MATERIALS SCIENCE AND ENGINEERING

The materials science and engineering department offers a variety of educational and research opportunities for graduate study including degree programs in materials science and engineering, ceramic engineering, and metallurgical engineering. The department offers the following degrees: M.S. and Ph.D. in materials science and engineering, M.S. and Ph.D. in ceramic engineering, and M.S. and Ph.D. in metallurgical engineering. Further information regarding these degree programs may be found below and under the individual degree programs within this catalog.

The requirement for entry into one of these programs includes a baccalaureate degree in materials science or engineering, ceramic engineering or science, glass science or technology, or metallurgical science or engineering. A baccalaureate degree in physics, chemistry, chemical engineering, or related discipline may also be acceptable.

In the areas of glass, ceramic, and biomaterials, the department carries out research in electronic ceramics, high temperature materials, structural ceramics, composites, ceramic processing, laser glasses, and nuclear waste encapsulation glasses. Fundamental and applied interests include structure and its relation to the properties of ceramics and glasses; defect chemistry, thermochemistry and phase equilibria; electrical, dielectric, optical, thermal and mechanical properties of ceramics; ceramic-ceramic, ceramic-metal, and ceramic-polymer composites; compositional effects on the optical properties and chemical corrosion of glass; solid oxide fuel cells; high temperature superconducting ceramics; ferroelectric ceramics; glasses and ceramics for biomedical applications such as drug delivery and medical implants; and processing, forming, and microstructure control of structural and functional ceramics. The department has extensive facilities for the synthesis, forming, and fabrication of ceramics and glasses, as well as for the detailed characterization of the properties of ceramics. A mechanical testing laboratory is available for characterizing mechanical properties under controlled temperature and atmospheric conditions.

In the areas of metallurgical science and engineering, the department carries out research in physical and mechanical metallurgy, extractive metallurgy, metals casting, joining and forming, and manufacturing metallurgy. Additional research activities include friction stir welding and adaptations known as friction stir processing. Interdisciplinary research opportunities are also available in other areas of specialization through collaborations with faculty members in other engineering and science departments on campus. The department has facilities for green sand casting, centrifugal casting, lost foam casting, and permanent mold casting, together with a variety of metal joining processes. Principal research interests include metal deposition, high temperature and intermetallic compounds, powder metallurgy, plasma spray deposition, and electro-metallurgical processes, environmental aspects of metal manufacturing, and treatment of metals industry waste. Capabilities for research in these areas include an apparatus for studying mixing in reactors, a vacuum induction furnace, a plasma melting furnace, and a metal atomizing pilot plant.

In the area of biomaterials the department carries out research in the synthesis and characterization of novel biomaterials, the design and fabrication of scaffolds for tissue engineering of biological tissues, interactions of biomaterials with living systems, and tissue-engineered restoration of biological tissues.

The department also has a strong affiliation with the Materials Research Center (MRC) at Missouri S&T, which houses major instrumentation for materials characterization. Faculty members within the MSE department are either senior research investigators or research investigators in this nationally recognized center. Facilities available within the MRC to support graduate research include electron microscopy, thermal analysis, Auger Electron Spectroscopy, FIB (Focused Ion Beam) x-ray diffraction, together with grazing incidence for film analysis, among others. Extensive capabilities for materials coatings, preparation and analysis are also available.

The department is a participating institution in an NSF-sponsored Center for Dielectric Studies at the Pennsylvania State University. Dielectric ceramics for high energy density applications form a major focus of the department’s research activities in this center.

Degree Requirements

M.S. and Ph.D. degrees are offered in materials science and engineering. Students may apply for either degree and may be admitted directly to the Ph.D. program upon approval (i.e., there is no M.S. requirement). Depending upon their intended career path, students may be encouraged to pursue one of the MSE graduate degrees or other degree programs noted above.

The total number of hours required for the M.S. in materials science and engineering is 30. The M.S. with thesis is oriented toward the completion of a research project and the degree requirements are 18 hours of course work and 12 hours of research. It is recommended that the student complete the core courses offered by the department including MS&E 6110, MS&E 6120, and MS&E 6130 which are graduate level crystallography, thermodynamics and kinetics. At least 6 hours of course work must be 6000-level courses. It is recommended that six additional hours be completed outside of the department. The other courses are chosen with the approval of the advisor.

For the non-thesis M.S. degree in materials science and engineering, 30 hours of course work must be completed with a minimum of 12 hours at the 6000-level.

The total number of hours required for the Ph.D. degree in materials science and engineering is 72. Ph.D. students are required to complete the three core courses, MS&E 6110, MS&E 6120, and MS&E 6130. To advance to Ph.D. candidacy, the student must pass and pass a qualifying exam. This must be completed prior to the beginning of the fifth semester after entering the graduate program. Students must also take and pass the comprehensive exam in accordance with Missouri S&T rules.

Mohsen Asle Zaeem, Assistant Professor
PHD Washington State University

Richard K Brow, Curators Professor
PHD Pennsylvania State University
Senior Investigator, Graduate Center for Materials Research. Physics and chemistry of inorganic glasses; spectroscopic characterization of glass structure; biomaterials; optical materials.

Fatih Dogan, Professor
PHD Technical University of Berlin
High temperature superconductors, solid oxide fuel cells, dielectrics, nanostructured electronic ceramics.
William G Fahrenholtz, Curators Professor
PHD University of New Mexico
Senior Investigator, Graduate Center for Materials Research.
Thermodynamics, phase equilibria, reactive processing, ultra-high temperature ceramics.

Gregory E Hilmas, Curators Professor
PHD University of Michigan-Ann Arbor
Senior Investigator, Graduate Center for Materials Research.
Microstructure-processing-mechanical property relationships in structural ceramics; novel processing techniques for the fabrication of ceramics and ceramic composites; biomaterials.

Wayne Huebner, Professor
PHD University of Missouri-Rolla
Department Chair. Structure-property relationships in ferroelectric, piezoelectric, and ioni-conducting materials.

F Scott Miller, Teaching Professor
PHD University of Missouri-Rolla
Electron microscopy, materials characterization.

Michael Scott Moats, Associate Professor
PHD University of Arizona

Joseph W Newkirk, Associate Professor
PHD University of Virginia
Intermetallic alloys, alloys for corrosion and high temperature, powder metallurgy.

Matthew J O'Keefe, Professor
PHD University of Illinois Urbana
Thin film and coating materials deposition, process development and characterization.

Ronald J O'Malley, Professor
PHD Massachusetts Institute of Technology
F. Kenneth Iverson Chair Professor of Steelmaking Technologies.

Mohamed N Rahaman, Professor
PHD University of Sheffield (UK)
Processing of ceramics; sintering and microstructure control; biomaterials.

Von L Richards, Professor
PHD University of Michigan-Ann Arbor
Metal casting, mold materials, property enhancement of cast alloys.

Mark E Schlesinger, Professor
PHD University of Arizona

Jeffrey D Smith, Associate Professor
PHD University of Missouri-Rolla
Thermochemistry and high temperature phase equilibria of condensed and non-condensed ceramic systems; chemical, mineralogical and microstructural analysis of refractory materials.

David C Van Aken, Curators Teaching Professor
PHD University of Illinois Urbana
Thermal spraying, fatigue and fracture, rapid solidification, advanced alloy design, electron microscopy.

Jeremy Lee Watts, Research Assistant Professor
PHD Missouri S&T

Caizhi Zhou, Assistant Professor

2015-2016
**MS&E 6040 Oral Examination** (IND 0.0)
(Variable) After completion of all other program requirements, oral examinations for on-campus M.S./Ph.D students may be processed during intersession. Off-campus M.S. students must be enrolled in an oral examination and must have paid an oral examination fee at the time of the defense/comprehensive examination (oral/written). All other students must enroll for credit commensurate with uses made of facilities and/or faculties. In no case shall this be for less than three (3) semester hours for resident students.

**MS&E 6050 Continuous Registration** (IND 1.0)
Doctoral candidates who have completed all requirements for the degree except the dissertation and are away from the campus must continue to enroll for at least one hour of credit each registration period until the degree is completed. Failure to do so may invalidate the candidacy. Billing will be automatic as will registration upon payment.

**MS&E 6085 Internship** (IND 0.0-15)
(Variable) Students working toward a doctor of engineering degree will select with the advice of their committees, appropriate problems for preparation of a dissertation. The problem selected and internship plan must conform to the purpose of providing a high level engineering experience consistent with the intent of the doctor of engineering degree.

**MS&E 6099 Research** (IND 0.0-15)
(Variable) Investigations of an advanced nature leading to the preparation of a thesis or dissertation. Consent of instructor required.

**MS&E 6110 Bonding, Crystallography, and Structure-Property Relationships** (LEC 3.0)
Principles of electronic structure and chemical bonding in solids and their relationships to electrical, mechanical, thermal, and optical properties. An exploration of reciprocal lattices and tensor properties of crystals; consideration of the impact of crystal symmetry on anisotropy. The influence of defects and grain boundary phenomena on material behavior. Prerequisite: Graduate standing, or undergraduate standing with instructor and advisor approval.

**MS&E 6120 Thermodynamics and Phase Equilibria** (LEC 3.0)
Classical thermodynamic treatment of materials and material processing based on the 1st and 2nd Laws of Thermodynamics and phase equilibria considerations. The course will cover equilibria in gaseous systems, gas-solid reactions including passive and active oxidation, solution thermodynamics, phase equilibria in solution systems, and electrochemistry. Prerequisite: Graduate standing, or undergraduate standing with instructor and advisor approval.

**MS&E 6130 Kinetic Theory for Materials** (LEC 3.0)
Phenomenological and atomistic theories of diffusion in materials including discussion of short circuit diffusion and ionic diffusion in an electric field. Fundamentals of phase transformation in materials; chemical fluctuation, nucleation and growth theory; kinetic models for evaluating and predicting diffusion controlled transformation kinetics. Prerequisite: Graduate standing, or undergraduate standing with instructor and advisor approval.

**MS&E 6210 Tissue Engineering II** (LEC 3.0)
The course will introduce graduate students to the principles and clinical applications of tissue engineering including the use of biomaterials, scaffolds, living cells and signaling factors to develop implantable parts for the restoration, maintenance, or replacement of biological tissues and organs. A related topic term paper and oral presentation are expected. Prerequisite: Graduate standing. (Co-listed with Bio Sci 6240).

**MS&E 6220 Advanced Energy Materials** (LEC 3.0)
The objectives of the graduate level course are to review the recent developments on advanced energy materials and systems in addition to basic understanding how chemical and physical properties of materials can lead to energy alternatives. Prerequisite: Graduate standing.

**MS&E 6230 Nanomaterials** (LEC 3.0)
Introduction of the fundamentals of nanomaterials and recent developments on nanomaterials. Topics include physical and chemical properties, synthesis, processing, and applications of nanomaterials. Example nanomaterials include nanoparticles, nanotubes, and nanowires. Students will need to complete a project related to nanomaterials. Prerequisite: Graduate Standing. (Co-listed with Chem Eng 6310).