Mg alloys during friction stir processing. Additionally, he is currently working on an industrial project involving the investigation of texture development and phase transformation in stainless steel alloys when manufactured by deep drawing process. Specifically, Mr. Hou is studying the effects of the resulting distribution of residual stresses in deep drawn cups on delayed cracking. For this investigation, he is obtaining experimental in-situ synchrotron X-ray diffraction data at Advanced Photon Source (Argonne National Laboratory) and neutron diffraction data at the Spallation Neutron Source (Oak Ridge National Laboratory).



Chanho Lee is a second year graduate student in the Department of Materials Science and Engineering at the University of Tennessee, Knoxville (UTK). He previously received his M.S. from the Department of Materials Science and Engineering (MSE) at Sejong University in Korea. His studies there focused on the effects of additional elements on the microstructure and mechanical properties of Ti-Fe ultrafine eutectic alloys, and he published four author and co-author papers and received one patent associated with his master's research.

Since joining the UTK MSE Department in 2014, Mr. Lee has been working on studying the microstructure evolution and associated mechanical properties of high-entropy alloys (HEAs) under the guidance of Prof. Liaw. Mr. Lee has excelled in the fabrication of metal alloys such as HEAs and bulk metallic glasses (BMGs) using arc-melting suction casting equipment. He is currently conducting neutron diffraction studies on the VULCAN (engineering materials diffractometer) and NOMAD (Nanoscale-Ordered MAterials Diffractometer) instruments at the Spallation Neutron Source (SNS) located at Oak Ridge National Laboratory (ORNL) for a detailed understanding of the phase transformations and mechanical mechanisms. Mr. Lee is using additional characterization tools including scanning electron microscopy (SEM), transmission electron microscopy (TEM), and electron backscatter diffraction (EBSD) to examine the microstructural evolution of the HEAs he fabricates. He is also obtaining nano-scale microstructural information using atom probe tomography (APT) at the Center for Nanophase Materials Science

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(CNMS) at ORNL. The goal of linking the fabrication with details of the resulting micro- and nano-structure of the HEAs is to further develop novel advanced materials with superior mechanical properties.

Seth Lawson is a Ph.D. student in the Materials Science and Engineering (MSE) Department at the University of Tennessee, Knoxville (UTK). Mr. Lawson is currently working as a graduate research assistant in the Radiochemistry Center for Excellence under the guidance of Professor Thomas T. Meek. A Knoxville native, Mr. Lawson began studying MSE in 2001 at UTK, working as an Undergraduate NSF-IGERT Intern from 2004 to 2005 before receiving his B.S. and commission as an officer in the United States Air Force in 2006. His undergraduate research involved compression testing of zirconium-based bulk metallic glasses. Lt. Lawson served as Space and Missile Officer as a member of the 12th Missile Squadron at Malmstrom AFB, providing command and control as part of a team responsible for 50 Minuteman III intercontinental ballistic missiles. In 2011, Mr. Lawson returned to UTK and the MSE Department as a teaching assistant for the undergraduate introduction to MSE laboratory, acting as instructor and grader for a section of 16 undergraduate MSE students. Additionally, he began work with Oak Ridge National Laboratory (ORNL) as a master's student under the direction of Dr. Easo George in the Alloy Behavior and Design Group as part of the Radioisotope Power Systems Program. Mr. Lawson received his M.S. in the spring of 2015 with his report titled "Effects of Silicon on the Microstructure and High Strain Rate Tensile Impact Properties of Iridium Alloys." Additional research was conducted into the effects of high-temperature aging on these iridium alloys as a part of the Oak Ridge Institute for Science and Education (ORISE) program in the summer of 2015. Currently, Mr. Lawson is pursing his Ph.D. studying the fabrication of uranium-based semiconductors as part of an effort for the Defense Threat Reduction Agency (DTRA) to design direct-conversion neutron detectors for counter-weapons of mass destruction (WMD) applications. Mr. Lawson presented a poster on July 20, 2016, at the DTRA Basic Research Technical Review titled "Fabrication and Microstructure of Sintered U3O8 Pellets." Mr. Lawson will present additional work at the American Vacuum Society's (AVS) 63rd International Symposium & Exhibition in November 2016 under the working title of "Dependence of Electrical Conductivity on Observed Microstructure of Sintered U_3O_8" and he will present a poster for the TMS 2017 146th Annual Meeting and Exhibition titled "Characterization of the Stoichiometry of Sintered Depleted U_3O_8 using Automated Cerimetry."

Tingkun Liu is a second year graduate student in the Materials Science and Engineering (MSE) Department at the University of Tennessee, Knoxville. Mr. Liu previously received his M.S. from Beijing Institute of Technology in 2013. While obtaining his master's degree, Mr. Liu worked on micro mechanical properties of single crystal alloys and residual stress measurements in metallic materials using X-ray diffraction. Mr. Liu worked as an assistant researcher in Shanghai Synchrotron Radiation Facility, Shanghai Institute of Applied Physics in 2013 and 2014 and

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continued his research on residual stress measurements using synchrotron X-ray diffraction.

After joining Prof. Yanfei Gao's group, Mr. Liu is focusing on the experimental and computational studies on mechanical behaviors of metallic alloys and bulk metallic glasses (BMGs). In his simulation study, finite element crystal plasticity analysis has been conducted to study the evolution of lattice strain under uniaxial loading in a representative volume element (RVE) using the commercial software package ABAQUS. In the spring of 2016, Mr. Liu served as a graduate teaching assistant for the undergraduate course "Introduction to Materials Kinetics Transformation Phenomenon." Additionally, Mr. Liu participated in a research project at Oak Ridge National Lab (ORNL) that focused on studying the deformation behaviors of high entropy alloys (HEAs). The complete texture of a NiFeCoCrMn HEA after plastic deformation was measured by neutron diffraction at the Spallation Neutron Source (SNS). Electron back-scattering diffraction (EBSD) was used to investigate the microstructure and gain orientation changes during plastic deformation. Future research will concentrate on the relationship between the mechanical properties and structure in BMGs.

Emily Morin is a fifth year doctoral student in the Department of Mechanical, Aerospace, and Biomedical Engineering (MABE) at the University of Tennessee, working under the guidance of associate professor Dr. Wei He. She graduated from the University of Tennessee in 2012 with a B.S. in Biomedical Engineering. Her dissertation research investigates versatile and responsive sub-micron sized hydrogel particles as nanostructured neural interfaces, for the goal of improving the functionality and longevity of neural devices. A publication of some of her research can be found in the American Chemical Society's Applied Materials & Interfaces from February 2016. Ms. Morin has presented her research at conferences such as the Biomedical Engineering Society and the Society for Biomaterials.

Ms. Morin employs several techniques to characterize the hydrogel particle modified material surfaces and investigate subsequent cell-surface interactions.

She particularly enjoys exploring cell-substrate interaction with the scanning electron microscope (SEM) as it allows her to see the beauty of cell adaptability towards her synthetic hydrogel particle coated surfaces. Her colored SEM images of neuron and macrophage cells on such surfaces earned her first place in the UTK Biomedical Engineering Society's biophoto contest (2014) and the cover image of MaterialsUT, the UTK Materials Science and Engineering annual departmental newsletter (2015).

Ms. Morin places a high importance on fostering scientific education and research interest in underrepresented minority students. She mentored and helped develop research projects for a female engineering Haslam Scholar's final thesis project and for two female high school seniors as part of their high school's unique independent research class. Along with the UTK Graduate Association of MABE Engineers, she develops and participates in science lectures and activity outreach programs for elementary and middle schools.

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Cody Pack is currently a Ph.D. candidate in the Department of Materials Science and Engineering at the University of Tennessee, Knoxville (UTK), working under the direction of Dr. Brett Compton. Mr. Pack received his B.S. in Chemistry from Lincoln Memorial University (LMU) in Harrogate, TN. While at LMU, he gained his first research experience in the area of polymer formulation and production for removal of heavy metals from water supplies. Prior to starting his graduate studies at UTK, Mr. Pack spent a year at Oak Ridge National Laboratory (ORNL), investigating the use and applications of strategic and critical materials in the National Stockpile.

In the fall of 2014, Mr. Pack received his Master of Science degree in Materials Science and Engineering with his thesis, "Protective Coating of Titanium Diboride Reinforcement Particulates for Improvement of Titanium Metal Matrix Composite Armor Systems." During the summer of 2015, he interned at the Manufacturing Demonstration Facility (MDF) at ORNL, where he gained experience in additive manufacturing (AM) of ceramics and polymer composites. His current research focuses on the processing, fabrication, and characterization of ceramic/metal composites with novel architectures, enabled by direct ink-write (DIW) AM technology. Such composites may enable patient-specific bone implants with superior strength and biocompatibility, longer-lasting brake pads with tailored heat flow paths and cooling channels, and more effective armor materials.

During the 2015 – 2016 academic year, Mr. Pack served as a graduate teaching assistant for the senior-level course on biomaterials and the junior-level Principles of Materials Laboratory. In previous summers, Mr. Pack has assisted with the Materials Teachers Camp, hosted by the Oak Ridge Chapter of ASM, and served as a mentor for local high school students attending the annual Materials Camp.

Stephen Puplampu is enrolled in the Ph.D. program in the Civil and Environmental Engineering (CEE) Department at the University of Tennessee, Knoxville (UTK). He is a graduate research assistant (GRA) working with Professor Dayakar Penumadu. Mr. Puplampu received his B.Sc. in Physics from the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi, Ghana, in 2008 and stayed as a teaching assistant until 2009. Mr. Puplampu started his graduate studies at UTK in the spring of 2012 and has been investigating mechanical properties of structural marine aluminum alloys and the effects of thermal stresses on these alloys. He has performed neutron diffraction measurements on bulk materials to better understand the anisotropic lattice plane response to mechanical loading. A majority of the neutron diffraction experiments were carried out at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) using the Neutron Residual Stress Mapping Facility (NRSF2) instrument. Similar experiments were conducted at the E3 instrument at the Helmholtz Zentrum Berlin (HZB) in Berlin, Germany. Mr. Puplampu has experience with other techniques such as time-of-flight (TOF) diffraction

Funded Graduate Students

(experiments conducted on the VULCAN engineering materials diffractometer at the Spallation Neutron Source (SNS) at ORNL) and three-dimensional imaging with X-ray and neutron tomography. Dr. Penumadu's and Mr. Puplampu's collaboration with Professor Larry Taylor and his group from the UTK Department of Earth and Planetary Sciences on the study of the internal texture of diamondiferous eclogites provides an example of the use of 3D imaging techniques. Another example is the investigation of stress-induced damage in an aluminum alloy of structural interest. During the fall of 2014, Mr. Puplampu worked as a teaching assistant for the graduate class Finite Element Applications for Engineering under the direction of Dr. Timothy Truster.

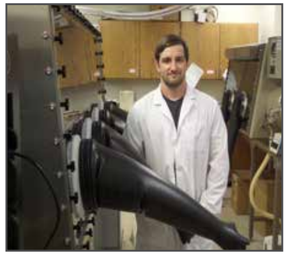
John Salasin is beginning his third year as a graduate student in the department of Materials Science and Engineering (MSE), and he has been partially supported by the CMP since August 2014. He received his bachelor's degree in Physics with a nano-manufacturing concentration from Shippensburg University. Mr. Salasin also completed a certification in nano-manufacturing and fabrication from the Penn State University in 2012.

Mr. Salasin became acquainted with the MSE department during the summer of 2013 while participating in a Research Experience for Undergraduates (REU) site funded by the National Science Foundation (NSF) and hosted by the MSE department. The REU site was directed towards projects fitting within the areas related to the synthesis and characterization of advanced functional materials, and Mr. Salasin's research focused on synthesizing layered double hydroxides for magnetic applications. The next summer, Mr. Salasin participated in the Higher Education Research Experience (HERE) at Oak Ridge National Laboratory (ORNL) learning how to collect and analyze low temperature single crystal neutron and x-ray data for determining structural details of thermoelectric materials derived from natural analogs. Data were collected on instruments at the Spallation Neutron Source (SNS) and the High Flux Isotope Reactor (HFIR).

Mr. Salasin's broad research interests include energy materials focusing on synthesis of novel thermoelectrics, battery materials, and anion-exchange media. He has actively served as a mentor for some of the Research and Instructional Strategies in Engineering Retention (RISER) program's Undergraduate Research Assistants (URAs). He mentored one student in the synthesis laboratory and two RISER URAs during the summer of 2015, helping them navigate synthesis-focused research projects from the first step of safety training to the final step of presenting their research as posters. Together with the RISER URAs, Mr. Salasin is exploring synthesizing doped calcium aluminate nanocages via sol-gel and hydrothermal processes in an attempt to increase electrical conductivity through induced cage disorder.

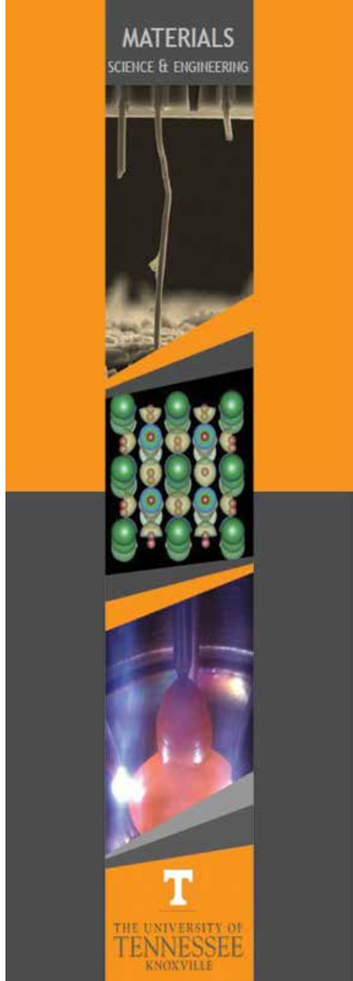
In addition to his research, Mr. Salasin is currently building a high pressure/temperature synthesis laboratory that will be implemented into the new Joint Institute for Advance Materials (JIAM). His research also demands that he use high density samples for physical property measurements, so he is activly using a uniaxial high pressure/high temperature press for consolidation of samples. Another source of funding for Mr. Salasin's receipt of a 2014-2015 College of Engineering's ESPN Fellowship provided another source of funding. In the fall of 2015, he also served as one of the teaching assistants for the senior/graduate level course offered on characterizing materials using X-ray powder diffraction.

Funded Graduate Students



Jeremy Tisdale is a third year Ph.D. student in the Materials Science and Engineering Department at the University of Tennessee, Knoxville (UTK). Mr. Tisdale previously received his Bachelor of Science and Master of Science from the Materials Science and Engineering (MSE) Department at the University of Tennessee in 2013 and 2016, respectively. His master's research focused on magneto-optical behaviors at ferromagnetic/organic semiconductor interfaces. With the recent explosion of interest in lead halide perovskites, Mr. Tisdale is focusing his Ph.D. research under the guidance of Dr. Bin Hu on the study of magnetic field effects on organic and organic-inorganic hybrid materials, such as lead halide perovskites (a well-known class of materials). Photoluminescence, time-dependent photoluminescence and magneto-resistance are a few of the experimental techniques Mr. Tisdale is utilizing to study magnetic field effects. Mr. Tisdale is also focusing on photovoltaic applications and fundamental studies for organic and organic-inorganic hybrid systems. These studies include finding ways to improve the power conversion efficiency of devices from device design and understanding the fundamental physics of photovoltaic devices. Recent work in this area, specifically on singlet fission in organic materials, is on track to be published soon.

Mr. Tisdale has also been a co-author on several recently published journal articles in his research group, including studies focused on the Seebeck effect in organic thermoelectric devices, magnetic Seebeck effect studies, and magneto-electric coupling in organic-inorganic hybrid systems.



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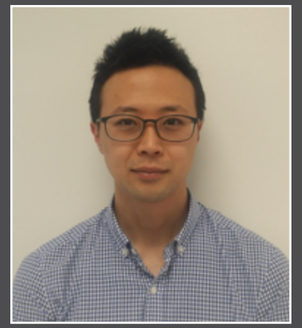


Gian Song

Throughout the year, the Center for Materials Processing hosts several student poster contests and awards the students with funds to travel to professional society meetings. One of the top posters at the 2015 Student Night belonged to Mr. Gian Song. Mr. Song used his award to travel to the TMS 2016 Annual Meeting & Exhibition, held February 14–18, 2016, in Nashville, Tennessee. At the TMS Annual Meeting Awards Ceremony, Mr. Song received second place in the TMS Best Paper Contest: Graduate Division for his paper "Investigation of Novel Hierarchical-Precipitate-Strengthened Ferritic Superalloys with Superior Creep Resistance." Mr. Song's research focuses on the fabrication of alloys, creep properties, microstructural characterization, and understanding of the creep deformation mechanism and utilizes transmission-electron microscopy, scanning-electron microscopy, atom-probe tomography, and advanced neutron diffraction techniques to characterize the alloys.

Materials Advantage (MA)

The University of Tennessee Chapter of Materials Advantage was recognized as the Fall Membership Challenge Winners for the most students recruited. The chapter saw a 227% increase in membership and was awarded $500 for its efforts. The UT Materials Advantage officers include Christina Cox and Josh Seylar as co-chairs and Jesse Johnson as the secretary. The three officers meet monthly with the Executive Committee of the Oak Ridge Chapter of ASM and participate in the local parent professional organization's planning of monthly technical meetings. The UT Materials Advantage also helped with recruitment and outreach activities such as Materials Camp and Engineers Day.

Twelve of the seventeen students graduated in FY16 and most of these students were supported by the CMP Undergraduate Research Program during their undergraduate studies.

From July 1, 2015, to June 30, 2016, the Center for Materials Processing (CMP) supported a variety of technical activities through supporting graduate research assistants, undergraduate research assistantships, travel support to students for presenting research at professional meetings, matching funds for ongoing and new programs, and state-of- the-art instruments and equipment. Areas of specific interest to the CMP include additive manufacturing, crystal growth, scintillator and nuclear materials, energy related materials, micro- and nanofabrication of electronic and biological devices, and welding, some of which are highlighted below.

In FY15, Drs. Claudia Rawn and Suresh Babu, UT/ORNL Governor's Chair for Advanced Manufacturing, received an Industry/University Cooperative Research Center (I/UCRC) Grant from the National Science Foundation (NSF) Directorate for Engineering's Division of Industrial Innovation and Partnerships. The grant establishes the University of Tennessee, Knoxville (UTK) as a new site in the existing Manufacturing and Materials Joining Innovation Center (Ma_2JIC); Ohio State University is the lead university, and other sites include Lehigh University and Colorado School of Mines. The funds from NSF are utilized mostly to support the administration of the UTK Ma_2JIC site and partially to support CMP Director Rawn and CMP Financial Specialist Boyce, while individual projects are supported by industrial memberships. While CMP industrial memberships can support a wide variety of materials processing projects, Ma_2JIC industrial memberships focus on a smaller subset of materials processing that is focused on joining techniques such as additive manufacturing and the joining of hybrid materials systems (e.g. joining polymer reinforced parts to metals). Initial industrial members to the Ma_2JIC site include Boeing, EPRI, ITW/Miller Electric, NASA, Oak Ridge National Laboratory, and the UT Institute for Public Service. One important aspect of I/UCRC industrial memberships is the support of students, preparing them for future employment in industry. An NSF Veteran's Research Supplement (VRS) was awarded to the project and supported Mr. Cameron Hilliard, a sophomore in Materials Science and Engineering, as he strove to develop and evaluate methods of joining 3D-printed titanium to carbon-loaded polymer using various adhesives.

Every year, the Office of Research and Engagement seeks applications for the Scholarly Activity and Research Incentive Fund (SARIF) Equipment and Infrastructure Fund. It is intended that these funds enhance UT's research mission by providing support for equipment purchases, upgrades, and repairs. Most FY's, CMP funds provide an important source of cost sharing towards new SARIF equipment purchases. This year, the CMP helped to support the application put forward by Professor Dayakar Penumadu in Civil and Environmental Engineering (CEE) to acquire a transportable universal load frame (μTS). This very advanced miniature load system can be utilized in multiple UTK laboratories and national synchrotron facilities, such as the Advanced Photon Source (APS), for evaluating structure-process-property relationships of materials. The μTS load cell leverages proprietary Psylotech technology with 400 mV/V sensitivity compared to 2 mV/V from the strain gauge alternatives typically found in universal load frames. The increased sensitivity results in approximately 100x higher resolution, which enables multiple force scale experiments and allows the μTS to be used in conjunction with an optical microscope for integrating digital image correlation area-based strain mapping.

In FY16, the CMP provided matching funds towards the support of two programs headed by Professor Philip D. Rack. One is an ongoing collaborative program between Professor Rack, Intel Inc. and Waviks Inc. Last year, Waviks Inc. gave UTK a $54k gift to help develop the laser delivery system that was installed and tested for supporting the ongoing research program funded by Intel. The overarching goals

Technical Activities

of the program are to simulate focused ion beam induced processing and experimentally explore a new laser-assisted focused ion beam induced processing system. The CMP matching funds help leverage funds including those that support Chancellorss Fellow Brett Lewis as he nears the end of his graduate studies. The funds are also used to provide associated supplies and travel for the project. The second program is a new NSF-funded program led by Professor Rack in collaboration with New Jersey Institute of Technology (NJIT). The overarching program goals are to explore a laser-assisted pulsed laser induced dewetting process to synthesize functional nanoparticle arrays. The UTK team leads the experimental program that is complemented by the NJIT modeling team. This program also connects to a DOE-supported program and collaboration with Notre Dame, where Rack's group studies the full plasmonic spectrum of novel dewetted nanoparticle materials and arrays.

In addition to supporting important instruments for the use of undergraduate research during FY16, the CMP jointly sponsored 48 undergraduates to conduct undergraduate research. Areas of research for these undergraduate studies include ion-implanted bulk metallic glasses, ceramic coatings, organolead halide perovskites, high-performance scintillators, nickel and iron layered double hydroxides, etc. These materials were studied with a variety of characterization methods such as differential scanning calorimetry, scanning electron microscopy, and energy dispersive X-ray spectroscopy.

The CMP also strives to provide valuable experience to undergraduate students by offering them a venue in which they can present their research to their peers, professors, and professionals. To achieve this, the CMP sponsored and hosted its 3rd end-of-summer undergraduate poster competition with 23 participants. The CMP also co-sponsored Student Night, held for the first time at AMS Corporation in West Knoxville, with the Oak Ridge Chapter of ASM and the American Association for Crystal Growth-Southeast Section (AACG-SE). Students were also encouraged to present their posters at the spring Exhibition of Undergraduate Research and Creative Achievement (EUReCA), sponsored by the UTK Office of Research. This year, CMP-supported undergraduate Will Hoskins, studying high temperature hydrogen attack (HTHA) resistance of C-½Mo steels, won second place in the research category for the College of Engineering and was recognized with one of the eight bronze Office of Research and Engagement (ORE) Undergraduate Research Excellence Awards.

Each year, the CMP recognizes the poster winners of the end-of-summer undergraduate poster competition and Student Night with travel awards so that they can present their research outside the local community. Venues include a wide variety of professional conferences and conferences focused specifically at celebrating undergraduate research. For the winners of the CMP end-of-summer undergraduate poster competition, the CMP offered travel awards to the 2016 National Conference on Undergraduate Research (NCUR) at the University of North Carolina at Asheville. The four students who received travel awards were Jesse Johnson, Michelle Lames, Austin Plymill, and Robert Minneci. The CMP partnered with the Office of Undergraduate Research to help transport some of the 65 UT participants to UNC, where they joined more than 4,000 students from institutions around the country to present their research at the three-day event.

One of the undergraduates that the CMP supports is Jesse Johnson, who is conducting research at the Scintillation Materials Research Center (SMRC). Research at the SMRC traverses the areas of biomaterials and nuclear materials by focusing on the discovery, synthesis, and characterization of new materials for use in radiation detection. The end result is new scintillation materials for gamma-ray,

X-ray and neutron detectors for use in the areas of medical imaging, homeland security inspection and monitoring, neutron and high-energy particle physics experiments, and remote exploration for new energy resources. This year, Mr. Johnson was one of the top winners at both the CMP end-of-summer undergraduate poster competition and Student Night.

The CMP is proud to be an early supporter of the College of Engineering (COE) Innovation and Collaboration Studio (ICS). The ICS (http://ics.engr.utk.edu) is a new resource supported in part by Engineering Fundamentals (EF) that provides resources to engineering students in the form of a studio that houses technology, tools and knowledge. The primary purpose of the ICS is to supplement classroom learning with hands-on experiences. In the ICS, students can turn their ideas into projects through collaboration with staff and other students; these labs are often referred to as Maker Spaces. The hands-on experiences students get from exploring in the ICS will directly support the work-force development needs of advanced manufacturing initiatives such as the Institute for Advanced Composites Manufacturing Innovation (IACMI) and the Manufacturing and Materials Joining Innovation Center (Ma_2JIC). Working with the equipment and materials in the ICS will better prepare our students to be leaders in these exciting new manufacturing initiatives.

Continuing last FY's support by the CMP to help build outstanding undergraduate Materials Science and Engineering laboratory space, several new pieces of research-grade equipment that will aid in undergraduate education and graduate research were purchased and installed. The instruments were acquired to further develop student understanding in structure-properties-processing relationships. The highlight of the equipment is a single zone 1100 °C dilatometer from TA Instruments. "The expansion and contraction of materials as a function of temperature change is largely due to processing conditions," says MSE undergraduate laboratory director Chris Wetteland. "The dilatometer will give our students the ability to track how their processing procedures manifest themselves in solidified objects. The instrument is particularly useful in characterizing sintered ceramics and metallic parts." Additionally, the undergraduate laboratories also received several new optical microscopes equipped with high-quality digital cameras.

Undergraduate Will Hoskins and graduate students Maneel Bharadwaj and John Bohling, all of whom work in the Materials Joining Group (MJG), are supported by CMP memberships in the Materials Processing Council and the Welding Research Council. In FY16, the MJG remained active in the continued study of graphitization in carbon steel weldments commonly used in petrochemical vessels and high temperature hydrogen attack (HTHA) in carbon and C-½ Mo steels. Additionally, the group has commenced work on several new projects on 9Cr 1Mo V Nb (Grade 91) steel involving investigation of the creep behavior of the heat-affected zone (HAZ). Some of the highlights for the MJG in FY16 include hosting faculty and students from the Nelson Mandela Metropolitan University (NMMU), located in South Africa, as well as a chief metallurgical engineer from SASOL Ltd. (an international integrated chemicals and energy company) to discuss the MJG's ongoing research in graphitization in carbon steels.

In FY16, the CMP continued its support of the Tennessee Crystal Center (TennXC) as it works towards being large enough to be fully self-sustaining. TennXC, in conjunction with the Center for Materials Processing and the University of Tennessee Research Foundation, seeks to provide single crystals for use in materials research at universities across the globe. The focus since inception has been on the growth of two-dimensional semiconducting crystals that prove

promising for applications such as flexible electronics. This year, however, marks new efforts in growing organic/inorganic hybrid perovskites such $MAPbI_3$ (MA = methylammonium), which have potential applications in solar cell technology.

In 2014, the University of Tennessee established the UT Core Facilities Program. The Core Facilities provide access to high-end instrumentation, technical support, and expert consultation to users from all departments at the university as well as external customers (i.e. local industries, local community colleges, and national laboratories) on a fee for service basis. The Panalytical X'Pert3 MRD XRD and the Panalytical Empyrean XRD instruments that arrived in fall of 2014 are now part of the Joint Institute for Advanced Materials (JIAM) X-Ray Diffraction Core Facility and are available for both assisted and unassisted use. In FY16, the instruments were housed and operational in the Science and Engineering Research Facility (SERF); they are scheduled to move to laboratories specially designed for housing X-ray diffraction instruments instruments in the JIAM during FY17. The CMP provided some of the matching funds necessary to procure the instruments and continues to support the development of the JIAM X-Ray Diffraction Core Facility through continued support of Dr. Maulik Patel and several undergraduate students assisting in the XRD laboratory and using the technique for research. The instruments included in the core facility are capable of performing quantitative and qualitative phase analysis, X-ray reflectometry, reciprocal space mapping, grazing incidence in-plane and out-of-plane diffraction, conventional and grazing incidence small angle X-ray scattering, texture, residual stress measurements, and Laue measurements. The Empyrean, the newest X-ray diffractometer from PANalytical, has an environmental chamber allowing for measurements to be collected at high temperatures (up to 1200 °C) in various environments for the experimental determination of the thermal expansion of various materials and the study of phase transformations. Data from the phase transformation studies, when coupled with the instrument's fast detector (PIXcel), allow for the kinetics of various transformations to be studied.

MSE students, Jesse Johnson (senior) and John Salasin (graduate), both use the Panalytical Empyrean X-ray powder diffractometer that is part of the JIAM X-Ray Diffraction Core Facility for their research.

Materials Camp 2016

During the summer of 2016, Materials Camp returned to the University of Tennessee's campus with a brand new whodunit story line. This year, a video was submitted to the campers showing the notorious Prof. Knucklehead in the furnace laboratory bossing graduate students and interrupting undergraduates' research in his quest for discovering a new superalloy and potentially winning a Nobel Prize. In the video, Prof. Knucklehead, a hero in his own mind with a less than magnetic personality, specializing in how to not make friends and allies, was knocked out and found by students next to his laboratory notebook with the hastily scribbled message "10,000x, eye of the eagle" and a quarter nearby. This started the materials related quest for the campers to come up with plausible solutions to who did it, how, and why. Along the way, the students learned about why different microscopes specialize in imaging features at different length scales, modifying materials to enhance mechanical properties, as well as characterizing and mechanically testing various materials. Every day at the end of camp, a new clue was provided that set the course for the next day's activities. Campers enjoyed smoothies made using solar power, and for those campers interested in biomedical engineering and biomaterials, this year the camp included a tour to see Mabeline, the UTK SynDaver (synthetic cadaver). On the last day of the camp, the campers made group presentations on what they think happened to Prof. Knucklehead including who did it and why. The laughter abounded as MSE lecturer, Chris Wetteland, was found guilty mainly through linking his last name with the 3D printed Florida gator provided as a clue. The winning team and their parents were invited to the opening technical meeting of the Oak Ridge Chapter of ASM, one of the main sponsors of local Materials Camp, to give their presentation and discuss their experiences during the week.

This year, nineteen high school students participated in Materials Camp. This included two students from out of state and several repeat campers. As always, a camp like this required many volunteers, and the Materials Science and Engineering (MSE) undergraduate and graduate students turned out in force to mentor the four groups of campers. Many of the mentors, early in their MSE education, often learned as much as the campers and found it a worthwhile volunteer activity. As part of an effort to actively recruit outstanding high school students to major in MSE and become part of the future MSE workforce, one of the campers was offered a scholarship jointly supported by the MSE Department and the CMP for joining the MSE as a freshman in the fall of 2017.

2016 Congressional Visits Day

"UTK students dispersed within the group of students, faculty, and professional society staff members participating in the Materials Advantage CVD."

In FY16, the Center for Materials Processing helped send four University of Tennessee, Knoxville (UTK) students to participate in the 2016 Congressional Visits Day (CVD) held in Washington, D.C., on April 19th. Representing UTK this year were MSE undergraduates Samantha Medina and Dylan Dozier, MSE Ph.D. candidate Ryan Ginder, and Bredesen Center Ph.D. candidate in Energy Science and Engineering Guinevere Shaw. Materials Advantage organized the trip with the goal of promoting awareness in the Senate and House of Representatives of the fact that students depend on the funding of basic and applied research through organizations such as National Science Foundation (NSF), Department of Energy (DOE), and National Institute of Standards and Technology (NIST). The Material Advantage CVD program also provided the participating students with an opportunity to gain exposure in government policy as it pertains to the scientific community and prepared students for discussing matters of interest to them with their representatives. This year, the UTK students met with Tennessee state senators, representatives, and staffers, including Sen. Lamar Alexander, Sen. Bob Corker, and Rep. Diane Black.

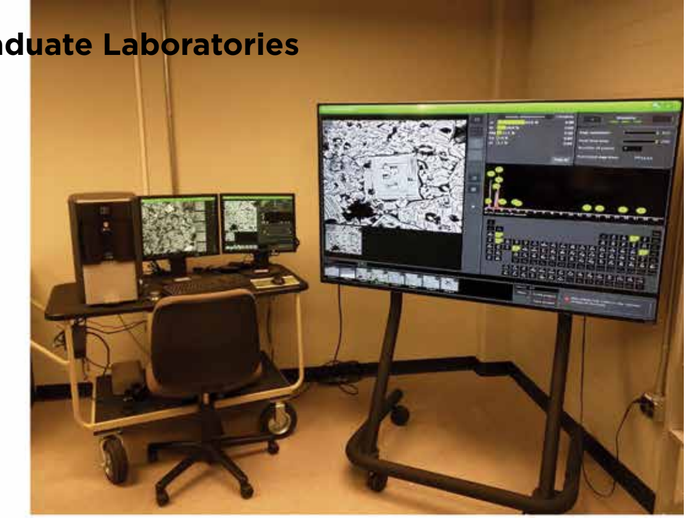
Governor's School for Engineering 2016

For the fourth year in a row, Materials Science and Engineering (MSE) has participated as part of Tennessee's Governor's School of Engineering (GSE). Twenty-seven high school rising juniors and seniors from across the state of Tennessee, selected from a large pool of applicants based on their outstanding academic achievements and recommendation letters, participated in the four-week GSE program. In 2015, Dr. George Siopsis, UTK Physics, took over the reins and made several substantial changes as Director of the Governor's Schools for Science (GSS) and Engineering (GSE), both held on the University of Tennessee, Knoxville campus. One of the changes focused on having all GSSE students participate in Science, Technology, Engineering, and Mathematics (STEM) in Society and STEM Skills curriculums. The STEM in Society portion aimed at having students learn and think about the interrelationship between science and public policy, and the STEM Skills portion introduced students to programming, 3D modeling and printing, mobile application development, engineering design, technical communications, data processing, image processing, microprocessor control, and robotics. During the afternoon, the GSE students exclusively participated in lectures, seminars, and laboratories that introduced them to fundamental materials science and engineering. The students were broken into groups of six or seven and rotated through four different laboratories: cold working of brass and mechanical testing; computer aided design (CAD) and 3D printing of polymeric materials; solid state synthesis of the spinel $MgAl_2O_4$ followed by density measurements, scanning electron microscopy, and X-ray diffraction; and bio-materials and the mechanical properties of bones. The laboratory experiences were designed to introduce students to metals, polymers, ceramics, biomaterials, and mechanical properties with the objective of allowing them to gain skills in two vital MSE operations: processing and characterization. This year, Claudia Rawn and Chris Wetteland organized and participated in the events. Assistance in the various laboratories was provided by teaching assistants (TA's) Willie Kemp, recent MSE graduate; Aaron Miller, double majoring in Mechanical and Biomedical Engineering; Brianna Musico, recent MSE graduate; and Zane Palmer, recent MSE graduate and shared staff member between the MSE and Mechanical, Aerospace, and Biomedical Engineering (MABE) Departments. Prof. Kurt Sickafus and MSE graduate student Bernadette Cladek also provided support to the laboratories by assisting the students with the characterization of their materials using scanning electron microscopy (SEM) and X-ray powder diffraction, respectively.

In addition to their laboratory experiences over the course of the month, the students were able to attend introductory lectures by faculty and students from various College of Engineering (COE) departments as well as workshops, led by the UTK Office of Information Technology (OIT), on using Excel. One highlight was a poster session featuring many of the Center for Materials Processing (CMP) funded undergraduate research assistants. The GSE students also toured several of the large facilities at Oak Ridge National Laboratory (ORNL), including the High Flux Isotope Reactor (HFIR) and the Manufacturing Demonstration Facility (MDF). The month concluded with teams of students preparing posters on their various laboratory experiences and presenting them to the students, faculty, and staff of the MSE Department. Later, the same posters were presented at the GSSE closing ceremony for the public (parents and siblings!) to view and ask questions. Each student was sent home with a poster to display at his or her high school during the upcoming academic year. Many of the students were not only outstanding academically but also engaged and communicated exceptionally well, resulting in several of them receiving scholarship offers jointly funded by the MSE Department and the CMP as a way of recruiting some of the top high school students in the state of Tennessee to study materials science and engineering.

MSE Undergraduate Laboratories

The Materials Science and Engineering Undergraduate laboratories located on the sixth floor of the Dougherty Engineering building host a wide assortment of state-of-the art instrumentation. Pictured on this page are the Instron 5960 dual column tabletop tensile tester, the Phenom Pro X desktop scanning electron microscope (SEM), the TA Instruments differential scanning calorimeter (DSC) and thermogravimetric analyzer (TGA), and two of the suite of 3D printers.



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