

# MATERIALS SCIENCE AND ENGINEERING

The field of materials science and engineering is expanding into a period of unprecedented intellectual challenges, opportunities and growth. Products created using materials science and engineering research contribute to the economic strength and security of not only the state, but also the country.

The School of Materials Science and Engineering (MSE) is located at OSU-Tulsa Greenwood campus at the Helmerich Research Center, a premier facility which places the College of Engineering, Architecture and Technology in a unique position to conduct world-class education, research and technology development and transfer in advanced materials of strategic importance to our nation. Current research programs focus on materials for energy technologies, bio-materials for medical technologies, advanced materials for aerospace and defense, and materials for electronics and control technologies.

## Program Educational Objectives

OSU is currently offering only a graduate program in Materials Science and Engineering.

## Courses

### MSE 5000 Master's Thesis

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Students will be performing thesis research under the guidance of a thesis advisor. This will involve performing literature search, writing proposal for the research and conducting research in the laboratories. At the end of the course students will present the findings of research to the committee and prepare a thesis for approval by the thesis committee. Offered for variable credit, 1-6 credit hours, maximum of 6 credit hours.

**Credit hours:** 1-6

**Contact hours:** Contact: 1-6 Other: 1-6

**Levels:** Graduate

**Schedule types:** Independent Study

**Department/School:** Materials Sci. & Eng

### MSE 5010 Materials Science and Engineering Seminar for Masters Students

**Prerequisites:** Graduate standing or consent of instructor.

**Description:** Advanced Research and Development Topics. Maximum 3 credit hours. Graded on pass/fail basis.

**Credit hours:** 0

**Contact hours:** Contact: 0 Other: 0

**Levels:** Graduate

**Schedule types:** Discussion

**Department/School:** Materials Sci. & Eng

### MSE 5013 Advanced Thermodynamics of Materials

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Thermodynamics of materials is important for materials synthesis, stability and performance. The course will cover basic laws of thermodynamics, solution theory, phase equilibrium diagrams and thermodynamics of electrochemical systems.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

### MSE 5022 Masters of Engineering Capstone Project

**Description:** Students will conduct independent literature review or research as guided by the graduate advisory committee. The capstone project will be completed in conjunction with an approved graduate course in Materials Science and Engineering. At the end of the course students will prepare a final report for approval by the graduate program committee.

**Credit hours:** 2

**Contact hours:** Contact: 2 Other: 2

**Levels:** Graduate

**Schedule types:** Independent Study

**Department/School:** Materials Sci. & Eng

### MSE 5023 Diffusion and Kinetics

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Diffusion and kinetics are important for materials processing, stability, microstructure evolution and performance. The course will cover basic concepts underlying diffusion and kinetics as they relate to materials behavior. Topics on diffusion, nucleation and growth, spinodal decomposition, reactions involving solid with solids, gases and liquids, and phase transformation will be covered.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

### MSE 5030 Independent Study in Materials Science and Engineering

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** This course can be used by individual faculty in specific areas related to a student's graduate study. Offered for variable credit, 1-3 credit hours, maximum of 3 credit hours.

**Credit hours:** 1-3

**Contact hours:** Lecture: 1-3 Contact: 1-3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5033 Composite Materials**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Composites are important for advancing performance and reliability of existing and new products for aerospace, electronics, and medical systems. This course is to introduce fundamental concepts for the design, fabrication and mechanical property evaluation of composites. This includes methods of fabricating fibers, matrices and composites, toughening mechanisms in composites, mechanical properties, and role of interfaces. The focus will be for composites useful at high temperatures.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5043 Advanced Materials Characterization**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Advances in materials require availability, training, and proficiency in advanced instrumentation to characterize materials at length scales from macro- to nanometer-scale. This course is to introduce fundamental concepts forming the basis of different equipments, their operation and capability for developing advanced materials. This includes instruments such as SES, TEM, x-ray diffraction, FTIR, AFM, and Nanoindentation. The lectures will be complemented with hands-on experience to students in labs housing these equipments.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5053 Smart Materials**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Advances in new technologies rely on the availability of "smart" materials that adapt to environment. Examples include sun-sensor glasses that become dark in sunlight and clear-out when indoors, and shape-memory materials used as stents in human body. In this course, the definition of a smart material and to understand principles of using electrical and other functional properties of materials to create smart systems is covered. Students are also taught to search literature on a suitable topic and work as a group to write a term paper and make a presentation to the class.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5063 Biomedical Materials**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** The course will discuss about structure, composition, properties, and performance of materials with applications in medical and health science.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5073 Tissue Engineering**

**Prerequisites:** Graduate standing or consent of instructor.

**Description:** Tissue engineering (TE) and the material strategy for different tissue constructs in bone TE, liver TE, neural TE, intestine TE, etc. will be discussed in this course. Same course as CHE 5073.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5083 Advanced Ceramics Processing**

**Prerequisites:** ENSC 2213 and ENSC 3233 and MATH 2153 or permission of instructor.

**Description:** An introduction to processing techniques to transform ceramics from raw materials to finished products. This includes powder synthesis and beneficiation, colloidal processing, forming techniques, sintering and finishing operations and an introduction to chemical processing routes.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5093 Fundamentals of Materials Science**

**Prerequisites:** Instructor approval.

**Description:** MSE 5093 is a first-year graduate course that covers basic concepts in materials science. The course is designed for both materials science and engineering graduates and graduates with other engineering or science backgrounds (physics, chemistry, mechanical engineering, chemical engineering, electrical engineering, etc.).

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5103 Electrical and Optical Properties of Ceramics**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Inorganic ceramic materials are useful in many applications because of their electrical, optical, dielectric, and magnetic properties. These are important for advancing performance and reliability of existing and new products for aerospace, electronics and medical systems. This course is to introduce fundamental concepts for the understanding of principles of electrical and optical behaviors of ceramic materials including atomic structure, conduction mechanisms, processing and electrical-optical properties.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5113 Diffraction in Materials**

**Prerequisites:** Graduate standing and consent of instructor.

**Description:** Introduction to crystallography and diffraction with an emphasis on X-ray diffraction, some exposure to Neutron diffraction, radiography, and tomography. Applications will focus on mechanical properties measurements. New methods will be surveyed with an emphasis on current research. Same course as MAE 5113.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5123 Advanced Composites Manufacturing: Materials, Methods and Applications**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Covers important topics such as basic concepts and definitions of composite materials, fabrication, structure, properties, and applications of fibrous materials, structure and properties of polymer matrix, metal matrix and ceramic matrix materials, constituent materials, fabrication and repair methods, properties and applications of polymer matrix composites, metal matrix composites, ceramic matrix composites and carbon/carbon composites and markets.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5133 Solid Oxide Fuel Cells**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** The objective of this course is to introduce fundamental concepts for energy production using solid oxide fuel cells. The course will include fundamentals of solid oxide fuel cells. Efficiency based on thermodynamics will be described. In addition, roles of important materials as electrolyte for oxygen transport, anode and cathodes as electronic conductors, and high temperature seals required for solid oxide fuel cells will be covered. The role of fuel cells in the current and future energy systems will also be described.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5143 Batteries and Supercapacitors for Energy Storage**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** The objective of this course is to introduce fundamental concepts for energy storage using batteries and supercapacitors. The course will include fundamentals of electrochemical systems/batteries and supercapacitors. Efficiency of storage based on thermodynamics will be described. In addition, role of important materials required in selected battery systems and capacitors will be included. The role of batteries and supercapacitors in the current and future energy storage devices will be described.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5153 Crystal Physics and Materials Properties**

**Prerequisites:** Graduate standing or consent of instructor.

**Description:** This course is about crystal physics and crystal chemistry, and their applications to engineering problems. It is designed as an introduction to the relationships between symmetry and the directional physical properties of crystals. Emphasis will be on the fundamental understanding of symmetry arguments as criteria in the material selection process for technological applications.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5163 Nondestructive Evaluation of Materials**

**Prerequisites:** Instructor Approval.

**Description:** MSE 5163 covers fundamentals of common methods for Nondestructive Evaluation (NDE) of materials, their application and advantages/limitations for engineering inspections. NDE techniques involving mechanical, optical, thermal and electromagnetic phenomena are covered and include radiographs, ultrasonics, eddy currents, penetrants, magnetic flux, and visual methods. The course is suitable for students in materials and other engineering majors (mechanical/chemical/industrial/civil/electrical).

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5173 Organic Electronic Materials and Devices**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** This course will serve as an introduction to organic materials with applications to active electronic and optoelectronic devices.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5174 Fundamentals of Photovoltaics**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** This course will serve as an introduction to photovoltaic materials and devices. This course will cover commercial and emerging photovoltaic technologies.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5193 Advanced Materials Processing**

**Prerequisites:** Instructor Approval.

**Description:** MSE 5193 is a first-year graduate course that covers basic concepts in materials processing. The course is designed for both materials engineering graduates and graduates with other engineering or science backgrounds (physics, chemistry, mechanical engineering, chemical engineering, industrial engineering, civil engineering, electrical engineering, etc.).

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5200 Applied Innovation I**

**Prerequisites:** Graduate standing or consent of graduate program coordinator.

**Description:** Theory and practice of commercialization of new technologies, business plan development and formation of project teams to commercialize technologies and new products. Same course as EEE 5200.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5223 Additive Manufacturing: Materials, Methods and Applications**

**Prerequisites:** Graduate standing or consent of instructor.

**Description:** Theory and practice of additive manufacturing, materials and their applications in various fields. Discuss their applications in product development, data visualization, rapid prototyping, and specialized manufacturing, with special emphasis on direct digital manufacturing.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5273 Recycling and Sustainability for a Circular Economy**

**Description:** An experiential graduate level course about sustainable materials development for recycling materials such as composites, carpet, construction and demolition waste, tires, E-waste, precious platinum group metals from catalytic converters, and polymers such as PET, LDPE, HDPE, and PP. This fits with OSU's efforts in recycling carpet and PET based materials. The students will understand how to conduct LCA and cradle to cradle assessment of the products being recycled.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5553 Fatigue and Fracture**

**Prerequisites:** MAE 4333 or consent of instructor.

**Description:** The course provides an introduction to the mechanics of fracture of brittle and ductile materials and covers the basics of both linear-elastic fracture mechanics (LEFM) and elastic-plastic fracture mechanics (EPFM). Crack initiation and propagation is studied under quasi-static, dynamic, and cyclic loading conditions. Models are presented for time dependent fracture including creep and fatigue crack growth. Methods to experimentally determine fracture properties, based on relevant ASTM standards, are introduced. Same course as MAE 5553.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5583 Corrosion Engineering**

**Prerequisites:** ENSC 3313 or equivalent.

**Description:** Modern theory of corrosion and its applications in preventing or controlling corrosion damage economically and safely in service. Same course as MAE 5583.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5683 Thermodynamics and Thermostatistics of Materials**

**Prerequisites:** ENSC 3313 or equivalent.

**Description:** Notions of energy, entropy, equilibrium, macrostates, and microstates and their relation to material processes and properties. Deriving material properties from equations of state: Maxwell relations. Statistical thermodynamics: predicting material properties from microstates. Partition function. Phase transformations. Thermodynamics of surfaces and defects. Electrochemistry. Same course as MAE 5683.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 5693 Phase Transformations in Materials**

**Prerequisites:** Graduate standing or consent of instructor.

**Description:** Principles of phase transformations in material. Structure of materials, phase diagrams, diffusion, solidification, and diffusional and diffusionless transformations will be covered. Recent developments in materials research relevant to phase transformations. Same course as MAE 5693.

**Credit hours:** 3

**Contact hours:** Lecture: 3 Contact: 3

**Levels:** Graduate

**Schedule types:** Lecture

**Department/School:** Materials Sci. & Eng

**MSE 6000 Doctoral Dissertation**

**Prerequisites:** Graduate standing and permission of instructor.

**Description:** Students will be performing dissertation research under the guidance of the student's doctoral dissertation advisor. This will involve performing literature search, writing proposal for the research, and conducting research in the laboratories. At the end of the course, students will present the findings of the research to the committee and prepare a dissertation for approval by the dissertation committee. Offered for variable credit, 1-9 credit hours, maximum of 60 credit hours.

**Credit hours:** 1-9

**Contact hours:** Contact: 1-9 Other: 1-9

**Levels:** Graduate

**Schedule types:** Independent Study

**Department/School:** Materials Sci. & Eng

**MSE 6010 Materials Science and Engineering Seminar for PhD Students**

**Prerequisites:** Graduate standing and consent of graduate program coordinator.

**Description:** Graduate students need to learn about the advances in materials and their processing, training and proficiency at length scales from macro to nanometer. This seminar course will allow students to interact with the experts and other students in the field and introduce descriptions of projects, as well as the concepts of structure-property co-relationships of advanced materials. This will allow the students to become better researchers and form the basis of future ideas and concepts. Guest speakers from different areas, industry and other universities will be invited from time to time. Graduate students will be allowed an opportunity to present their work and obtain feedback from other students for improving their research projects. Maximum of three credit hours. Graded on pass/fail basis.

**Credit hours:** 0

**Contact hours:** Contact: 0 Other: 0

**Levels:** Graduate

**Schedule types:** Discussion

**Department/School:** Materials Sci. & Eng

## Graduate Programs

The School of Materials Science and Engineering offers programs leading to the Master of Science and Doctor of Philosophy. A program of independent study and research on a project under the direction of a member of the Graduate Faculty will be satisfactorily completed by all graduate students. For the Master of Science candidate, the project may result in a thesis. For the Doctor of Philosophy candidate, the project results in a dissertation.

Four research areas of strategic importance have been identified at the Helmerich Advanced Technology Research Center (HRC) at OSU by industry leaders in and around Tulsa. These include: Materials for Energy Technologies, Bio-Materials for Medical Technologies, Advanced Materials for Aerospace, and Materials for Electronics and Control Technologies. All areas fall under the broad umbrella of the School of Materials Science and Engineering.

## Admission Requirements

Admission to either the Master of Science or Doctor of Philosophy degree program requires graduation from a materials science and engineering or related curriculum approved by the ABET or a recognized equivalent from any international program.

Students with related undergraduate degrees, such as chemistry, physics, engineering physics, applied physics, etc., can be admitted conditionally, subject to completing prescribed Materials Science and Engineering program core courses. Admission is competitive based on undergraduate GPA, GRE and TOEFL (for international students), statement of interests, experience and recommendations.

## The Master of Science Degree

The M.S. degree in MSE has both thesis and creative component (non-thesis) options. The thesis option requires a total of 30 credit hours, which includes 24 hours of formal coursework (regularly scheduled classes, not independent study) and 6 hours of a thesis. The non-thesis option or creative component requires a total of 35 credit hours, which includes 33 hours of formal coursework (regularly scheduled classes, not independent study) and 2 hours of a creative component or project. The main difference between the two options is that in the thesis option, students conduct independent research while in the creative component

option, students conduct critical review of the literature on an advanced topic of interest to the MSE program. Both options require a professional report or thesis and an oral presentation. Students take 15 hours of core courses (required) with the remainder of the hours being MSE elective courses or their equivalent (to be approved by MSE graduate coordinator and the thesis advisor or has been considered as an equivalent MSE course). Students must complete no less than 21 hours of MSE 5000- and 6000-level courses through Oklahoma State University. For both options the courses taken must include:

Code	Title	Hours
MSE 5013	Advanced Thermodynamics of Materials	3
MSE 5023	Diffusion and Kinetics	3
MSE 5043	Advanced Materials Characterization	3
MSE 5093	Fundamentals of Materials Science	3
MSE 5193	Advanced Materials Processing	3
MSE 5010	Materials Science and Engineering Seminar for Masters Students	0

## The Doctor of Philosophy Degree

The general credit requirement is a minimum of 90 credit hours beyond the BS degree, including at least 36 hours of credit for research and at least 30 hours of class work. It is expected that the courses must include:

Code	Title	Hours
MSE 5013	Advanced Thermodynamics of Materials	3
MSE 5023	Diffusion and Kinetics	3
MSE 5043	Advanced Materials Characterization	3
MSE 6010	Materials Science and Engineering Seminar for PhD Students	0

Students are responsible for consultation with their doctoral advisory committee in preparing the plan of study. Furthermore, students have to pass the PhD qualifying exam and the dissertation proposal defense to become eligible for candidacy for the PhD Degree, successfully conduct independent research for the dissertation, and pass the final dissertation defense in order to qualify for the PhD degree. More details can be found in the MSE Graduate Student Handbook.

## Faculty

James Smay, PhD—**Colcord Endowed Chair, Professor and Department Head**

**Professor, Associate Dean for Engineering at OSU-Tulsa, Director, Helmerich Advance Technology Research Center, Director of State EPSCOR Office for Oklahoma and Helmerich Endowed Chair.** Raman P. Singh, PhD

**Regents Professor:** Raj N. Singh, Sc.D.

**Varnadow Endowed Professorship:** Ranji Vaidyanathan, PhD, PE

**Associate Professor:** Do Young Kim, PhD; Pankaj Sarin, PhD

**Teaching Assistant Professor:** Srinivas Kolla, PhD