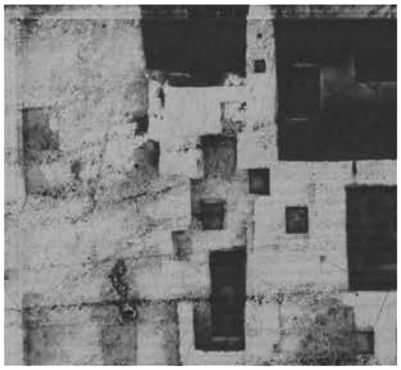

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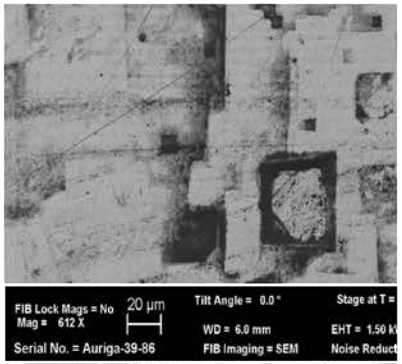

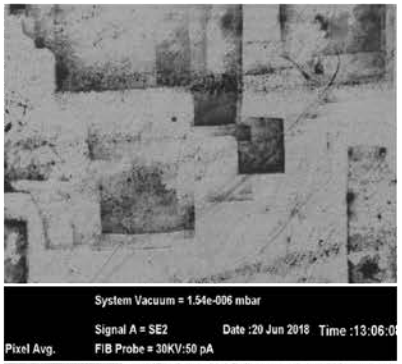

TICKLE
COLLEGE OF ENGINEERING

CENTER FOR MATERIALS PROCESSING

Center for Materials Processing
Annual Report 2018

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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.

Executive Summary

Key components of the CMP Mission are the support of teaching and research in areas where materials processing plays a significant role. One of the cornerstones of materials science and engineering is the relationship between processing, structure on various scales, and the resultant electronic, magnetic, mechanical, optical, physical, and thermal properties. CMP funds are focused on supporting graduate and undergraduate students in several disciplines who are undertaking research in the various aspects of the processing, structure, and properties relationships. The CMP works as an advocate in the field of materials processing on many levels, including recruiting outstanding future students to study and work in materials processing related fields.

In addition to partially or fully supporting student assistantships through stipends, the CMP annually sponsors several poster sessions, participates in Materials Camp and the Tennessee Governor's Schools for Science and Engineering, and maintains key pieces of processing equipment for CMP supported students and industrial members to use. The CMP poster sessions are competitive, and students with posters that the judges recognize as the best are provided travel support to present their research externally and represent Tennessee at professional conferences. Current areas of specific interest to the CMP include additive manufacturing, characterization techniques, crystal growth, scintillation detectors, nuclear materials, and energy related materials. Another important component of the CMP mission is transferring improvements to the applied sector. To address technology transfer, the CMP offers Industrial Memberships, where membership funds can be used to support students and/or access to facilities.

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Dr. Claudia J. Rawn

CMP Director

Dr. Claudia Rawn has been director of the Center for Materials Processing (CMP) since July 1, 2012. She 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) performing 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. 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 six years, she has been an instructor for Governor's School for the Sciences and Engineering. She has served as 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 the secretary for 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 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.

CMP Supporting Staff

Center Associate Director of Industrial Relationships and Undergraduate Research

Chris Wetteland demonstrating the operation of the CMP's particle size analyzer to MABE graduate student Denzel Bridges

Chris Wetteland is currently serving as the associate director for industrial partnerships and undergraduate research for the Center for Materials Processing. His main appointment is with the Department of Materials Science and Engineering (MSE) as a senior lecturer. Mr. Wetteland received his B.S. in Geology from Northeastern Illinois University, his M.S. in Ceramics and Materials Engineering from Rutgers University, and is completing his Ph.D. in Earth and Planetary Sciences at the University of Tennessee, Knoxville (UTK). Prior to joining the MSE Department at UTK, Mr. Wetteland worked at Los Alamos National Laboratory as a staff member from 1997-2006, where his research focused on ion beam analysis and radiation damage in materials. From 2010-2013, he was a research fellow at the University of Wisconsin-Madison, where he investigated accelerated aging of nuclear materials using particle accelerators. Mr. Wetteland presently teaches the laboratory coursework and advises senior design projects in the MSE Department and serves as the faculty advisor of several student outreach organizations. His research interests include early solar system processes, radiation damage in nuclear materials, ceramic processing, solar energy, ion beam analysis, advanced manufacturing, and STEM outreach.

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

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.

Amber White is the administrative specialist for the CMP and the RMC since November 2016. Before joining the university, she spent five years in social work, specializing in low-income senior housing and fair housing regulation.

2017 – 2018 CMP Advisory Committee Members

Established in early 2014, the CMP Advisory Committee works with the CMP Director (Rawn) and Associate Director for Industrial Partnerships and Undergraduate Research (Wetteland) regarding various areas of research that the CMP can advocate for and invest in for the future. The CMP leadership and the Advisory Committee are working together with the goal of bringing positive recognition to the CMP, the Tickle College of Engineering, and the University of Tennessee in areas related to materials processing. In early May 2018, the CMP Advisory Committee met to begin discussing how the CMP can help provide a link between local industry and the University of Tennessee.

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

Dr. Neal Evans
Local Industrial Consultant

Dr. Veerle Keppens
Professor and Head, Materials Science and Engineering
Director – Joint Institute for Advanced Materials
College of Engineering
University of Tennessee, Knoxville

Ms. Beth Matlock
Senior Materials Engineer
Technology for Energy Corporation (TEC)

Dr. Charles Melcher
Director – Scintillation Materials Research Center
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
Research Engineering
Analysis and Measurement Services (AMS) Corporation

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 have either joint appointments between the two institutions or 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).

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 the fabrication of welds and the 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. The results of the research performed at UTK are disseminated worldwide in WRC Bulletins and are useful in preventing failures and contributing to the improvement of international codes and standards, which are closely monitored by industry representatives from many countries serving on WRC committees. Dr. Martin Prager, executive director of MPC and WRC, often visits the University of Tennessee, Knoxville,

Center for Materials Processing Partnerships

campus to discuss the progress of the MJG research with Professor Lundin and the MJG graduate students.

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 of hygroscopic materials, crystal growth, and numerous 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) holds the distinction of being the only joint institute housed on the UT campus, specifically UT's new Cherokee Farm campus. The construction of the $30 million facility was completed in FY17, and many of the CMP supported graduate students and faculty work in new laboratories at the JIAM. Research activities at the JIAM focus on a variety of materials synthesis techniques and advanced characterization methods that often require sensitive instrumentation and highly qualified personnel. Dr. Veerle Keppens, the JIAM Director, serves on the CMP Advisory Committee.

The CMP is located within the Tickle College of Engineering (TCE) and endeavors to collaborate with all departments within the TCE that undertake materials research. The mission of the CMP is closely aligned with activities pursued by the TCE 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, microscopy, electronics, and machining. This support makes the partnership between the CMP and the MSE Department strong and productive for both parties.

Undergraduate Spotlight

Sabrina Schwerzler is currently a senior in the Materials Science and Engineering department's five-year BS/MS program at UT. At the end of her freshman year, she became an undergraduate research assistant, funded through the Research and Instructional Strategies for Engineering Retention (RISER) NSF supported program, under the supervision of John Salasin, a graduate student in Dr. Claudia Rawn's group. Her role in the research was heavily focused on ceramic synthesis and material characterization through x-ray diffraction. Ms. Schwerzler has applied those skills on other research projects including a Joint Directed Research Development (JDRD) project related to molten salts and a UT Summer Internship. The UT Summer Internship program is a competitive program managed by the University of Tennessee's Office of Undergraduate Research, to which Ms. Schwerzler submitted a proposal and was funded to study hydrothermal synthesis. She has presented her research at several CMP-sponsored poster sessions and university poster sessions, including Exhibition of Undergraduate Research and Creative Achievement (EUReCA) and Discovery Day, receiving an honorable mention in the engineering category for her poster "Sol-Gel Synthesis and Cation Doping of $Ca_{12}Al_{14}O_{33}$ Nanocages" in the 2017 EUReCA competition.

CMP Undergraduate Research Support

The CMP continues its role in supporting undergraduate research at the University of Tennessee by using roughly 10% of its available funds to support 45 different undergraduate students performing undergraduate research and working with CMP equipment. Undergraduate support includes both matching internal university research support and connecting students to local industry and Oak Ridge National Laboratory. The CMP is expanding its support of materials processing initiatives by funding new undergraduate research from the Departments of Nuclear Engineering (NE) and Mechanical, Aerospace, and Biomedical Engineering (MABE) at UT. Mechanical Engineering Assistant Professor Brett Compton states, "Undergraduate student research support has allowed our group to further explore the processing of epoxy composite feedstocks for additive manufacturing of high strength, lightweight composite cellular structures. Additionally, our students are examining multiphase ceramic/metal suspensions to enable new high toughness, wear resistant materials with architected microstructures." Maik Lang, an associate professor in Nuclear Engineering, comments that, "Our undergraduate students have recently explored synthesis of ceramics to study the nature of heterogeneous disorder by means of neutron total scattering. The students also helped gather data to characterize the short range order of the structures of interest at the Spallation Neutron Source of Oak Ridge National Laboratory." The CMP sponsors poster sessions in the fall and late summer as opportunities for students to present their work to the judges from the technical Knoxville/Oak Ridge community, faculty, and other students. Travel support is provided to the students with the best posters so that they can attend professional conferences. This allows for the high quality research in the area of materials processing that is coming out of the University of Tennessee and funded by the CMP to be disseminated to the broader technical community.

Undergraduate Scholarships

In FY18, the CMP partnered with the Materials Science and Engineering (MSE) Department to jointly sponsor scholarships for recruiting three promising undergraduate students into the MSE program at the University of Tennessee. These students were Allison Campbell, Samantha Maness, and Jackson Spurling. Prior to becoming Tickle College of Engineering freshmen, these students were already known to faculty in the MSE Department based on their participation in Materials Camp and/or Governor's School for Science and Engineering. Below are biographies for each of these students. Although interested in different aspects of MSE, they all are highly motivated and participate in and share a passion for undergraduate research.

Alison Campbell is aspiring to be a pediatric neurosurgeon with a background in MSE. She plans to use this specialized education to impact lives through both research and the operating room. Ms. Campbell is dedicated to advocacy for children with neurological conditions and other invisible disabilities. Her current research focuses on improving the treatment of hydrocephalus, a serious and often fatal buildup of cerebrospinal fluid on the brain, both in the United States and overseas. Ms. Campbell has volunteered in a variety of activities to benefit East Tennessee Children's Hospital (ETHC) and the Ronald McDonald House, such as establishing an annual supply drive for Children's Hospital, designing an activity booklet for young patients, and refurbishing the neurosurgery waiting room for children. Her newest addition to her ETCH involvement is UTK's VOLthon organization, which raises funds for the hospital. Ms. Campbell is a proud ambassador for ETCH through her representation of the neurosurgery program and her membership on ETCH's Teen Advisory Council.

Ms. Campbell's independent research began when attending the Governor's School for Science and Engineering at the University of Tennessee, Knoxville. She was inspired by her Governor's School experience to incorporate advanced manufacturing technology into improving the design and fabrication of ventricular catheters used to treat patients with hydrocephalus. No matter how great the surgeon's surgical skills are, patients' prognoses cannot be optimized without better treatment equipment. Ms. Campbell applies the knowledge she gains from her academic course work in MSE to revolutionize the way hydrocephalus patients live. She feels that designing a shunt with a new material is key for improving the performance of ventricular catheters. Hydrocephalus patients and their families are in constant fear of shunt failure, so designing a more reliable shunt would immediately improve their psychological health as well as the patient's physical health. Working with professors, doctors at UT Medical Center, and UT-ORNL Governor's Chair Suresh Babu, she has been striving to experiment with 3D printing to improve the design of biocompatible shunts that relieve pressure on the brain, making them more effective and more reliable.

Since before Samantha Maness could remember, engineering has been a part of her life. Throughout her childhood, her family's kitchen table was constantly piled with papers, pens, and calculators, attended by at least one of her parents. She was fascinated by her father's process and instrumentation diagrams, trying to discern meaning from the countless symbols and numbers during her visits to his office at Eastman Chemical Company. As soon as Ms. Maness had the chance to dig her own hands into engineering, she did so with gusto. One of her first experiences with engineering was when, as a sophomore in high school, she attended a Duke TIP Scholar Weekend at the University of Georgia where the focus was on genetic engineering. During the weekend, the students spliced E. Coli with fluorescent jellyfish DNA in a lab, and Ms. Maness was captivated by the precision instruments and meticulous attention that the task required. During the summer of 2016, Ms. Maness was selected from a pool of applicants to attend the Governor's School for the Sciences and Engineering at the University of Tennessee in the subject area of materials science and engineering. Prior to this, she, like many high school students, had never heard of the field of materials engineering. During her Governor's School experience, she was exposed to numerous fun and fascinating laboratory experiments,

Undergraduate Scholarships

including X-ray diffraction and SEM imaging of sintered pellets, cold rolling of brass, and tensile testing of chicken bones. During the tour of Oak Ridge National Laboratory, she was intrigued by the automotive research being carried out at the Manufacturing Demonstration Facility (MDF). Governor's School MSE faculty Claudia Rawn and Chris Wetteland encouraged Ms. Maness to pursue the discipline beyond Governor's School as an undergraduate academic major.

While attending the university, Ms. Maness has dedicated herself to pursue a hands-on understanding of engineering and has been participating in undergraduate research with Dr. Brett Compton's group, working cross-discipline between the MSE and MABE departments. This position has given her the opportunity to be exposed to a variety of processing equipment, including 3D printers, waterjet cutters, vacuum chambers, furnaces, and high-speed mixers. Materials that Ms. Maness has worked with include epoxies, polyurethane, and silicone, and she has been studying IZOD impact testing of composites. Ms. Maness is a member of the Engineering and Chancellor's Honors Programs, the Engineering Mentorship Program, and the Society of Women Engineers SWEeties program. She is pursuing a minor in industrial design and is an avid digital artist. Her high school accolades include being a National Merit Finalist, a Distinguished AP Scholar, and she is a proud alumnus of the Dobyns-Bennett High School marching band. Her future goals include interning at ORNL's MDF and earning a master's degree in either materials or mechanical engineering prior to obtaining employment in the area of manufacturing and development for the automotive industry.

Jackson Spruling's father always told him that "Engineers solve problems" and that the world is full of problems, which means that he would always have steady work as an engineer. But what really hooked Mr. Spruling on engineering was attending Materials Camp, during which he had the opportunity to use a scanning electron microscope and X-ray diffractometer to characterize materials. He was amazed by the scientific formulas and high-tech equipment used by the materials campers to perform their research. To him, the work was both fun and challenging, gleaning facts from scientific research and piecing them together to solve a puzzle. During one camp, the campers performed failure analyses on prosthetic implants, examined the chemical composition of materials, and made parts with 3D printing. This experience helped him to see how engineering can help people in practical ways. Prior to his freshmen year, Mr. Spruling participated in an internship at Oak Ridge National Laboratory (ORNL) in the Materials Science and Technology Division under the direction of Drs. Lawrence Allard and Kinga Unocic, during which he gained experience using electron microscopes. While interning at ORNL, he prepared and loaded samples, took images, and organized and presented findings. These experiences led Mr. Spruling to major in materials science and engineering at UTK. His goal is to use engineering to develop practical solutions to everyday problems, and he approaches his goal excited about the potential for discovery in materials science and how those discoveries can help his community, the nation, and the world. Mr. Spruling plans to obtain a B.S. in MSE while focusing on undergraduate research and then attend graduate school to pursue a Ph.D. His long-term career goal is to become a materials science expert and research fellow at a university or national laboratory and solve problems of global importance.

Mr. Spruling currently serves as a southeast regional liaison for the Microscopy Society of America Student Council, where he reaches out to university students to encourage them to consider study, research, and career opportunities in fields within which microscopy plays a significant role. His accolades include being a National Merit Scholar, an Eagle Scout, an AP Scholar with Distinction, and class of 2017 valedictorian of Anderson County High School, Clinton, Tennessee. He served as the junior member on the City of Norris Conservation/Recycle Commission from 2010–2017 and was the long snapper (#60) for the Mavericks football team at Anderson County High School, receiving a scholar–athlete award from the East Tennessee Chapter of the National Football Foundation in 2017.

CMP Supported and Associated Graduate Students

Christine Ajinjeru is a Ph.D. candidate in the Bredesen Center's Energy Science and Engineering graduate program. She is working under the direction of Dr. Chad Duty at UTK and the Manufacturing Demonstration Facility (MDF) on determining the printability of thermoplastics and thermosets on various extrusion-based additive manufacturing (AM) platforms. Ms. Ajinjeru moved to the United States from Uganda via the United Kingdom in pursuit of a higher education and received a bachelor's degree in chemistry at Grinnell College, Iowa, in 2014. While at Grinnell College, she participated in Oak Ridge National Laboratory's (ORNL) Higher Education Research Experience's (HERE) semester-long program, which introduced her to ORNL and the University of Tennessee.

Ms. Ajinjeru's dissertation work is aimed at expanding the current selection of 3D printable materials for extrusion-based AM platforms. Developing new materials for AM requires screening across all areas of the printing process, from material selection to final part properties. She worked with her advisor, Dr. Chad Duty, on the first four-part framework that evaluates polymer feedstock as candidates for 3D printing across a variety of extrusion-based platforms. The framework uses thermal and rheological characterization to predict successful printability. For a successful print, pressure-driven flow of the melt through the nozzle must first occur. Additionally, the deposited material must form a stable bead with the right geometry, and the deposited bead must be able to support the weight of other subsequent layers and bridge a free spanning gap. Finally, the 3D printed structure needs to be dimensionally stable during the transition to the final part when cooling to ambient temperature.

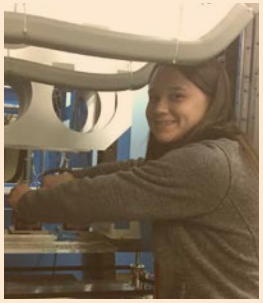
Ms. Ajinjeru's work delves into evaluating the applicability and effectiveness of the extrusion criteria to minimize costly trial and error. The pressure-driven extrusion criterion is modeled by calculating the necessary pressure required to extrude a material through a nozzle and comparing that to the system's maximum pressure. Her work will provide a basis for both optimizing the use of current thermoplastic and thermoset materials as AM feedstock and guiding the development of new materials, especially high-performance materials.

John Bohling is a Ph.D. candidate in the Department of Materials Science and Engineering and is working within 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."

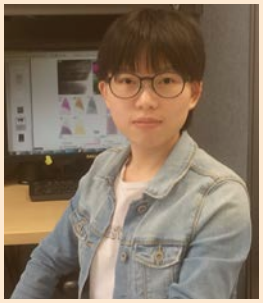
Mr. Bohling has been involved in several research areas with the Materials Joining Group, including microstructural characterization of creep-damaged, submerged-arc weldments in 1.25Cr-0.5Mo steels for steam piping, microstructural characterization and investigation of Type IV creep behavior of 9Cr-1Mo-V-Nb (P91) steels, high temperature hydrogen attack of C-0.5Mo steels, weldability investigations of high entropy alloys (HEAs) such as AlxCoCrFeNi, and dissimilar resistance spot welding of aluminum to steel using HEA interlayers. For his M.S. degree, his work centered on a 20Cr-32Ni-1Nb heat-resistant austenitic stainless steel casting alloy (ASTM A351 Grade CT15C), which is used for outlet headers and manifolds in hydrogen reformers. Weldability problems with this alloy have been reported during repair welding of service-exposed material, primarily as the occurrence of cracking in the base metal heat-affected zone (HAZ). Mr. Bohling's research focused on Gleeble hot ductility testing together with microstructural characterization to evaluate the HAZ liquation cracking susceptibility of CT15C materials provided by an industrial sponsor (Air Products and Chemicals Inc.). Mr. Bohling successfully defended his M.S. thesis in July 2016, has passed his Ph.D. qualifying exams, and

CMP Supported and Associated Graduate Students

completed all the necessary coursework. Mr. Bohling is finalizing his Ph.D. research under the guidance of Dr. Lundin, focusing on Type IV creep behavior in P91 steel weldments.
During his time with the MJG, Mr. Bohling has worked as a teaching assistant in 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 planning of experiments, sample preparation, and microstructure analysis for their group projects. In 2013, he received the MSE Departmental Student Award for Excellence in Service in recognition of his efforts.

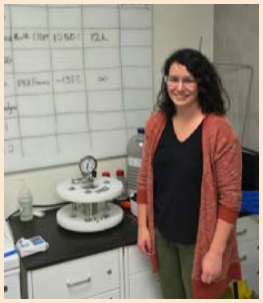


Katie Browning is currently a master's student in the Material Science and Engineering Department (MSE) at the University of Tennessee, Knoxville (UTK). She is co-advised by Dr. Gabriel Veith of Oak Ridge National Laboratory (ORNL) and Dr. Claudia Rawn from the UTK MSE Department. Ms. Browning received her B.S. degree in Materials Science and Engineering from UTK in May of 2015. Following graduation, she spent two years at ORNL in the Physical Chemistry of Materials group under the direction of Dr. Veith, where her work focused on materials for energy storage.
Ms. Browning's current research focuses on a better understanding of polymeric binder used in composite electrodes and its effect on the performance of next generation silicon anodes. She utilizes in situ neutron reflectometry to better understand structures of buried interfaces within batteries and surface sensitive techniques, such as x-ray photoelectron spectroscopy, to better understand reaction chemistries occurring at those interfaces.

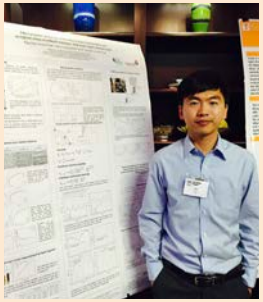


Shuying Chen is a fifth-year graduate student in the Materials Science and Engineering (MSE) Department at the University of Tennessee, Knoxville (UTK). Prior to joining UTK, Ms. Chen studied the mechanical properties of the refractory high entropy alloy (HEA) AlxNbTiMoV at the University of Science and Technology in Beijing, China, receiving her Master of Science degree in 2014.
Ms. Chen's research under the direction of Prof. Peter Liaw is mainly focused on the serrated flow mechanism and fatigue behavior in Al0.5CoCrCuFeNi and TaNbHfZrTi HEAs. The temperature and strain rate effects on the compression, tension, fracture stress, and creep-life of Al0.5CoCrCuFeNi HEAs are currently being investigated to establish statistical models for serration behaviors. TaNbHfZrTi alloys are being investigated using the experimental techniques of scanning electron microscopy (SEM), electron backscatter diffraction (EBSD), and transmission electron microscopy (TEM) along with complementary computational techniques such as finite element analysis (FEA) and statistical calculations. The goal of these investigations is to predict the fatigue life and understand the dislocation structure evolution during non-monotonic loading. Characterization tools including atom probe topography (APT) and high-energy synchrotron X-ray diffraction and neutron diffraction are being employed for studying phase transformations and determining the structure of HEAs down to the nanoscale, such as nano-particles, slip bands, twinning, and interactions of dislocations. These characterization studies combined with computer modeling could potentially provide in-depth mechanisms for plastic deformation and precursors to fracture of serrations within these application-attractive materials.
Ms. Chen's presentations include an MSE departmental seminar and the TMS 144th, 145th, 146th, and 147th annual meetings.

CMP Supported and Associated Graduate Students



Bernadette Cladek is a fourth-year Ph.D. student working with Dr. Claudia Rawn in the Department of Materials Science and Engineering at the University of Tennessee, Knoxville (UTK). She is jointly supported by the Center for Materials Processing and a University of Tennessee Chancellor's Fellowship. To complement her Ph.D., Ms. Cladek is working towards an Interdisciplinary Graduate Minor in Computational Science. 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. Natural hydrates are a potential source for methane and CO_2 sequestration, and Ms. Cladek is interested in the effects of mixing gases, such as carbon dioxide with methane, on the temperature and pressure conditions of decomposition. Ms. Cladek assembled a hydrate-synthesis lab, which is included in the new Joint Institute for Advanced Materials (JIAM) ceramics processing laboratory. She performed structural studies with in situ total neutron scattering and dynamic studies with inelastic neutron scattering experiments on synthesized CH_4, CO_2, and mixed CH_4-CO_2 hydrates at the Spallation Neutron Source. She also uses complimentary classical molecular dynamics simulations and density functional theory of these systems to complement neutron data analysis. These structural and thermodynamic studies will provide a more comprehensive understanding of CO_2-CH_4 solid solutions, exchange kinetics, and implications on hydrate structure to better inform the production of CH_4-CO_2 exchange. During this past year, Ms. Cladek has presented posters on her research at the Gordon Research Conference on Natural Gas Hydrates in Galveston, TX, and locally at the Oak Ridge Chapter of ASM (ORCASM) Student Night. She has given oral presentations at the 2017 Joint Nanoscience and Neutron Scattering User Meeting and at the American Geophysical Union 2017 Fall Meeting in New Orleans, LA.



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 working on an industrial project involving the investigation of residual stress distribution, texture development, and phase transformation in stainless steel alloys when manufactured by deep drawing process. For this investigation, he is conducting experimental in-situ synchrotron X-ray diffraction experiments at Argonne National Laboratory's Advanced Photon Source (APS) and neutron diffraction experiments at Oak Ridge National Laboratory's Spallation Neutron Source (SNS).

Mr. Hou has presented his work at the Metals, Minerals, and Materials Society (TMS) Annual Meeting (ICOTOM). Mr. Hou was awarded first place in the 2017 poster competition cohosted by the Oak Ridge Chapter of ASM and the Center for Materials Processing.

Chanho Lee is a third-year graduate student in the Department of Materials Science and Engineering at the University of Tennessee, Knoxville (UTK), under the direction of Dr. Peter Liaw. Mr.

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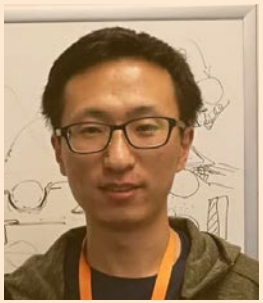
Lee received his M.S. from Sejong University, Korea, in Materials Science and Engineering (MSE) in 2013. During that time, he published four first-author or co-authored papers and received one patent. Since joining the UTK MSE Department in 2014, Mr. Lee has been working on the investigation of the microstructural evolution and mechanical properties of refractory high-entropy alloys (HEAs), especially the influence of additional elements (e.g., Bi, Mg, and Sn) on Ti-Fe ultrafine eutectic alloys. He is an expert in the fabrication of metal alloys such as HEAs and bulk metallic glasses using arc-melting suction casting equipment. He is performing in-situ neutron diffraction using the VULCAN Engineering Materials diffractometer at Oak Ridge National Laboratory's (ORNL) Spallation Neutron Source (SNS) for an in-depth understanding of the mechanical behaviors demonstrated by his modified refractory HEAs. Mr. Lee is also obtaining complementary nano-scale microstructure characterization using atom probe tomography (APT) at ORNL's Center for Nanophase Materials Science (CNMS). These investigations will be included in the future publication "Lattice Distortion in a Strong and Ductile Refractory High-entropy Alloy" and three additional papers. Mr. Lee presented his results at the 2016 CNMS user meeting and was recognized with a poster award. In 2018, he received the Chancellor's Citation Award for Extraordinary Professional Promise. His goal, combining in-depth studies of the fundamental materials science and engineering with developing new HEA's, is to discover advanced materials with superior mechanical properties.



Yongtao Liu is a third-year Ph.D. student in the Department of Materials Science and Engineering at the University of Tennessee, Knoxville. Mr. Liu received his Bachelor of Science in the College of Chemistry from Nankai University, Tianjin, China, in 2014. His current research focuses on clarifying how local structural-chemical interaction alters hybrid organic-inorganic perovskites (HOIPs) physics, revealing the ferroic nature of HOIPs, and how local properties affect the photovoltaic performance of HOIPs. Mr. Liu employs multiple techniques to study the microstructure and microchemistry of HOIPs, including scanning probe microscopy, secondary ion mass spectrometry, and nanoscale infrared spectroscopy. Mr. Liu's research interests include interface direct assembly, nanoscale imaging of functional properties, chemical imaging methods, and image processing with machine learning. Mr. Liu's recent publications as a co-author and first author focus on $CH_3NH_3PbI_3$ perovskite materials.

Robert Minneci is a third-year Ph.D. candidate in the Department of Materials Science and Engineering (MSE) at the University of Tennessee, Knoxville (UTK), who is working with his advisor, Dr. Claudia Rawn. Mr. Minneci recently completed a concurrent non-thesis master's degree in MSE during the summer of 2018. In addition to CMP financial support, Mr. Minneci is supported via a NASA membership in the Manufacturing and Materials Joining Innovation Center (Ma2JIC). The National Science Foundation (NSF) provides administrative funds for the UTK Ma^{2}JIC site while various industrial memberships support graduate students.

Mr. Minneci's research interests lie broadly in additive manufacturing research and development and diffraction-based research and characterization using both X-ray and neutron scattering techniques. His current research project involves working closely with staff from both NASA's Marshall Space Flight Center (MSFC) in Huntsville, Alabama, and Glen Research Center in Cleveland, Ohio, on the development of an additively-manufactured copper-based alloy that is used by NASA for high-temperature applications. He has conducted experiments (with more planned for the future) at the Neutron Residual Stress Facility (NRSF2) beamline at ORNL's High Flux Isotope Reactor (HFIR) and the Spallation Neutron Source's (SNS) VULCAN Engineering Materials Diffractometer. These experiments focus on (1) determining the residual stresses of alloy builds that have experienced large temperature gradients during fabrication, (2) determining the residual stresses caused by shape and thermal

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mismatch between the alloys that make up the build, and (3) in-situ mechanical testing. As part of this research, Mr. Minneci mentored an undergraduate student, Mr. Jared Floyd, through a Veterans Research Supplement that was funded by the NSF in 2017. Mr. Floyd assisted in data collection and sample preparation for a neutron experiment and assisted Mr. Minneci with sample preparation, metallography, and characterization. In addition to his research, Mr. Minneci was the graduate teaching assistant for both the senior/graduate-level course in materials characterization using X-ray diffraction and one of the MSE senior design groups during the 2017-2018 academic year. Mr. Minneci has served as a teaching assistant (TA) for the Tennessee Governor's School for the Sciences and Engineering in 2015, 2017, and 2018.

Prior to becoming a graduate student, Mr. Minneci earned his bachelor's degree in MSE at UTK with honors distinction in May 2016. During his time as an undergraduate, he was a Higher Education Research Experience (HERE) intern at Oak Ridge National Laboratory (ORNL) in the polymers research division at the Manufacturing Demonstration Facility (MDF). Mr. Minneci worked with large- and small-scale thermoplastic printers and small-scale thermoset printers to perform composite fabrication and design. During his undergraduate career, Mr. Minneci synthesized and post processed anionic clays as an undergraduate research assistant for Dr. Rawn. Wet chemistry synthesis, post processing at high temperatures and pressures, and characterization of the final product using X-ray powder diffraction were techniques included in this research.

Brianna Musicó is a third-year graduate student in the Materials Science and Engineering (MSE) Department at the University of Tennessee, Knoxville (UTK). Ms. Musicó received her B.S. degree in Materials Science and Engineering from the University of Tennessee in August of 2016. Her previous undergraduate and graduate experience as a research assistant was in the Radiochemistry Center for Excellence, where she studied 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. Ms. Musicó specifically studied the uranium trioxide system and investigated the electrical and material properties as a function of processing condition. She was a recipient of an MSE Travel Support Award in spring 2017 that she utilized to present a poster on the fabrication and characterization of UO3 pellets at the 12th Pacific Rim Conference on Ceramic and Glass Technology in May of 2017. Under the direction of Dr. Veerle Keppens, Ms. Musicó is currently focusing on the synthesis and characterization of high entropy oxides, a new class of ceramic materials. Multicomponent, high entropy systems have been investigated for their variety of physical properties achieved by forming new phases. This type of research has been performed on many metallic alloy systems (HEAs) but has only recently been expanded into ceramic systems by creating configurational disorder into a sublattice of mixed oxides to form a high entropy oxide (HEO). These classes of materials are of interest as they have potential for multi-functionality. Ms. Musicó is focused predominately on spinel and perovskite HEO systems, synthesizing single phase materials, and investigating the structure and magnetic properties. She also uses resonant ultrasound spectroscopy (RUS) for elastic moduli determination.

Ms. Musicó was awarded 2nd place poster at the Oak Ridge Chapter of ASM/Center for Materials Processing Student Night in the fall of 2017 for work on one-dimensional diffraction grating simulation of spinodal decomposition in a binary alloy. She was the recipient of the Graduate Student Service Award at the 2018 MSE Banquet. She applied for and was accepted to attend the highly competitive National School on Neutron & X-ray Scattering from July 21-August 3, 2018, which was held at Argonne National Lab (ANL) and Oak Ridge National Lab (ORNL).

Ms. Musicó has served as a graduate teaching assistant for many undergraduate classes, including the sophomore-level introductory course in materials science and the junior-level Principles of Materials Laboratory,

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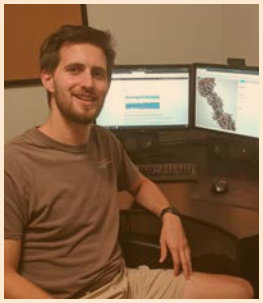
which she will be a TA for again this academic year. Ms. Musicó mentored seven interdisciplinary undergraduate students who worked as research assistants, educating them on safe methods for material processing, handling, and characterization. As someone who enjoys outreach, organization involvement, and making others aware of what materials science has to offer, Ms. Musicó has served as a mentor for high school students during the annual summer Materials Camp and as a teaching assistant for the 2016, 2017, and 2018 Governor's School for the Sciences and Engineering, for which she teaches the ceramic processing laboratory. She is a member of the Society of Women Engineers and helped found the UTK Engineering Mentors Program. Ms. Musicó was the 2017-2018 vice president for the UTK chapter of the Materials Research Society and is delighted to be serving as the 2018-2019 President.



Chris Ostrouchov is currently a Ph.D candidate and Chancellor's Fellow in the department of Materials Science and Engineering (MSE) working under the direction of his advisor, Dr. William Weber. His group focuses on understanding the fundamental physics behind radiation effects in materials, especially ion beam modification of materials. Mr. Ostrouchov received his bachelor's degree in applied mathematics with a minor in computer science from Clemson University.

While working in Dr. Weber's group, Mr. Ostrouchov has helped teach several graduate thermodynamics courses and a computational material science class focusing on density functional theory. For his teaching, Mr. Ostrouchov received the "Graduate Student Award for Excellence in Teaching" from the MSE department in the spring of 2017. In addition to teaching, he was the president of the UTK Materials Research Society, leading outreach events that educated others about material science.

Mr. Ostrouchov's broad research interests include the intersection of computation, statistics, and materials science. His undergraduate experiences taught him the importance of testing, reproducibility, and documentation to scientific codes, and he hopes to help bring that to computational materials research. Currently, his research focuses on interatomic-potential development for molecular dynamics. Mr. Ostrouchov is passionate about this work due to the application of advanced optimization methods and workflow automation of codes such as LAMMPS, VASP, and SIESTA. These potentials are especially important in the field of radiation materials due to current potentials not being suitable for non-equilibrium conditions.

Cody Pack is 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, where he performed research in polymer formulation. Prior to starting his graduate studies, he 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".

Mr. Pack's current research lies in the area of 3D printing, for which he employs direct write (DW) additive manufacturing to investigate the application of novel architectures with various feedstock materials to create and characterize multi-material hybrid structures. In DW, a viscoelastic feedstock is deposited by extrusion through a small nozzle to build structural or functional components with complex geometry or compositional architecture. DW is compatible with a broad range of feedstock materials, provided certain rheological requirements are met. Because it directly deposits material only where desired, DW is ideally suited for printing multi-material composites and novel hybrid architectures where properties can be tailored in unique ways. Broadly, his research addresses issues of feedstock

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formulation, printing hardware design, printing process challenges, and sample production, testing, and analyses. More specifically, Mr. Pack's current research involves application of a core-shell motif via DW with material systems, such as a foam core-carbon fiber shell architecture for improved stiffness in cellular structures, a stainless-steel core-hydroxyapatite shell for biomedical applications, and a nickel core-titanium carbide shell for cermet wear applications.

In the past year, Mr. Pack was the recipient of two travel grant awards from the National Science Foundation to present his research at the joint POWDERMET/AMPM 2018 conference in San Antonio, TX, and at the Solid Freeform Fabrication (SFF) Symposium in Austin, TX. In past years, Mr. Pack served as a graduate teaching assistant for a senior-level course on biomaterials and the junior-level Principles of Materials Laboratory. During previous summers, Mr. Pack assisted with the Materials Teachers Camp and served as a mentor for local high school students attending the annual Materials Camp.

Grace Pakeltis is a second-year Ph.D. student in the Materials Science and Engineering Department at the University of Tennessee, Knoxville (UTK). Ms. Pakeltis previously received her Bachelor of Science from the Materials Science and Engineering (MSE) Department at the University of Illinois in 2017. During her career at Illinois, she gained research experience working on the fabrication of biomedical electronic devices and on thin film device synthesis. While working with the CMP, she was under the direction of Professor Kurt Sickafus and investigated defect structures and dynamics in complex oxides exposed to extreme environments. Grace worked on processing various complex oxides in high-temperature and high-pressure environments using a hot uniaxial press. To investigate the defects induced in these structures, x-ray diffraction and transmission electron microscopy were used as characterization tools. This investigative science can lead to the discovery of new/improved materials for applications in nuclear reactors or high-temperature thermal barrier coatings.

Beginning in May 2018, Ms. Pakeltis began work on nanoscale synthesis and characterization of plasmonic materials and architectures. Using fabrication techniques such as electron beam lithography and focused electron beam induced deposition, she is investigating interesting plasmonic signatures that can be exploited. During the 2017-2018 academic year, Ms. Pakeltis served as a graduate teaching assistant for the introductory lab course and the senior design course. She is passionate about outreach activities and helping to introduce materials science and engineering to younger students. Ms. Pakeltis helped with the Materials Science and Engineering competition in the 2018 Tennessee Science Olympiad State Tournament held on the UTK campus and served as a mentor for a high school group during the week-long Materials Camp 2018. Ms. Pakeltis' Materials Camp group was recognized as having the best presentation describing the materials mystery that the campers were charged with solving.

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.S. in Physics from the Kwame Nkrumah University of Science and Technology (KNUST), Ghana, in 2008. Mr. Puplampu started his graduate studies at UTK in the spring of 2012 and focuses on mechanical and microstructural characterization of structural alloys.

Using in-situ neutron diffraction measurements, Mr. Puplampu aspires to better understand the post-yield anisotropic lattice plane response to mechanical loading. The experimental results provide data for validation of crystal plasticity finite element models. He is also collaborating with other scientists on the development of two-dimensional neutron detectors for diffraction measurements. Mr. Puplampu carried out experiments

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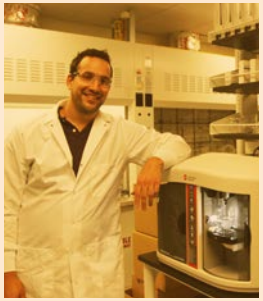
using the Neutron Residual Stress Mapping Facility (NRSF2) instrument at the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory (ORNL) and the E3 instrument at the Helmholtz Zentrum Berlin (HZB) in Berlin, Germany.

Other characterization techniques that Mr. Puplampu uses include digital imaging correlation for strain measurements, X-ray diffraction, and electron backscatter diffraction (EBSD) for microstructure evolution analysis. In addition, he has experience with time-of-flight (TOF) diffraction and small angle scattering (SANS) experiments conducted at ORNL on the VULCAN engineering materials diffractometer at the Spallation Neutron Source (SNS) and the GP-SANS instrument at the HFIR, respectively.

Dr. Penumadu and Mr. Puplampu made use of non-destructive 3D imaging with X-ray and neutron tomography in a collaboration with the late 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. These techniques were also used in the investigation of stress-induced damage in an aluminum alloy of structural interest.



John Robert Salasin finished his Ph.D. 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 Penn State University in 2012.

Dr. 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 Dr. Salasin's research focused on synthesizing layered double hydroxides for magnetic applications. The next summer, Dr. 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).

Dr. Salasin's broad research interests include energy materials, focusing on synthesis of novel thermoelectrics, battery materials, and anion-exchange media. He actively served as a mentor for some of the Research and Instructional Strategies in Engineering Retention (RISER) program's Undergraduate Research Assistants (URAs) and MSE undergraduate students performing research supported by the CMP. His mentoring ranged from supervising them in the laboratory to helping them prepare poster presentations of their research. Together with the undergraduate students, Dr. Salasin explored synthesizing doped calcium aluminate nanocages via sol-gel and hydrothermal processes in an attempt to increase electrical conductivity through induced cage disorder. At the Joint Institute for Advanced Materials (JIAM) Diffraction Facility, he pioneered kinetic investigations of phase transformations using rapid high-temperature X-ray diffraction. Dr. Salasin culminated his Ph.D. with three first-author papers that are currently under review. He is also the first author on a review manuscript published in a special issue of Crystals that focuses on the crystallography of functional materials, bringing his total scientific contribution to four first-author papers while funded by the CMP.

In addition to his research and mentoring responsibilities, Dr. Salasin operated as the manager of the CMP laboratory, where he designed and implemented a materials process and synthesis laboratory in the JIAM. He also worked to procure, install, and train students on equipment in the CMP processing laboratory. This included new characterization equipment to analyze and process starting reactants before densification and to measure density after processing. His research demanded that he use

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high-density samples for physical property measurements, so he actively used a uniaxial high-pressure/high-temperature press for consolidation of samples.

Clifton Sluss is a Ph.D. candidate in the Materials Science and Engineering Department. He received his bachelor's degree in mechanical engineering from the University of Tennessee in 2005. Mr. Sluss is a licensed professional engineer who currently works for the Y-12 National Security Complex in the Weapons Technical Support group, where he contributes to a variety of evaluation methods, including mechanical metallurgy, radiographic examination, dynamics, and mass properties.

Under the guidance of Dr. David Keffer, Mr. Sluss uses classical molecular dynamics simulations of materials to develop and extend an entropy functional. His research aims to make a robust entropy functional that is more accessible to both theorists and experimentalists.

Brandon Shaver is an engineering science Ph.D. candidate in the Department of Mechanical, Aerospace, and Biomedical Engineering (MABE). Mr. Shaver completed his B.S. and M.S. in Materials Science and Engineering (MSE) at the University of Tennessee in 2013 and 2015, respectively.
His Ph.D. research interests involve exploring the role of microstructure and non-stoichiometry on the semiconducting properties of uranium oxides, specifically uranium dioxide. This material is ubiquitous as a nuclear fuel but could exhibit promising electrical properties for solid-state applications such as neutron detection. Improving our understanding of the structure-property relationship of uranium oxides is required for such applications to be viable. Mr. Shaver also has an interest in space-related research topics and has recently been involved with work testing the mechanical properties of asteroid regolith simulant materials on a project supported by NASA. In the previous year, Mr. Shaver has presented his work at the 2018 Society of Advancement of Material and Process Engineering (SAMPE) conference and at the Symposium on Radiation Measurements and Applications (SORMA). He is anticipating completion of his dissertation in the fall of 2018.

Tyler Smith is a Ph.D. candidate in the Department of Physics and Astronomy at the University of Tennessee, Knoxville (UTK), working with Dr. Hanno Weitering. Mr. Smith received his B.S. in Mathematics from Lee University (LU) in 2012 and his M.S. from UTK in 2015, at which time he began his work with Dr. Weitering.
His main area of interest is the optimization and growth of sub-monolayer surface phases, which are probed using scanning tunneling spectroscopy (STM), X-ray photoelectron spectroscopy (XPS), and low energy electron diffraction (LEED). Mr. Smith's most recent study focuses on driving electronic instabilities, such as superconductivity or charge/spin density waves, in strictly two-dimensional metallic systems on semiconductor surfaces. Specifically, the systems are examined through modulation and adsorbate doping, with a greater goal of understanding electronic correlations in relatively simple systems. Prior to joining the CMP, Mr. Smith was a co-author for several articles, including "Realization of a Hole-Doped Mott Insulator on a Triangular Silicon Lattice" in Physical Review Letters and "Atomic and Electronic Structure of Doped Si(111)($2\sqrt{3} \times 2\sqrt{3}$)R30° -Sn Interfaces" in Physical Review B. His current research involves the optimization of additional dopants on these surfaces to drive further interesting electronic phenomena, with the exciting possibility of realizing superconductivity on a simple silicon platform. Such a discovery would result in possible applications in quantum technologies. Mr. Smith is currently working on a manuscript containing exciting results from alkali metal doping experiments of these 2D systems, where the surface undergoes a metal-insulator transition as the valence electrons condense into a beautiful Kagome pattern with potentially exotic topological quantum properties.

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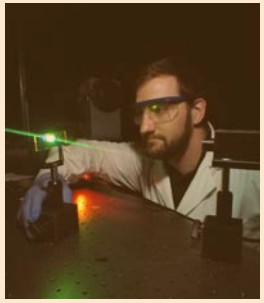

Jeremy Tisdale is a fifth-year Ph.D. student in the Materials Science and Engineering Department at the University of Tennessee, Knoxville, who is expecting to graduate in December 2018. Mr. Tisdale previously received his Bachelor of Science and Master of Science from the Materials Science and Engineering (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 organometallic halide perovskites, Mr. Tisdale is focusing his Ph.D. research under the guidance of Dr. Bin Hu on the development of organic-lead halide perovskite single crystals towards high-resolution, room temperature gamma-ray sensing. This research includes synthesis of single crystalline methylammonium lead halide perovskites and optimization of growth techniques towards high optoelectronic quality crystals. After synthesis, post-growth treatments and characterization of bulk and surface properties through photoluminescence, current-voltage characteristics, impedance spectroscopy, XRD, etc., are vital to understanding the optoelectronic properties and mechanisms inside the single crystals for high-resolution sensing. Once high-quality crystals are grown, research moves towards device fabrication to be tested for high energy radiation sensing performance. Recent work in this area on interfacial properties between metals and single crystal hybrid perovskites has been published in Advanced Materials Interfaces, with additional work on the synthesis of organometallic hybrid perovskite single crystals under review in other high impact journals.

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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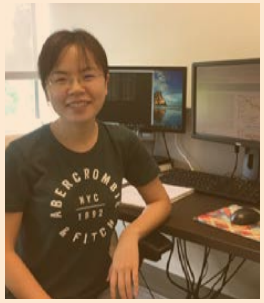
Joshua Tharpe graduated from Union County High School in 2013 and enrolled at the University of Tennessee later that year. During his time as an undergraduate, Mr. Tharpe was involved with several research projects that encompassed materials science and engineering (his area of study) and several other disciplines. With support from the Center for Materials Processing, he enrolled in a five-year BS/MS program during the senior year of his undergraduate career and graduated with a bachelor's degree in materials science and engineering with a minor in reliability and maintainability in May of 2017. While Mr. Tharpe was working towards his master's degree during the fall of 2017, he accepted a position to found an advanced manufacturing program at Union County High School, where he graduated four years prior. In the spring of 2018, Mr. Tharpe began teaching advanced manufacturing part time while completing his course work for his master's degree in materials science and engineering. In June, he completed the requirements for receiving a non-thesis master's degree and participated as a mentor for Materials Camp 2018. In fall of 2018, he will begin teaching full time at Union County High School and is excited to use his education to make an impact in the studies of science, engineering, and technology in his home town.



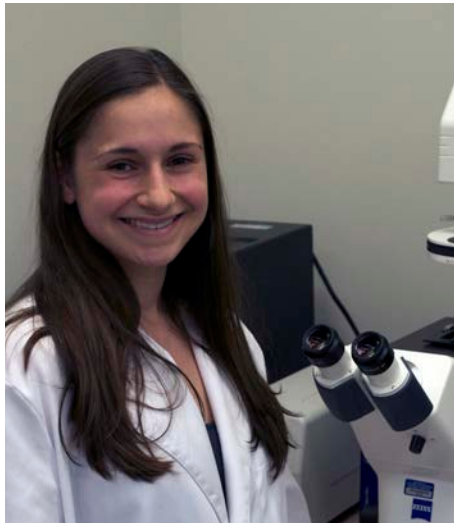
Xue Wang is a third-year graduate student in the Materials Science and Engineering (MSE) Department at the University of Tennessee, Knoxville. Previously, Ms. Wang received her Bachelor of Engineering in Engineering Mechanics in 2011 and her Master of Science in Engineering Mechanics in 2014 from Dalian University of Technology, China. Ms. Wang joined Prof. Yanfei Gao's group in 2016 and began focusing on computational modeling and simulation of metallurgy problems that depend on the relationships between processing, microstructure, and property. In the spring of 2017, she served as a graduate teaching assistant

Graduate Students Cont.

(GTA) for the graduate course "Metallurgy of Deformation and Fracture." Ms. Wang is currently working on a research project focused on friction stir welding and trying to quantify the transition of the stick-slip zone of the workpiece during the welding process based on theoretical contact mechanics and finite element analysis. She also contributes to studies aimed at the design and development of optimal microstructures in bulk-metallic-glass composites (BMGCs) by using finite element analysis and developing a new code to treat both plasticity and temperature in the simulations. Ms. Wang's major source of financial support is through an industrial membership in the Manufacturing and Materials Joining Innovation Center (Ma2JIC), and she participates in the semiannual Industrial Advisory Board meetings by presenting her research results as posters and oral presentations.

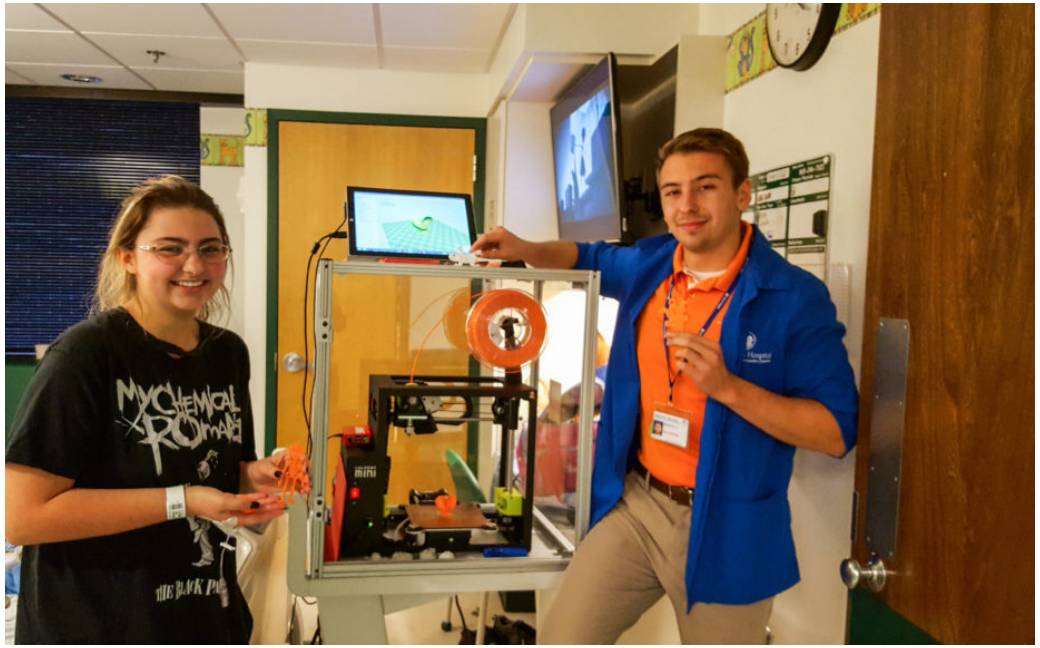
Dissertation and Thesis Titles

Student: *Benjamin Wolf*
Degree: Master of Science
Graduation Date: August 2017
Committee Members: Philip Rack, Jason Fowlkes, Claudia Rawn
Title: Dewetting Properties of Ag-Ni Alloy Thin Films
Current Position: Waviks



Student: *Emily Morin*
Degree: Doctor of Philosophy
Graduation Date: August 2017
Committee Members: We He, Madhu Dhar, Andy Sarles, Xiaopeng Zhao
Title: Crafting Nanostructured Neural Interfaces with Hydrogel Particles
Current Position: Tesa Tape

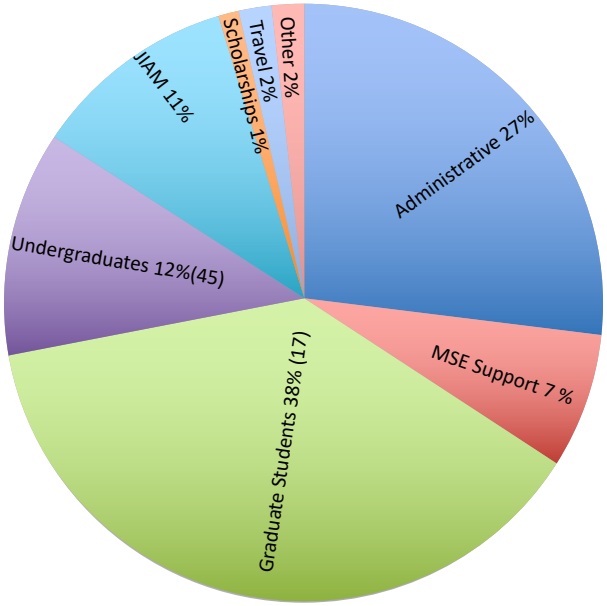
Printers for Patients



The CMP provided support for a Mobile Materials Science Cart that is used in outreach events to support materials processing education. The cart made its way to East Tennessee Children's Hospital, where UT students entertained and educated patients through the use of a portable 3D printer. One of those students, Brandon Rowell, recently graduated from the Materials Science and Engineering Department with a biomaterials concentration. Mr. Rowell has volunteered at the hospital since high school and is part of its Childlife program, which is devoted to caring for and enhancing the lives of the children undergoing treatment. "Anything that can help them focus on something else for a moment, help pass the time, and maybe take their minds off the stresses of treatment is a win," said Rowell. "It's been wonderful to see the reaction of the kids to the printer and their curiosity in how it works." The project has been a cross-departmental collaboration and a service-learning activity for students. The project has spawned a UT service organization that is expanding the program by taking the cart to local elementary and middle schools to further broadcast the educational initiative. The organization SLOPE (Service Learning and Outreach with 3D Printers by Engineers) includes over 20 engineers from five different engineering majors in the Tickle College of Engineering at UT.

Program Overview and Accomplishments

In FY18, approximately 86% of the appropriation expenditures for the **Center for Materials Processing (CMP)** were for supporting personnel, with about half of salary expenditures used to support graduate and undergraduate assistantships. These students remember the CMP and its support long after they have graduated and joined the workforce. Undergraduate research and experiential learning is becoming of more and more importance for students to include on their transcripts and resumes. The CMP was an early supporter of undergraduate research and continues to support undergraduate students' meaningful participation in research. In FY18, the CMP either fully or partially supported 45 undergraduates; **Ms. Sabrina Schwerzler,** one of the CMP supported undergraduates, is featured in the undergraduate highlight.



A pie chart of the FY18 expenditures is featured and divided into the categories of administration, **Materials Science and Engineering** support (partial support of two staff members), graduate students (stipends, tuition, health insurance), undergraduates (hourly wages), support for the **Joint Institute for Advanced Materials (JIAM)**, scholarships, travel, and other. The administrative cost in FY18 increased from recent years, where it has been around 16-21% of the expenditures. The increase is mostly attributed to the addition of **Chris Wetteland** to the position of **associate director of industrial relationships and undergraduate research**, with the goal of increasing the number of Industrial Memberships that support students who conduct materials processing related research. The support of MSE staff members has decreased slightly from recent FY's, with the decrease attributed to retirements in FY18. The percentages of both graduate and undergraduate financial support increased in FY18. The CMP supported JIAM activities by providing partial support to JIAM Diffraction Facility Laboratory Manager **Dr. Michael Koehler** and by supporting students to use both the diffraction and microscopy facilities. New in FY18 is the category of scholarships. As a way of recruiting undergraduate students to the field of materials science and engineering, the CMP matched scholarship funds from the MSE department for recruiting students; these students are featured in a separate section of the annual report. The CMP awards full or partial travel support to students who have won local poster competitions so that they can attend professional meetings and present their research. These travel awards act as a way of disseminating the outstanding research by University of Tennessee students to a larger community; the majority of travel funds were used in this manner. In FY18, the CMP financially assisted students in presenting their research at the **Materials Science & Technology (MS&T) Technical Meeting and Exhibition** in Pittsburgh, Pennsylvania, in October 2017 and the TMS Annual Meeting and Exhibition in Phoenix, Arizona, in late March 2018. Additional partial travel support was provided for four undergraduates to attend **Congressional Visit Days**, held April 2018 in Washington, DC, where the students participated in the training and networking sessions as well as visits with legislators and staffers (see feature in separate section). The other section of the pie chart includes expenditures for media processing (poster printing), computer services, communications, and laboratory supplies.

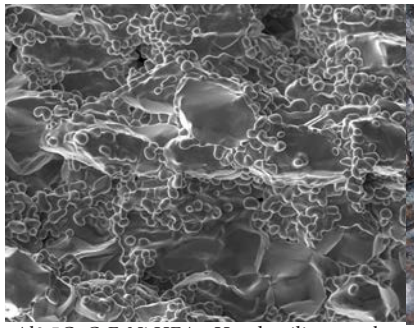
Program Overview and Accomplishments

Two big changes for the CMP occurred in FY18. The first change is that the CMP moved from its long-time home on the fifth floor of East Stadium Hall to Ferris Hall in December 2018. Being located in the same building as the MSE department brings a larger volume of visitors to the CMP office. The other change in FY18 was that the CMP hosted its first competition for graduate student support. Historically, the CMP graduate student support was offered as matching funds for faculty submitting proposals to various funding agencies. The new method of graduate student support encourages the graduate students to apply for support by submitting applications featuring discrete projects related to materials processing. These applications are judged by a committee comprised of **Dr. Bill Dunne** (Tickle College of Engineering associate dean for research and facilities), **Dr. Chad Duty** (associate professor in the Mechanical, Aerospace and Biomedical Engineering department), **Dr. Veerle Keppens** (MSE department head and director of JIAM), and **Dr. Claudia Rawn** (associate professor in the MSE department and director of the CMP). In January, **Christine Ajinjeru** and **Tyler Smith** started as the first two students supported in this manner. The section on graduate students includes biographies on Anjinjeru and Smith, both of whom conduct research at the **Manufacturing Demonstration Facility** and the **JIAM**, respectively. Ajinjeru's research is focused on developing new polymeric materials for additive manufacturing, and Smith's research is focused on the optimization and growth of sub-monolayer surface phases to push interesting electronic phenomena.

CMP supported graduate students are involved in the fabrication, manufacturing, and synthesis of a wide range of materials. The focus of these projects is on the materials science and engineering links between the processing of materials, the ultimate performance of material systems, and the structure at various scales. CMP students are involved in research aimed at improving electronic, magnetic, mechanical, optical, and/or thermal properties with the hope that the improved materials will ultimately be used in industrial applications within the aerospace, automotive, chemical, and energy sectors. Specific materials include Li-ion battery components, organometallic hybrid perovskites for solar applications, and high entropy alloys and high entropy oxides for improved mechanical properties. The research is focused on developing new materials with advanced properties, improving specific properties, and finding materials that have compromising properties for specialty applications (e.g., lightweight and strong). Some of the CMP students use computational studies to complement and/or guide experimental research, and most perform characterization techniques using state-of-the-art facilities. For the latter, CMP students use various neutron and X-ray scattering techniques, electron microscopy, and physical property measurements to assess material improvements. Facilities where CMP students work include the JIAM Microscopy and Diffraction Core Facilities and Oak Ridge National Laboratory facilities, including the MDF, the High Flux Isotope Reactor (HFIR), and the Spallation Neutron Source (SNS). Detailed information can be found in the student biographies.

Another mode of supporting students is through the CMP covering initial membership dues for students to join **Materials Advantage (MA)**. In FY18, nineteen student memberships at $30/student were funded by the CMP; in subsequent years, the students are expected to pay for their own membership dues. The UTK MA chapter gets a rebate of $5/member, and the students become members in the American Ceramic Society, Association for Iron & Steel Technology, ASM International, and TMS. As part of the membership, the students receive rotating print and monthly electronic subscriptions of American Ceramic Society Bulletin, Iron & Steel Technology, Advanced Materials & Processes, and JOM.

Program Overview and Accomplishments



Al0.5CoCrFeNi HEA - Hot ductility sample - John Bohling

Cast iron 200X

Rawn, Wettleland and CMP students continued to participate in outreach activities including **Materials Camp** and the **Tennessee Governor's Schools for Science and Engineering** (see updates later in this volume). These events host high school students, mostly from Tennessee, that are academically gifted and interested in science, technology, engineering, and mathematics (STEM). These experiences help the students to evaluate majoring in a STEM discipline and, more specifically, in materials science and engineering. The eventual goal is to add more materials scientists and engineers as part of the STEM workforce. During previous Materials Camps and Governor's Schools, we targeted some of the high-performing students from these two activities and partnered with the **Department of Materials Science and Engineering** to offer joint scholarships. Three students (**Alison Campbell, Samantha Maness, and Jackson Spurling**) received these scholarships starting in fall of 2017.

In past FY's, the CMP has helped to provide matching funds to acquire several instruments in the **JIAM Diffraction (XRD) Facility**, part of the University of Tennessee's Core Facilities Program intended to provide access to high-end instrumentation, technical support, and expert consultation to both users from across the university and external customers for a fee. The new PANalytical X'Pert3 MRD and Empyrean X-ray diffractometers are located in the JIAM. **Dr. Michael Koehler** acts as the laboratory manager and is in charge of the day-to-day operations of the laboratory, including helping students to collect and analyze X-ray diffraction data, and **Dr. Kurt Sickafus** serves as the JIAM Diffraction Facility's director and scientific leader. Throughout FY18, the JIAM Diffraction Facility served 99 unique users from departments across UTK, such as forestry, microbiology, physics, materials science and engineering, civil engineering, food science, and nuclear engineering, among others. The Diffraction Facility was used to determine levels of crystallinity in lactose and cellulose, to perform phase identification and lattice parameter calculations as a function of chemical composition and heat treatment of thin films, and to investigate the structure of various carbon fibers and carbon fiber precursors.

One of the main goals of the Diffraction Facility in FY18 was to further develop its high-temperature capabilities. Through attending the NCSU Non-ambient X-ray Diffraction Symposium, Dr. Koehler, Dr. Claudia Rawn, and Mr. John Salasin learned how to modify the software of the Diffraction Facility's high-temperature sample stage to allow for kinetic studies of materials. As a result, users were able to perform in situ synthesis studies of ceramic materials using both solid-state and sol-gel synthesis techniques, determine the temperatures at which crystallization and phase transitions occurred in bulk metallic glasses, and study the growth of thin oxide layers on samples exposed to air at elevated temperatures.

Drs. Koehler, Rawn, and Sickafus have been working together to expand the Diffraction Facility's capabilities through the purchase of new hardware. Funding was acquired in late FY18 to purchase a cobalt X-ray tube in early FY19. Copper X-ray tubes (the only type currently found in the JIAM Diffraction Facility) cause fluorescence in samples rich with iron or cobalt. This fluorescence serves to

greatly increase noise and background in diffraction patterns, potentially hiding important details such as small amounts of impurity phases. With the addition of the cobalt X-ray tube, users with samples that would normally suffer from fluorescence (e.g., steel samples) will find the JIAM Diffraction Facility much more accommodating.

The UTK site of the **Manufacturing and Materials Joining Innovation Center (Ma²JIC),** with research interests closely aligned with the CMP, continued to grow in both industrial support and students. In FY18, a proposal was submitted to **National Science Foundation (NSF)**, positively reviewed, and funded, allowing the UTK site of Ma²JIC to move to the second phase of the NSF Industry/University Collaborative Research Center (I/UCRC) Program along with The Ohio State University (the lead university site) and Ma²JIC sites at Colorado School of Mines and Lehigh University. **Dr. Claudia Rawn** and **Ms. Karen Boyce** are both partially supported by the funds allocated for the administration of the UTK site of Ma²JIC.

CMP Equipment

In FY18, the CMP saw increased usage of its core experimental equipment, which includes a Gilson AutoSiever, Fritsch Ball Mill, Beckman Coulter particle size analyzer, and Quantachrome helium gas pycnometer. The instruments are supplemented by a suite of furnaces, which are all located at the Joint Institute for Advanced Manufacturing (JIAM) building. Equipment usage has been predominately from undergraduate and graduate students, however, the CMP has been actively working to increase industrial interest. A full list of CMP equipment and introductions to various processing and characterization techniques can be found at https://cmp.utk.edu/catalog-of-experimental-equipment/.

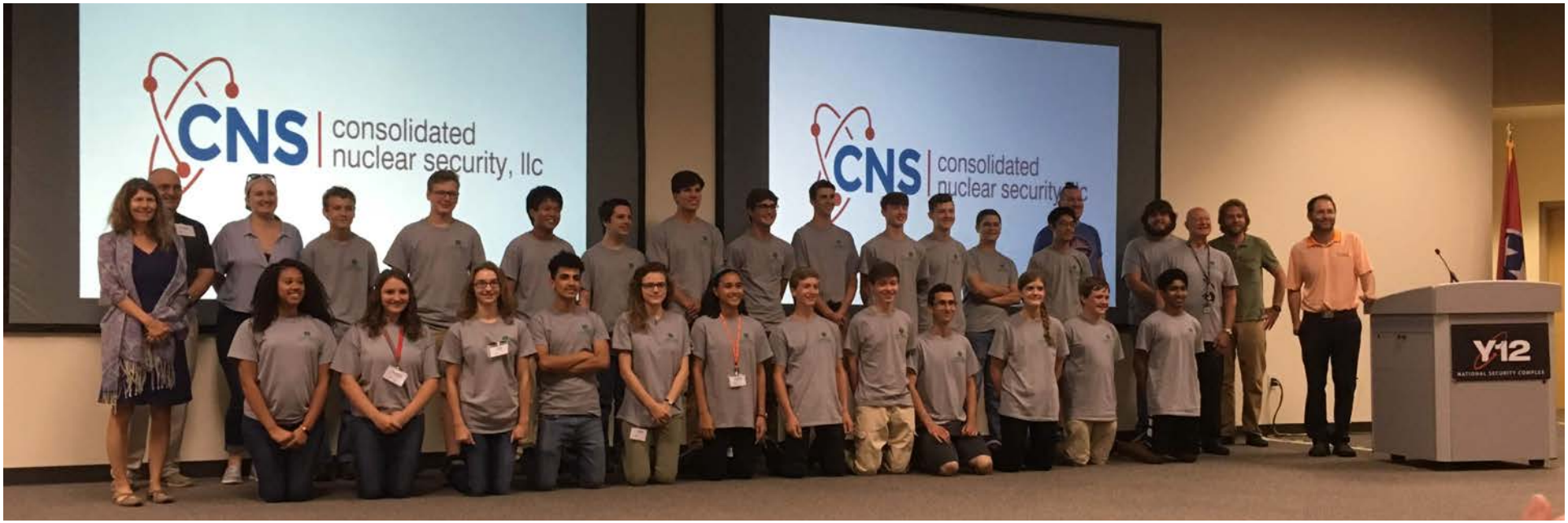
Goals/Future Plans

In FY18, the CMP started its new competition for providing financial support of graduate students who propose discreet short (one to one-and-a-half years) projects. One FY19 goal is to continue to grow this program and increase the number of graduate students that receive CMP support through this program.

With Chris Wetteland joining the CMP administrative team as the associate director of industrial partnerships and undergraduate research in FY19, the CMP will be focused on increasing the number of industrial memberships. In FY18, there was an extensive review of the CMP membership agreement, and one of the goals for FY19 is to see a new approved CMP membership agreement in place with intellectual property agreements that are more attractive to potential industrial members. In FY19, we will be focused on increasing the number of Industrial Memberships, including the Facility Level membership introduced in FY17 and memberships that support student research. One way the CMP is planning to engage with industry is through the Center for Industrial Services (CIS), which is one of five units of the University of Tennessee Institute for Public Service. The CIS helps companies and communities succeed, grow, and create high quality jobs by providing consulting, training, and connecting services across the state. It is a FY19 goal of the CMP to support materials processing efforts that overlap with the CIS.

In FY19 and beyond, the CMP will be encouraging students supported by the CMP to (1) participate in CMP sponsored and co-sponsored events, such as the end of summer research poster session and Student Night in fall, (2) participate in University sponsored events, such as the Exhibition of Undergraduate Research and Creative Achievement (EUReCA) in the spring and Discovery Day in the fall, and (3) recognize and acknowledge the CMP and the Tennessee Higher Education Commission for their support. In an effort to increase the visibility of materials processing research, the CMP will be alerting both faculty and students to external materials processing related funding and scholarship announcements and encouraging competitive applications.

Materials Camp 2018



Twenty-two high school students from Tennessee, Florida, and Maryland attended Materials Camp 2018. This was the 13th Materials Camp held in the Knoxville/Oak Ridge area and represents a team effort between faculty, staff, and students from the University of Tennessee, Oak Ridge National Laboratory, Consolidated Nuclear Security, LLC (Y-12 National Security Complex), and (for the first year) Pellissippi State Community College. The scientific equipment companies Mager Scientific and Zeiss also participated in the outreach event by bringing in equipment for the Materials Campers to gain hands-on experience.

At the beginning of the camp, the students were briefed on a fictional whodunit involving sabotage in space. They then divided into four teams and were provided samples of the galactic incident to examine. During the week, the campers used mechanical testing, scanning electron microscopy, optical microscopy, X-ray diffraction, computer-aided design, 3-D printing, photovoltaics, and other materials science techniques. At the culmination of the camp, the campers presented results and conclusions about the space sabotage to family members, materials science professionals, and a panel of judges.

Materials Camp is a great way for the CMP to promote materials processing education and recruit the next generation of scientists and engineers into the field. Since the camp started, about 10% of the campers have attended the MSE Department at UTK to obtain their bachelor's degree in MSE, and many of them have stayed on to pursue either their master's or doctoral degrees.

Oak Ridge Chapter of ASM/Center for Materials Processing Student Night

Student Night 2017, an annual event celebrating student research, was held on October 26th at the Crescent Bend House just west of campus. This year, the event was co-sponsored by the Oak Ridge Chapter of ASM and the Center for Materials Processing (CMP). Over 40 students presented their research, and judges from Oak Ridge National Laboratory and the University of Tennessee spoke with the students at their posters to learn about the details. Both experimental and computational studies were presented on materials, including high entropy alloys, metals, ceramics, perovskite solar cell materials, and materials found in nature such as gas hydrates and lignin. Some research focused on processing techniques, including select laser melting and direct ink writing additive manufacturing techniques, crystal growth, and ion radiation, while other research focused on characterizing materials including their microstructure and mechanical properties. The Undergraduate Award recognized UTK Materials Science and Engineering (MSE) senior Madeline Wimmer for her work on crack growth measurement for in-pile irradiation-assisted stress corrosion cracking (IASCC). Judges were unable to determine a clear third-place winner and decided to recognize three graduate students, Stian K. Romberg, Melonie Thomas, and Anna Hoffman, for their work. Stian is a graduate student working with Dr. Brett Compton in the UTK Mechanical, Aerospace, and Biomedical Engineering Department and presented on 3D printing of functionally graded cellular structures. Melonie is a chemistry major at the University of Kentucky studying the morphology control and magnetic properties of FeSe2 and FeS nano-clusters, nano-flowers, and nano-platelets. Anna is a graduate student in the MSE Department working with Dr. Philip Rack studying the effects of air adsorbents on electrical properties of 2D materials. Second place was awarded to the team of Brianna Musico and Cordell Delzer, graduate students in MSE and Nuclear Engineering, respectively, for their work with Dr. Kurt Sickafus on one-dimensional diffraction grating simulation of spinodal decomposition in a binary alloy. First place was awarded to Peijun Hou, a graduate student in the MSE Department working with Dr. Hahn Choo studying delayed cracking phenomenon in deep-drawn stainless steel alloys and focusing on the role of transformation kinetics, microstructure, and texture. The Oak Ridge Chapter of ASM recognized 1st, 2nd, and 3rd places with cash awards of $500, $300, and $200, respectively, and an undergraduate award of $300. The CMP matched most of the awards with equivalent travel support to be used by the students for presenting their work at professional conferences.

Congressional Visit Day

Pictured from left to right: Melanie Buziak, Max Neveau, and Christina Cox in front of the Capital.

Congressional Visit Day (CVD) is a Material Advantage sponsored event that allows college students to advocate for the allocation of non-defense discretionary funding towards STEM-related federally funded organizations (i.e., National Science Foundation and the Department of Energy). Held annually, CVD is an opportunity for students to communicate the pertinence of federal funding in order to drive our society, economy, and nation towards a better future. CVD assists representatives in understanding the necessity for federal recognition of STEM research by those who will be most directly impacted by future federal spending, in this case materials science and engineering undergraduate students. CVD allows students to meet in-person with Congressional representatives, usually from their own state, significantly improving the student's professional development and public speaking in a unique, high-stress environment. Congressional Visits Day is a once in a lifetime opportunity, encouraging the growth of networking skills and professional development for students and, more importantly, communicating to them the necessity for research in their field. Students representing the University of Tennessee, Knoxville, Chapter of Materials Advantage in April 2018 were Melanie Buziak (sophomore), Christina Cox (senior), Max Neveau (junior), and Christopher Walker (senior). For Cox and Walker, this was their second year attending CVD, and Buziak and Neveau hope to attend again with new students in 2019.

Tennessee Governor's School for Science and Engineering - 2018

For the sixth year in a row, the Department of Materials Science and Engineering (MSE) participated in the Tennessee Governor's School for Science and Engineering (GSSE). Seventeen Tennessee high school rising juniors and seniors were selected out of a large pool of applicants based on their outstanding academic achievements and recommendations, and they participated in the MSE section of GSSE. The four-week schools are held on the University of Tennessee, Knoxville, campus during the month of June. During the afternoon, MSE GSSE students exclusively participated in lectures, creative projects, and laboratories introducing them to fundamental materials science and engineering concepts. The students were separated into two groups of roughly equal size and rotated through two different laboratories. The first laboratory involved mechanical testing and solid state synthesis of ceramics ($MgAl_2O_4$) and the cold working of brass, and the second laboratory involved density measurements, scanning electron microscopy, and X-ray diffraction. In addition to the laboratory experiences, the class attended field trips at ARCONIX in Alcoa, ORNL's newest super computer (Summit), and the Manufacturing Demonstration Facility (MDF). This year, Claudia Rawn and Chris Wetteland organized and participated in the events with the help of teaching assistants for the various laboratories, including graduate students Robert Minneci and Brianna Musico from the MSE department. The month concluded with teams of students preparing posters on their various favorite laboratory experiences and presenting them to the students, faculty, and staff of the MSE department. The same posters were presented at the GSSE closing ceremony.

Schedule 7

CENTERS OF EXCELLENCE ACTUAL, PROPOSED, AND REQUESTED BUDGET

Institution: THE UNIVERSITY OF TENNESSEE, KNOXVILLE **Center:** Materials Processing

	FY 2017-18 Actual			FY 2018-19 Proposed			FY 2019-20 Requested		
	Matching	Appropr.	Total	Matching	Appropr.	Total	Matching	Appropr.	Total
Expenditures	**$1,073,349**	**$627,866**	**$1,701,215**	**$1,187,017**	**$698,459**	**$1,885,476**	**$1,246,367**	**$690,192**	**$1,936,559**
Salaries									
Faculty	$168,401	$101,539	**$269,940**	$176,821	$105,000	**$281,821**	$185,662	$110,250	**$295,912**
Other Professional	$47,135	$64,902	**$112,037**	$49,491	$62,000	**$111,491**	$51,966	$65,100	**$117,066**
Clerical/ Supporting	$135,216	$56,516	**$191,732**	$141,977	$45,000	**$186,977**	$149,076	$47,250	**$196,326**
Assistantships	$317,578	$220,176	**$537,754**	$333,457	$265,000	**$598,457**	$350,130	$265,000	**$615,130**
Total Salaries	**$668,329**	**$443,134**	**$1,111,463**	**$701,746**	**$477,000**	**$1,178,746**	**$736,833**	**$487,600**	**$1,224,433**
Longevity (Exclude from Salaries)	$4,566	$2,738	**$7,304**	$4,794	$3,000	**$7,794**	$5,034	$3,500	**$8,534**
Fringe Benefits	$139,215	$95,373	**$234,588**	$146,175	$144,000	**$290,175**	$153,484	$147,330	**$300,814**
Total Personnel	**$812,109**	**$541,245**	**$1,353,354**	**$852,715**	**$624,000**	**$1,476,715**	**$895,351**	**$638,430**	**$1,533,781**
Non-Personnel									
Travel	$31,874	$10,897	**$42,770**	$33,467	$10,000	**$43,467**	$35,141	$8,000	**$43,141**
Other Supplies	$42,831	$5,994	**$48,825**	$44,972	$6,000	**$50,972**	$47,221	$6,000	**$53,221**
Equipment			**$0**	$60,000	$15,000	**$75,000**	$63,000	$10,000	**$73,000**
Scholarships (listed as Awards)	$8,600	$6,156	**$14,756**	$9,030	$8,459	**$17,489**	$9,482	$7,542	**$17,024**
Other (Specify):									
Media Processing	$122	$2,337	**$2,459**	$128	$4,000	**$4,128**	$134	$4,200	**$4,334**
Utilities & Fuel		$102	**$102**		$200	**$200**		$210	**$210**
Communication	$376	$159	**$534**	$395	$100	**$495**	$414	$105	**$519**
Computer Services		$526	**$526**	$0	$100	**$100**		$105	**$105**
Grants & Subsidies	$116,922	$40,469	**$157,392**	$122,768	$20,000	**$142,768**	$128,907	$10,000	**$138,907**
Contractual & Special Services	$60,516	$13,374	**$73,890**	$63,541	$10,000	**$73,541**	$66,718	$5,000	**$71,718**
Other Services & Expenditures		$570	**$570**		$600	**$600**		$600	**$600**
UT Direct Cost Share		$6,037	**$6,037**			**$0**			**$0**
Total Non-Personnel	**$261,240**	**$86,621**	**$347,861**	**$334,302**	**$74,459**	**$408,761**	**$351,017**	**$51,762**	**$402,779**
GRAND TOTAL	**$1,073,349**	**$627,866**	**$1,701,215**	**$1,187,017**	**$698,459**	**$1,885,476**	**$1,246,367**	**$690,192**	**$1,936,559**
Revenue									
New State Appropriation		$644,858	**$644,858**		$657,297	**$657,297**		$690,192	**$690,192**
Carryover State Appropriation		$24,170	**$24,170**		$41,162	**$41,162**			**$0**
New Matching Funds	$1,073,349		**$1,073,349**	$1,187,017		**$1,187,017**	$1,246,367		**$1,246,367**
Total Revenue	**$1,073,349**	**$669,028**	**$1,742,377**	**$1,187,017**	**$698,459**	**$1,885,476**	**$1,246,367**	**$690,192**	**$1,936,559**

PI	Account	Amount	Source
Thompson	E010129034	$ 1,315	Chancellor Fellowship FY 16
Weitering	E011060	$ 155	Physics
Rawn	E011310	$ 11,153	MTRLS PROCESSING CTR
Rawn	E011310009	$ 57,213	CTR OF EXC-MATERIAL PROCESSING-E&G
Keppens	E011315	$ 344,073	Materials Science and Engineering
Keppens	E011315072	$ 280	ORU-IMHM 18 - Xu
Khomami	E011320	$ 15,390	Chemical and Biomolecular Engineering
Mench	E011370004	$ 3,678	StartUp-Duty
Mench	E011370005	$ 5,523	StartUp-Compton
Hines	E011380024	$ 622	StartUp - Donovan
Keppens	E011398	$ 168	Materials Science & Engineering Research
Keppens	E011398001	$ 3,218	MSE Course Fees
Keppens	E019901016	$ 56,177	JIAM Diffraction Facility
Carrier	E111425	$ 590	Biosystems Engr & Soil Science F&A
Holland	E180110	$ 3,460	Research-Large Animal Clinical Sciences
Weitering	R011065354	$ 10,060	NSF DMR: Tuning Electronic Instabilities in Triangular Surface Lattices via Subsurface Doping
Blache	R011302079	$ 76,606	RMC - Private
Rawn	R011310035	$ 1,658	CMP-Small Scale Mech Test-Phar
Rawn	R011310068	$ 1,658	Agilent Technologies Fnd - Rawn
Rawn	R011310091	$ 25,948	NSF IUCRC Project 3 ICME Tools Additive
Rawn	R011310093	$ 34,099	UT-B: 4000155953
Melcher	R011314027	$ 2,065	US DHS - Developing Low Cost Scintillators with Excellent Energy Resolution
Melcher	R011314028	$ 7,261	Siemens Molecular Imaging 2015/20 Melcher
Keffer	R011315022	$ 240	Faculty Grant Enrichment Fund - Keffer
Keppens	R011315024	$ 8,600	E EUGENE STANSBURY FUND
Weber	R011315102	$ 5,699	Gov Chair Weber Discretionary Research Funds
Keppens	R011316041	$ 1,185	Material Sci & Engr Enrichment
Duscher	R011316095	$ 1,665	Faculty Grant Enrichment Fund Duscher
Lundin	R011318070	$ 57,199	CMP Welding Research
Choo	R011318254	$ 26,700	NSF DMR: In Situ Neutron Diffraction & Fluid Dynamics Modeling of Dynamic Recrystallization in Mg Alloys
Liaw	R011318272	$ 21,238	Univ of Illinois 2013-04279-01 Liaw
Mandrus	R011318280	$ 2,365	NSF DMR: Building New Spintronic Materials with Layered Chalcogenides
Xu	R011318286	$ 350	DOE DE: Integrated Computational & Experimental Study of Radiation Damage Effects in Grade 92 Steel and Alloy 709
Hu	R011318303	$ 7,057	NSF CBET: Addressing Donor: Acceptor Interface and Electrode Interface for Enhancing Photovoltaic Actions in Organic Solar Cells
Rawn	R011318308	$ 23,493	NSF IIP 1540000 Rawn
Meek	R011318311	$ 33,499	DOD DTRA: Urania-based Direct Conversion Neutron Detectors
Zhuravleva	R011318312	$ 1,130	US DHS - Scale-up to Success: Pioneering Crystal Growth of Large High Resolution Scintillators
Rack	R011318314	$ 235	NSF: CPS: Synergy: Collaborative Research: Cyber-Physical Digital Microfluidics Based on Active Matrix Electrowetting Technology
Choo	R011318317	$ 18,302	Directed Vapor Internet Phase 2: High-Performance Magnesium Alloys and Composites by Efficient Vapor Phase Processing
Rawn	R011318322	$ 23,239	NSF IUCRC Proj 2 Neut (NASA-Choo) Rawn
Rawn	R011318327	$ 280	I/UCRC: Center for Integrative Materials Joining Science for Energy Appliation - VRS & RET
Liaw	R011318331	$ 69,466	NSF DMR-1611180 Liaw
Rack	R011318334	$ 235	NSF CBET: Collaborative Research: Computations, Modeling & Experiments
Melcher	R011318335	$ 8,162	Univ of California Berkeley: Nuclear Science and Engineering Nonproliferation Research Consortium
Liaw	R011318345	$ 1,576	Computational Materials Assessment of High-Entropy Alloys & Entropic Stabilization of Nickel Superaloys for Turbine Applications
Wetteland	R011318346	$ 15,914	UT-B 4000155686 Wetteland
Choo	R011318355	$ 9,743	CNS, LLC: Synchrotron X-Ray Micro-tomography Imaging of Defects in 3-D Printed Stainless Steel Alloys
Penumadu	R011334464	$ 8,874	Collaborative CS Task 6.1 BP3 (IACMI)
Mench	R011370015	$ 455	UTF-Mech, Aerospace & Biomed Eng Fund (Gifts)
Ekici	R011373420	$ 1,280	NSF CBET: Career: A Multidisciplinary Framework for Innovative Design of Wind Turbines
Rucker	R011373510	$ 820	NSF CMMI: NRI: Parallel Continuum Manipulators for Safe Interaction and Endoscopic Dexterity
Babu	R011373575	$ 160	SFP Works LLC: Characterization of Flash Processed Steels for Automotive Applications - Technical Support for SFP Works LLC
Babu	R011373579	$ 1,450	Aeroject Rocketdyne Prog Income
Babu	R011373667	$ 400	RevV UTREVV: Next Generation Aerospace Weapon Mount
Babu	R011373721	$ 1,405	Eaton Corp: Additive Manufacturing of Metallic Materials with Controlled Microstructures
Compton	R011373725	$ 20,095	Honey FM&T LLC: Thermoset Composite Materials for Additive Manufacturing
Donovan	R011382496	$ 953	UT-B: Fusion Materials and Technology
Rawn	R013318105	$ 3,551	COE JDRD: Science Alliance to fund JDRD Proposal
Keppens	R013360006	$ 692	COE - Cohort Mentor - Keppens
Mandrus	R015010004	$ 17,036	Gordon and Betty Moore FDN 4416
Hu	R015010013	$ 2,130	US DHS: Low Cost Methylammonium Lead Halide Semiconductor for dual Gamma/Neutron Sensing
Xu	R015010015	$ 170	NSF DMR: Career: Deformation Mechanism in Concentrated Alloys from Multiscale Simulations
Riedinger	R015110107	$ 13,938	Bredeson Center - Christine Ajinjeru GRA
Total		$ 1,073,349	

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Ajinjeru, C., Kishore, V., Lindahl, J., Sudbury, Z., Hassen, A.A., Post, B., Love, L.,Kunc, V., **Duty, C.**, "The influence of dynamic rheological properties on carbon-fiber reinforced polyetherimide for large-scale extrusion-based additive manufacturing." *The International Journal of Advanced Manufacturing Technology*. doi.org/10.1007/s00170-018-2510-z, accepted and published online August 2018

Ajinjeru, C., Kishore, V., Liu, P., Lindahl, J., Hassen, A.A., Kunc, V., Post, B., Love, L., **Duty, C.**, "Determination of melt processing conditions for high performance amorphous thermoplastics for large format additive manufacturing." *Additive Manufacturing, 21*, 125-132. doi:10.1016/j.addma.2018.03.004, May 2018.

Chen, P.Y., **Lee, C.**, Wang, S.Y., Seifi, M., Lewandowski, J.J., Dahmen, K.A., Jia, H.L., Xie, X., Chen, B.L., Yeh, J.W., Tsai, C.W., Yuan, T., **Liaw, P.K.**, "Fatigue behavior of high-entropy alloys: A review." *Science China-Technological Sciences, 61*(2), 168-178. doi:10.1007/s11431-017-9137-4, February 2018.

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Diao, H.Y., Feng, R., Dahmen, K.A., **Liaw, P.K.**, "Fundamental deformation behavior in high-entropy alloys: An overview." *Current Opinion in Solid State & Materials Science, 21*(5), 252-266. doi:10.1016/j.cossms.2017.08.003, October 2017.

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Feng, R., Gao, M.C., Zhang, C., Guo, W., Poplawsky, J.D., Zhang, F., Hawk, J.A., Neuefeind, J.C. Ren, Y., **Liaw, P.K.**, "Phase stability and transformation in a light-weight high-entropy alloy." *Acta Materialia, 146*, 280-293. doi:10.1016/j.actamat.2017.12.061, March 2018.

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