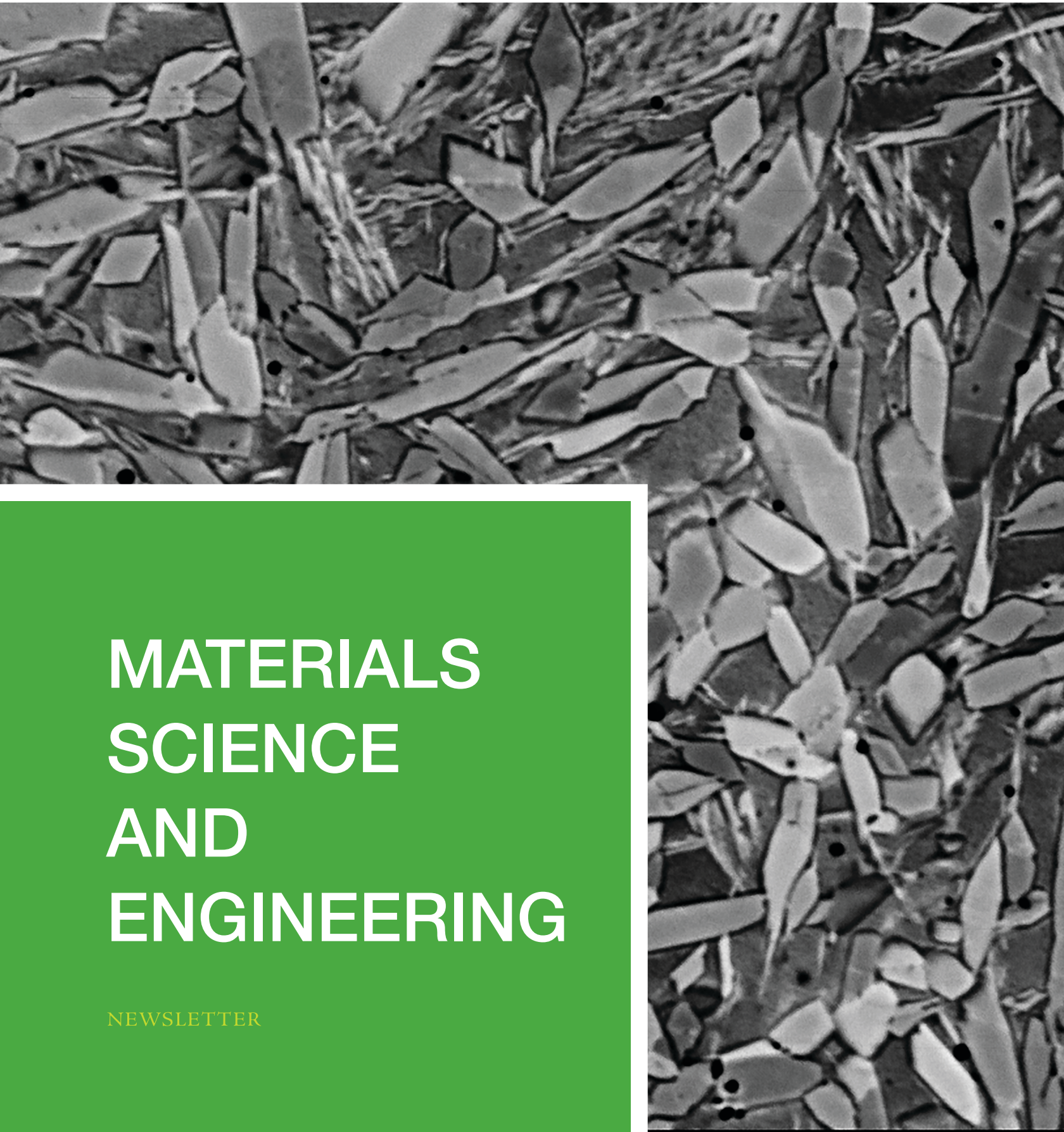
UNT
EST. 1890

AUGUST 2017

RESEARCH HIGHLIGHT
High Entropy Alloys

2016-2017 GRADUATES
Master's and Ph.D. Recipients

NEW FACULTY
Dr. Anupama Kaul



MATERIALS SCIENCE AND ENGINEERING

NEWSLETTER

Andrey Voevodin
Chair

Message from the Chair

Dear Friends,

I am happy to reach out to you with this newsletter on recent updates and news from our department, which continues our growth trajectory with excellence in education and research.

The department faculty research spans from structural aerospace alloys and processing, to corrosion and tribology for oil and gas industries, medical implant materials and radiation stable glasses and ceramics, energy storage and optoelectronic materials. We continue to grow our faculty, and are glad to welcome Professor Anupama Kaul to join us this fall. Professor Kaul has a senior level expertise in electronic materials and devices, which will enhance the breadth of our department's functional material research and open new horizons for our graduate program.

We were very excited to receive recent large awards from U.S. Army organizations to develop materials for protective armor and lightweight shelters utilizing the department's expertise in metals, ceramics and friction stir welding. We also joined the Army Research Laboratory (ARL) South initiative and have an ongoing presence of ARL scientists in our department, facilitating collaborative work in metal alloys and processing. In addition, we received several large awards from the National Science Foundation, Department of Energy and Air Force employing our expertise in laser surface processing, additive manufacturing of metal alloys and radiation damage of ceramic glasses.

While 2017 is still under way, we already have over $6M in new awards and have rapidly increased the number of Ph.D. students and postdoctoral scientists working on research projects. As one example, this issue highlights our research in high entropy alloys – an exciting area where the department has considerable expertise and made significant research progress. Our graduate program maintains the steady stream of high quality Materials Science and Engineering doctoral and master graduates. Last academic year, we graduated 8 M.S. and 12 Ph.D. students who found jobs in industry, academia and national laboratories. With this number of master and doctoral graduates and over 120 publications last year, the department is one of the most research productive organizations in the university supporting UNT's top-tier research institution designation.

After receiving ABET accreditation last year, our undergraduate program had grown to over 100 enrolled students. About half of our recent B.S. graduates had continued with either M.S. or Ph.D. degrees, and we also see an increased enrollment into our Fast Track graduate pathway designed for exceptional seniors. We are happy to have many talented and bright B.S. students to support this accelerated path. This year, our students had won the Materials Bowl competition at the 2017 TMS International Conference, and they are united in their drive to defend their title next year. Another important development is an international agreement with Dalian Jiatong University in China for a student exchange program, which will increase our number of international undergraduate students. With many social activities, cohort advising and extensive research participation – our undergraduate program is attracting regional, local and international students, and this newsletter provides some highlights of their accomplishments and our program.

On behalf of my dynamic and vibrant team of faculty, staff and students I am happy to offer this newsletter, which captures our recent accomplishments and future perspectives. I hope that you will find these interesting and will follow us through our website or by contacting us directly.

Facts and Figures

17
FULL TIME FACULTY

6.9
PUBLICATIONS PER FACULTY/YEAR

18th/76
ARTICLES PER FACULTY RANKING

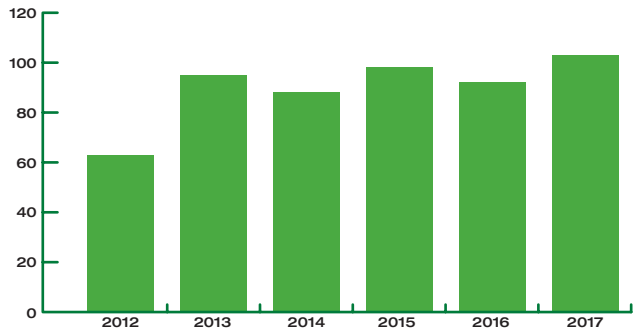
31st/76
CITATIONS PER FACULTY RANKING

55th/76
RESEARCH AWARDS RANKING

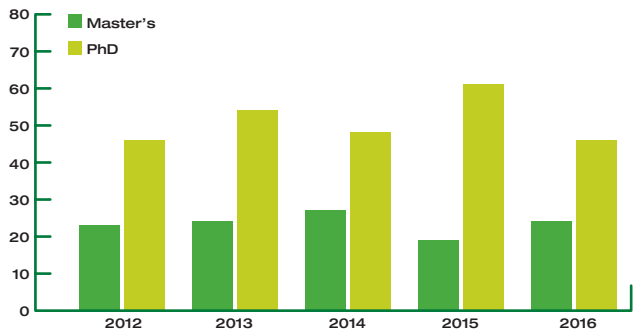
23 Bachelor's
DEGREES AWARDED IN 2016

12 Master's
DEGREES AWARDED IN 2016

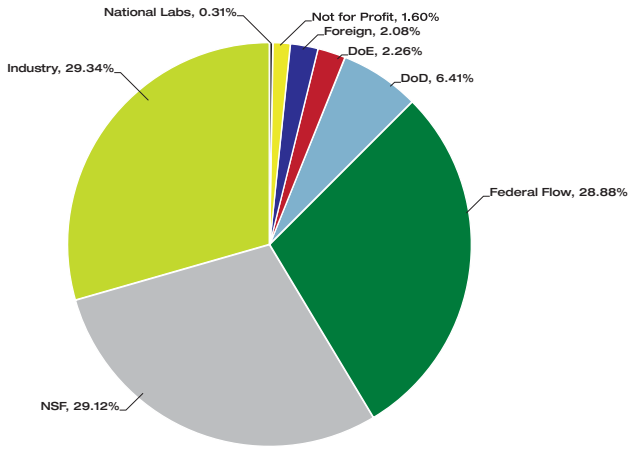
12 Ph.D.
DEGREES AWARDED IN 2016



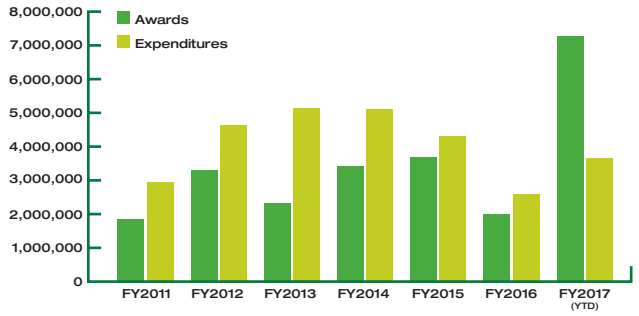
UNDERGRADUATE ENROLLMENT



GRADUATE ENROLLMENT



MTSE RESEARCH FUNDING
2011-2017



MTSE RESEARCH EXPENDITURES

Materials Science and Engineering Staff

Ashley Parsons

ASSISTANT TO THE CHAIR

Hometown: Oklahoma
Years at UNT: 6
What do you do away from UNT? Amateur storm-chaser

Lisa Dunlop

STUDENT RELATIONS

Hometown: Riverside, California
Years at UNT: 1
What do you do away from UNT? Write science fiction

David Garrett

MICROSCOPE SUPERVISOR

Hometown: Dallas, TX
Years at UNT: 25
What do you do away from UNT? Off-road motorcycle riding and benchrest rifle shooting

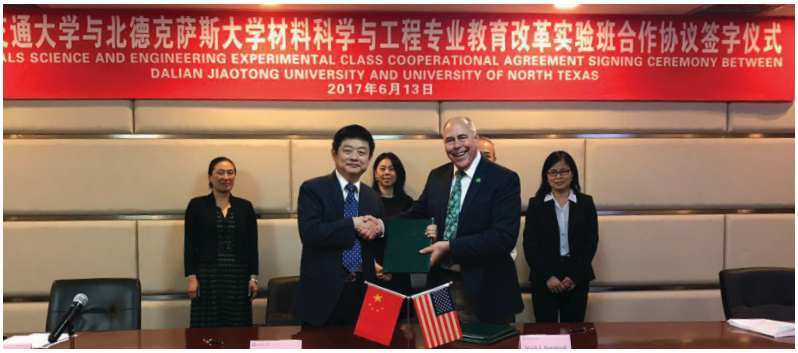
Craig Collins

ENGINEERING LAB TECHNICIAN

Hometown: San Angelo, TX
Years at UNT: 12
What do you do away from UNT? I spend time with grandsons, fly fishing for trout, and benchrest shooting.

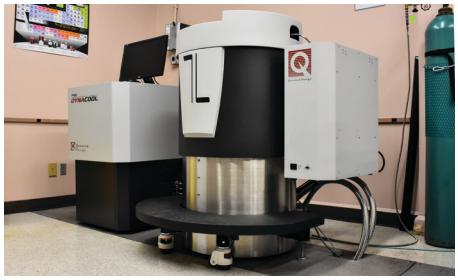
UNT-China Cooperative Agreement

UNT and Dalian Jiaotong University signed a cooperative agreement to share students and faculty. Dalian MTSE students will attend their first year at home, then spend three years at UNT, and complete their degree at Dalian. In the summer prior to their departure to Denton, the students will learn English and Introductory Materials Science and Engineering from UNT professors to assist in their transition. The first Dalian students will arrive in 2018. In the photo to the right, University presidents Guan Tianmin and Neil Smatresk sign the agreement.

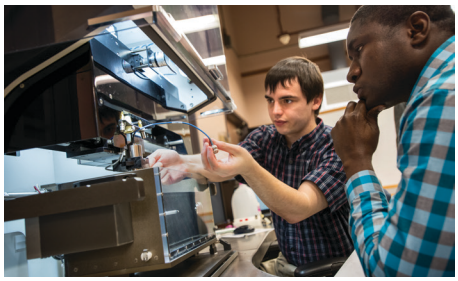


Advanced Materials Manufacturing and Processing Institute

REL Sure-Test Split-Hopkinson Pressure Bar testing platform



Quantum Design PPMS Dynacool



Sonoscan Gen 6 scanning acoustic microscope

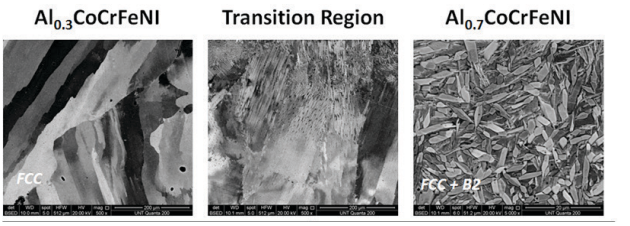
The Advanced Materials and Manufacturing Processes Institute (AMMPI) at the University of North Texas was established as a UNT Institute of Research Excellence. AMMPI is a multi-disciplinary team of researchers committed to collaborating on large research projects with an emphasis on application of findings and solutions to meet market issues and needs.

As part of the high velocity impact research with the Army Research Laboratory and the UNT research office, AMMPI has acquired several new instruments:

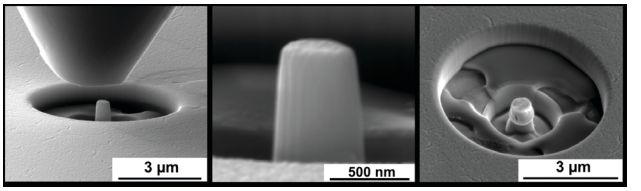
- Hikari Super Electron Backscatter Diffraction (EBSD) system with Energy Dispersive Spectroscopy
- Hysitron PI 87x picoindenter for in situ measurements on an SEM

Designing High Entropy Alloys (HEAs) with the appropriate balance of properties for targeted applications

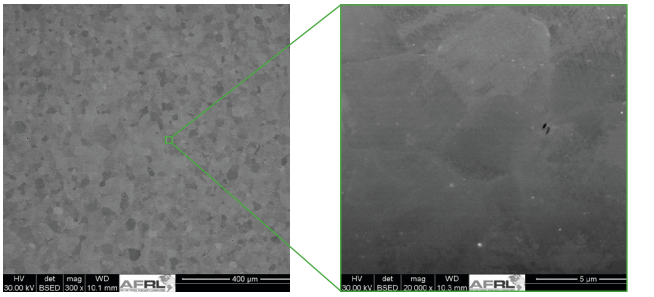
MTSE faculty are conducting fundamental investigations of phase stability and deformation mechanisms in high entropy alloys and designing hierarchical microstructures that exploit appropriate strengthening mechanisms.



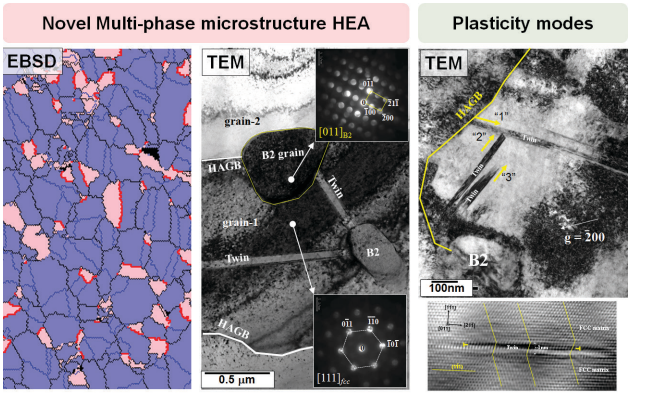
For impact applications, MTSE researchers are studying the strain rate dependence in HEAs and are employing friction stir processing and other thermo-mechanical processing routes to obtain high strength-ductility combination materials. Related efforts include the design of fcc-based HEAs that exhibit high strain hardening and are capable of precipitation strengthening. Site localized and specific plastic deformation is being examined using high-speed nano-indentation and in-situ SEM pico-indentation.



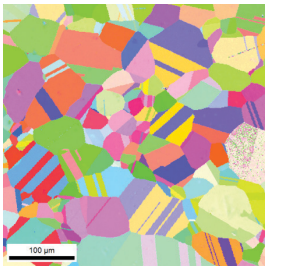
MTSE researchers have examined phase distribution and load partitioning in HEAs during quasi-static dynamic loading using in situ synchrotron x-ray diffraction and imaging and have developed refractory HEAs capable of being rolled into wire.



Developed a novel microstructure comprising of fine grained mixture of soft fcc & hard intermetallic B2 phases via bulk thermo-mechanical processing. The new microstructure demonstrated strength comparable to commercial Titanium alloys, along with excellent ductility and work hardenability. The enhanced work-hardenability was caused by extensive deformation twinning, which is typically not observed in very fined grained alloys.



HEAs (also known as complex concentrated alloys) are alloys with five or more elements in approximately equal proportions



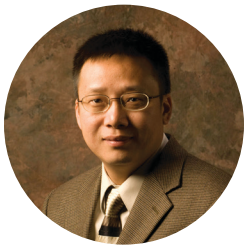
Above: EBSD map of HEA showing high density of annealing twins likely due to low stacking fault energy

Research Highlight: High Entropy Alloys

Faculty: Raj Banerjee, Rajiv S. Mishra, Sundeep Mukherjee, Zhenhai Xia, Marcus Young

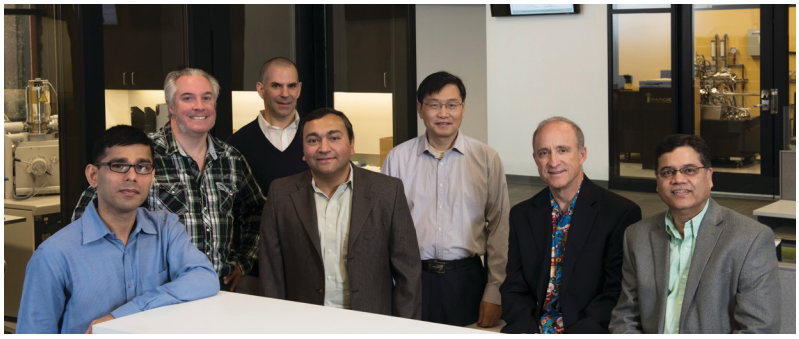
Faculty Research Awards total $6.8M

During fiscal year 2017, the Department of Materials Science and Engineering has received 17 research awards totaling more than $6.8M. These awards came from federal agencies (NSF, DoD, and DoE) and industry. Some of these awards are highlighted below:



Dr. Jincheng Du is part of a newly awarded Department of Energy (DOE) Energy Frontier Research Center (EFRC) to study materials degradation headed by Ohio State. Their mission is to understand the fundamental mechanisms of nuclear waste degradation of materials and to design new containers with improved performance.

Drs. Sundeep Mukherjee, Rajiv Mishra, and AndreyVoevodin received $500,000 for developing Lightweight Composite Structures for Advanced Tactical Shelters for the U.S. Army. This program is in collaboration with Northeastern University, the University of Southern Mississippi and the UNT Department of Engineering Technology.



Drs. Raj Banerjee, Rajiv Mishra, Sundeep Mukherjee, Rick Reidy, Thomas Scharf, Zenhai Xia, and Marcus Young are part of a $20M program with the Army Research Laboratory to develop materials with improved protection capability. The UNT focus is on finding new ways to improve protection against high velocity impacts. In this effort, UNT is working with Temple University, the University of Southern Mississippi, the University of Southern California and Quad Cities Manufacturing.

New Faculty Member

Dr. Anupama Kaul

Dr. Anupama Kaul joins our department in September 2017 as PACCAR Professor in Engineering and Director of the PACCAR Technology Institute. She also has a joint appointment in the Department of Electrical Engineering at UNT.

Dr. Kaul comes to UNT from the University of Texas at El Paso (UTEP) where she is currently associate dean for Research and Graduate Studies in the College of Engineering and AT&T Distinguished Professor. Dr. Kaul received her B.S. degree with honors in physics and engineering physics from Oregon State, and her M.S. and Ph.D. degrees are from the University of California at Berkeley in materials science and engineering.

Prior to joining UTEP, Dr. Kaul was a program director in the Engineering Directorate at the National Science Foundation (2011-2014) and a senior member of the technical staff at the Jet Propulsion Laboratory, California Institute of Technology (2002-2014) in Pasadena, Calif. Dr. Kaul is the recipient of the National Science Foundation's Director's Award for Program Management Excellence for leadership in the creation of a new initiative at NSF totaling nearly $50M in partnership with the Department of Defense.

At JPL-Caltech, Dr. Kaul received the NASA Service Award, a NASA Team Accomplishment Award, multiple NASA patent awards and numerous NASA technology brief awards for her research.

Dr. Kaul was selected to be a participant at the U.S. National Academy of Engineering (NAE) 2012 Frontiers of Engineering (FOE) Symposium, and in 2014, she was invited to participate in the bi-lateral Indo-US FOE. She has delivered nearly 70 invited and keynote talks at major international conferences and meetings sponsored by professional societies, including the IEEE, SPIE, MRS, TMS, and NSTI, among others.

She is currently the associate editor of the IEEE Sensors Journal, international advisory panel member of the Materials Xpress Journal for the Institute of Physics, american editor of Nanoscience and Nanotechnology Letters, associate editor of Reviews in Advanced Sciences and Engineering and serves on the Editorial Board of several other journals. Dr. Kaul is also the editor of Microelectronics to Nanoelectronics: Materials, Devices and Manufacturability, that was published by CRC Press, and is a fellow of the Class of 2016 Executive Leadership in Academic Technology and Engineering Program coordinated by Drexel University.

Dr. Kaul has an impressive record of interdisciplinary research, including exploring the exotic electronic and optical properties of transition metal chalcogenides and nanocarbons. These materials are being developed for a wide-gamut of devices ranging from high-performance photodetectors, flexible electronics, nanoelectronics and bio-sensors.

In her prior work at JPL, Dr. Kaul conducted extensive research on nano-electro-mechanical (NEM) switches and resonators for energy-efficient electronics and high frequency sensors, where such sensors can also be adapted for extreme environment electronics and in bio-related platforms.

Her current research is being supported by grants from the Army Research Office, the Air Force Office of Scientific Research and the National Science Foundation.

Recent Highlights

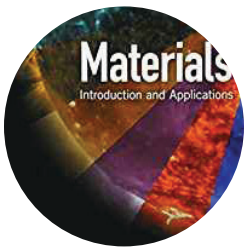
Dr. Raj Banerjee was recently named 2017 UNT Distinguished Research Professor. This award recognizes tenured faculty at the rank of professor who have achieved an exceptionally outstanding record of creative activities or research productivity and who demonstrate a record of continued extraordinary productivity.

Dr. Thomas Scharf was elected to the National Board of Directors of the National Society of Tribologists and Lubrication Engineers (STLE). Dr. Scharf is on the editorial boards of five tribological journals, and has been an active member of STLE for 17 years, chairing several committees and symposia.

Dr. Diana Berman has been named a winner of the 2017 Ralph E.Powe Junior Faculty Enhancement Award from the Oak Ridge Associated Universities (ORAU) for her work on the fundamental mechanisms of tribological behavior of 2-D materials under applied stresses and during mechanical deformation.

Dr. Jincheng Du was promoted to full professor. Dr. Du joined UNT in 2007 and has established an outstanding record (more than 100 peer reviewed publications and more than $3.6M in external funding) and internationally recognized group in materials modeling, specifically in the modeling of glasses and ceramics.

Dr. Narendra Dahotre was named UNT interim associate vice president for Research and Innovation. Dr. Dahotre is a University Distinguished Research Professor and the recent recipient of the UNT Foundation Faculty Leadership Award. He has more than $7M in research awards, holds 16 U.S. patents, has published more than 200 refereed journal publications, is a fellow in 10 professional societies and is currently the editor of two scientific journals.



Dr. Witold Brostow and UNT alumna Dr. Haley Lobland recently published their textbook, "Materials: Introduction and Applications."

Student Awards

M.S. student Calvin Mikler won the Science, Mathematics, & Research for Transformation (SMART) Scholarship from the National Defense Education Program. After defending his thesis this summer, Mikler will attend The Ohio State University to complete a Ph.D. in Materials Science and Engineering.

Ph.D. graduate Aditya Ayyagari was recently recognized in the 2nd Annual Class of Golden Eagles. The Golden Eagle Award is the most prestigious award that UNT bestows on a student leader. Aditya recently defended his thesis on "Surface Degradation Behavior of Metallic Glasses and High Entropy Alloys."

Senior Tyler Torgerson competed and won first place in the fourth annual College of Engineering Showcase of Undergraduate Research in Engineering (S.U.R.E.) competition. Under Dr. Thomas Scharf, Torgerson spent the summer as a National Science Foundation REU recipient. For 10 weeks, Torgerson studied the self-adaptive friction behavior and thermal stability of molybdenum disulfide-antimony(III) oxide-carbon coatings used on satellites.

Graduate student Bharat Gwalani won the Best Poster Award in Physical Sciences at the Microscopy Society of America annual meeting.

The UNT MTSE team won the Materials Bowl Competition at TMS. This was the first Materials Bowl win for the North Texas team made up of students, left to right, Calvin V. Mikler, Brandon Ohl, Spencer Taylor and Bharat Gwalani.

2016-2017 Graduates

Master of Science

SUMMER AND FALL 2016

Yang Cao
Zachary David Hoyt *Compostable Soy-Based Polyurethane Foams with Kenaf Core Modifiers*
Dheyaa Fahad Kadhim Kadhim *Sliding Friction and Wear Behavior of High Entropy Alloys at Room and Elevated Temperatures*
Sohrab Mirzaabedini *Angular Analysis of a Wide-Band Energy Harvester based on Mutually Perpendicular Vibrating Piezoelectric Beams*
Yu Chia Yang *Improving the Long-term Performance of PVC Compositions*

SPRING 2017

Ravi Kiran Rao Avirineni
Seth Thomas Garrison *Catalytic Properties and Mechanical Behavior of Metallic Glass Powders*
Rahul Pilligundla

Doctor of Philosophy

SUMMER AND FALL 2016

Shamiparna Das *Microstructures for Enhanced Plasticity and Toughness*
Andres Crisotomo Garcia *Design and Manufacture of Molding Compounds for High Reliability Microelectronics in Extreme Conditions*
Mandana Hendrickson *The Role of Misfit Strain and Oxygen Content on Formation and Evolution of Omega Precipitate in Metastable Beta Titanium Alloys*
Yee Hsien Ho *In Vitro Corrosion Behavior of Magnesium Alloy AZ31B-Hydroxyapatite Metallic Matrix Composite Processed via Friction Stir Processing*
Jitendra Kumar Jha *Workfunction Tuning of AZO Films through Surface Modification for Anode Application in OLEDs*
Nelson Yojan Martinez *Friction Stir Welding of Precipitation Strengthened Aluminum 7449 Alloys*
Harpreet Sidhar *Friction Stir Welding of High Strength Precipitation Strengthened Aluminum Alloys*
Wei Sun *Defect Behaviors of Zinc Oxide and Zinc Titanates Ceramics from First Principles Computer Simulations*

SPRING 2017

Aniket Kumar Dutt *Microstructural Evolution and Mechanical Response of Materials by Design and Modeling*
Sanghita Mridha *Structural Evolution and Nano-Mechanical Behavior of Bulk Metallic Glasses and Multi-Principal Element Alloys*
Vedavyas Tungala *Exceptional Properties in Friction Stir Processed Beta Titanium Alloys and an Ultra High Strength Steel*
Zhenghang Zhao *Design Principle on Carbon Nanomaterials Electrocatalysts for Energy Storage and Conversion*

Alumni Profiles

Arun Devaraj

PH.D. 2011

Hometown: Kannur, Kerala, India
Current Position: Senior Research Scientist, Pacific Northwest National Laboratory, Richland, Washington
Previous Positions: Postdoctoral Research fellow, PNNL (2011-2012); QA/QC engineer, Essar Steel Ltd, Surat, India (2005-2007)

Interesting Experience: My Ph.D. research at UNT was focused on microstructural evolution in titanium alloys. Once I moved to PNNL in 2011, I was involved in many other research areas ranging from nuclear reactor structural materials, battery electrode materials, magnetic materials, catalysts, advanced microstructural characterization by Atom Probe tomography, etc., all with a focus on understanding microstructure-property relationships. Although I enjoyed all these new areas of research, deep inside I still loved my research in Titanium (Ti) alloys, and I wasn't sure if anyone at PNNL worked in this area. Then one day, during a casual meeting in one of the labs in PNNL, one of my colleagues from another PNNL directorate mentioned that he is working on a new, low-cost Ti alloy production method with a senior scientist who had been working with industries on Ti alloys for more than 15 years. That sparked my enthusiasm, and after meeting the senior scientist, he was also excited to know that there is a PNNL researcher with background in fundamental physical metallurgy of beta Ti alloys. That discussion led to start of a small research collaboration between us, which I completed successfully and gave a clear explanation on why the alloy they made had a very high strength based on a unique microstructure it had. In 2016, I published the results in Nature Communications, which truly was one of the most enjoyable moments of my career, because I was able to make a meaningful contribution to the field in which I did my PhD. Also, that research interaction led to several research collaborations between me and that group of researchers, to an extent that now, a major portion of my research time is dedicated to developing advanced high performance light weight structural alloys with novel processing methods.

How did your time at UNT help you with your career: Once I was at UNT doing my Ph.D., I was introduced to the fascinating world of the microstructure of metallic materials. I could study how heating and cooling an alloy to different temperatures and time leads to different types of phase transformations that influences the development of final microstructure of the alloy. Additionally, I learned the power of many advanced microscopy and diffraction methods that I can use, including electron microscopes, x-ray diffraction, atom probe tomography etc., to see how atoms get rearranged in materials when they undergo phase transformations. Also, through my Ph.D. co-advisor, I learned the power of first principle computation methods in providing complementary information to what we see using microscopy methods. Once I finished my Ph.D. and moved to this new organization, my daily work is still strongly rooted in these fundamentals I learned from my time at UNT; the only change is that I now study a much broader list of material systems, and in addition to heating and cooling materials to different times, I now also look at how radiation, electric fields, high shear stress or chemical reactions modify the microstructure of materials changing their mechanical, physical or chemical properties and then propose solutions to make materials resistant to such changes. To summarize, although my research areas have become much broader, the fundamentals I learned during my Ph.D. have been directly beneficial for every day of my career.

Chance Cooper

B.S. 2013

Hometown: Rockwall, Texas
Current position: Bell Helicopter, Material and Process Engineer II
Previous Position: Zodiac Aerospace, Material and Process Engineer (2 years), Zodiac Aerospace, Manufacturing Engineer (2 months)
Previous School: Tarleton State University, Stephenville, Texas
Interesting Experience: I did not have the confidence in myself when it came to my schooling. Being dyslexic presented me with many challenges in an academic setting. Although, when I started my path of earning my degree in material science and engineering, the challenges where still there but I had the passion and drive to overcome my lack of confidence. I accredit this change in attitude to the Department of Materials Science and Engineering. With the chance to have hands on experience, a focus on students' different learning abilities, and resources at my disposal, it was no wonder I felt like I was thriving in school. The confidence instilled in me from my time at UNT still helps me today. When working on major projects at Bell, I lean on the knowledge and experience I gained at UNT to overcome any challenges

COLLEGE OF ENGINEERING
UNT
EST. 1890

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