DEPARTMENT OF MATERIALS SCIENCE AND ENGINEERING

The Department of Materials Science and Engineering is jointly operated by the College of Engineering and College of Science.

The department offers Master of Science, Master of Engineering and Ph.D. degrees and has more than 100 graduate students currently in the program who are working on a wide range of materials-related interdisciplinary research projects. This multidisciplinary department includes faculty members from several disciplines, including aerospace engineering, biology, biomedical engineering, chemical engineering, chemistry, electrical engineering, mechanical engineering, nuclear engineering and physics. Many of today's most pressing scientific problems stem from the limitations of materials currently available, and this department is at the forefront of new knowledge and discovery at Texas A&M University.

What is Materials Science and Engineering?

Materials science and engineering involves the characterization of the physical and chemical properties of solid materials—metals and alloys, ceramics, magnetic materials, polymers, optical materials, semiconductors, superconductors, and composites—for the purpose of using, changing, or enhancing inherent properties to create or improve end products. Materials science and engineering involves examining how the microstructure (crystalline or amorphous) of a material can be changed to influence the strength, electrical conductivity, optical, or magnetic properties of a material. This field is inherently multidisciplinary, encompassing mechanical, chemical, biomedical, civil, electrical, and aerospace engineering; physics; and chemistry.

Materials science comprises the study of materials from the macro to the atomic scale—from highway building materials to carbon nanotubes—but, independent of scale, the study of materials is concerned fundamentally with the effect of structure and chemistry on the properties of materials. Materials have historically been so important that different eras of civilization were named according to the materials from which tools were fabricated; for example, the Stone Age, the Bronze Age, and the Iron Age. The development of the semiconductor spawned the modern era of information technology often called the Silicon Age. Advances in materials science might make this new millennium the Biomaterials/ Nanomaterials/Optical Materials Age.

What do Materials Scientists and Engineers do?

In industry, materials scientists and engineers work with natural or synthetic materials and, most often, with combinations of materials, to improve existing products or to develop novel products. For instance, at Intel, the developer of the processing chip used in most PCs, materials scientists optimize the materials used in chip packaging, balancing differing coefficients of thermal expansion, head dissipation, brittleness and compliancy, and cost for optimum performance and economic feasibility.

Other materials scientists are on the forefront of the revolution in biotechnology, developing materials for the components of artificial joints, heart valves, and other replacement body parts. Smart materials show a tremendous potential in medical and dental applications, such as compressible stents that reform to their intended shape upon contact with body heat once inserted into an artery, ceramic cement for bone repair, or shape-memory alloys to correct misplaced teeth or spine curvature. (Smart materials have one or more properties that can be dramatically altered, such as multiviscosity oil, with a viscosity that varies with temperature.)

Related research involves developing smaller and more reliable components, such as ferromagnetic activators acting as tiny machines in military and other applications. In aerospace engineering, materials scientists are developing airframe and fuselage materials with high strength-to-weight ratios, as well as developing smart materials into integrated sensors and actuators for reconfigurable wings and other adaptive structures.

For more information, visit the Department of Materials Science and Engineering (http://engineering.tamu.edu/materials) website.

Faculty

Arroyave, Raymundo, Professor
Materials Science And Engineering
PHD, Massachusetts Institute of Technology, 2004

Cagin, Tahir, Professor
Materials Science And Engineering
PHD, Clemson University, 1998

Case, Raymundo P, Professor of the Practice
Materials Science And Engineering
PHD, University of Manchester Institute of Science and Technology, 2001

Creasy, Terry S, Associate Professor
Materials Science And Engineering
PHD, University of Delaware, 1997

Demkowicz, Michal J, Associate Professor
Materials Science And Engineering
PHD, Massachusetts Institute of Technology, 2005

Hartwig, Karl T, Professor
Materials Science And Engineering
PHD, University of Wisconsin - Madison, 1977

Karaman, Ibrahim, Professor
Materials Science And Engineering
PHD, University of Illinois at Urbana-Champaign, 2000

Lendlein, Andreas, Professor
Materials Science And Engineering
PHD, Swiss Federal Institute of Technology Zurich, 1996

Ma, Ji, Lecturer
Materials Science And Engineering
PHD, Texas A&M University, 2012

Needelman, Alan, Distinguished Professor
Materials Science And Engineering
PHD, Harvard University, 1971

Pharr, George M, Professor
Materials Science And Engineering
PHD, Stanford University, 1979
Qian, Xiaofeng, Assistant Professor
Materials Science And Engineering
PHD, Massachusetts Institute of Technology, 2008

Radovic, Miladin, Associate Professor
Materials Science And Engineering
PHD, Drexel University, 2001

Shamberger, Patrick J, Assistant Professor
Materials Science And Engineering
PHD, University of Washington, 2010

Srivastava, Ankit, Assistant Professor
Materials Science And Engineering
PHD, University of North Texas, 2013

Su, Hung-Jue, Professor
Materials Science And Engineering
PHD, University of Michigan, 1988

Sukhishvili, Svetlana A, Professor
Materials Science And Engineering
PHD, Lomonosov Moscow State University, 1989

Minors

Courses

**MSEN 201 Fundamentals of Materials Science and Engineering**
*Credits 3. 3 Lecture Hours.*
Fundamental principles of materials science and engineering and their application toward complex engineering challenges; relationship between materials structure and structural and functional properties of engineered materials; property-performance relationships; principle classes of materials, as illustrated through key materials advances; current directions in the field.

**Prerequisites:** CHEM 102 or CHEM 104 or CHEM 107; PHYS 218.

**MSEN 210 Thermodynamics of Materials**
*Credits 3. 3 Lecture Hours.*
Basic concepts and fundamental laws of thermodynamics; processes and thermodynamic engines; phase equilibria and phase diagrams of simple substances; chemical reactions of condensed phases; computational software for thermodynamic and phase diagram calculations.

**Prerequisites:** MSEN 201 and MATH 152, or concurrent enrollment.

**MSEN 220/CHEN 220 Physics and Chemistry of Inorganic Materials**
*Credits 3. 3 Lecture Hours.*
Structure, properties and function of materials developed from an atomistic and molecular perspective emphasizing quantum chemical descriptions; elements of solid-state chemistry and physics including bonding, crystal structure and symmetry, origin of electronic band structure, synthesis and characterization tools in materials chemistry and role of finite size effects.

**Prerequisite:** PHYS 208 or CHEM 102, or concurrent enrollment.

**Cross Listing:** CHEM 220/MSEN 220.

**MSEN 222/MEEN 222 Material Science**
*Credits 3. 3 Lecture Hours.*
Mechanical, optical, thermal, magnetic and electrical properties of solids; differences in properties of metals, polymers, ceramics and composite materials in terms of bonding and crystal structure.

**Prerequisites:** CHEM 102, or CHEM 104 and CHEM 114, or CHEM 107 and PHYS 218.

**Cross Listing:** MSEN 222/MSEN 222.

**MSEN 240 Kinetics of Materials**
*Credits 3. 3 Lecture Hours.*
Application of physical principles that drive evolution of materials as they approach thermodynamic equilibrium states; includes Gibbs free energy, driving forces, point defects, diffusion in solids, interface and grain boundary motion, nucleation, growth, transformation diagrams, precipitation, phase separation, ordering and solidification.

**Prerequisite:** MSEN 210.

**MSEN 250 Soft Matter**
*Credits 3. 3 Lecture Hours.*
Structure, properties and function of various classes of soft matter including colloids, polymers, amphiphils, liquid crystals and biomacromolecules; basic concepts of viscoelasticity, glass transition, liquid-liquid and liquid-solid transitions and gelation; forces acting between mesoscopic objects; supramolecular self-assembly in soft condensed matter.

**Prerequisites:** PHYS 208, CHEM 102 and CHEM 112.

**MSEN 281 Materials Science and Engineering Seminar**
*Credit 1. 1 Lecture Hour.*
Presentation of technical advances in the field of materials science and engineering; applications toward solving engineering challenges; presentations from visiting industry, academic speakers, and faculty; introduction to current research themes and focal points in industry.

**Prerequisite:** MSEN 201.

**MSEN 285 Directed Studies**
*Credits 1 to 4. 1 to 4 Other Hours.*
Directed study of selected problems in the area of materials science and engineering. May be taken for credit 4 times.

**Prerequisite:** Approval of instructor.

**MSEN 289 Special Topics In...**
*Credits 1 to 3. 1 to 3 Lecture Hours. 0 to 3 Lab Hours.*
Selected topics in an identified area of materials science and engineering. May be repeated for credit.

**Prerequisite:** Approval of instructor.

**MSEN 301 Unified Materials Lab I**
*Credits 3. 2 Lecture Hours. 3 Lab Hours.*
Integration of materials synthesis, structural characterization and property evaluation; theory and practice of experimental and simulation techniques; emphasis on relationship between processing parameters and resulting materials structure.

**Prerequisites:** MSEN 240 and MSEN 310 or concurrent enrollment.

**MSEN 302 Unified Materials Lab II**
*Credits 3. 2 Lecture Hours. 3 Lab Hours.*
Integration of materials synthesis, structural characterization and property evaluation; theory and practice of experimental and simulation techniques; emphasis on relationship between materials structure and resulting materials physical properties.

**Prerequisite:** MSEN 301.
MSEN 310 Structure of Materials
Credits 3. 3 Lecture Hours.
Materials structure over many orders of scale; structure of non-crystalline materials; symmetry, unit cell and the atomic structure of crystalline materials; liquid crystals; structural defects in ordered solids; microstructures and hierarchical structures.
Prerequisite: MSEN 201, MSEN 222/MEEN 222, AERO 413, BMEN 343, CHEN 313, CVEN 306, ENTC 206, or NUEN 265, or approval of instructor.

MSEN 320 Deformation and Failure Mechanisms in Engineering Materials
Credits 3. 3 Lecture Hours.
Survey of deformation and failure mechanisms in different materials, including metals, ceramics, polymers and composites; effect of atomistic structure, defects and microstructure on deformation and failure; deformation and failure mechanism maps and effects of temperature and deformation rate.
Prerequisite: MSEN 310 or approval of instructor.

MSEN 330 Numerical Methods for Materials Scientists and Engineers
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Computing platforms addressing scientific/engineering problems related to materials science and engineering; analyze data; implement mathematical models of materials behavior; numerical methods to solve materials-related problems.
Prerequisite: MATH 307.

MSEN 340 Case Studies in Materials
Credits 2. 2 Lecture Hours.
Case studies illustrating materials failure and consequences thereof; materials selection process in the face of uncertainty; industry standards and regulatory frameworks; design tradeoffs and cost analysis; ethical and business implications of materials failure.
Prerequisite: MSEN 310.

MSEN 370 Computational Materials Science and Engineering
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Studio emphasizing methods to simulate materials behavior across multiple scales; includes electronic structure calculations, classical molecular dynamics, computational thermodynamics and kinetics of materials, microstructure evolution simulation and continuum models of materials behavior.
Prerequisites: MSEN 210 and MSEN 330.

MSEN 400 Design and Analysis of Materials Experiments
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Systematic design of experimental investigations; team approach to identify topics and develop experiment designs including establishing the need, associated requirements and objectives; conduct experiments; characterize materials; analyze and interpret results; documenting the procedures, analysis, results and conclusions; present written and oral reports.
Prerequisites: MSEN 220/CHEM 220, MSEN 302 and MSEN 320.

MSEN 401 Materials Research and Design I
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Research and design process; need definition, functional analysis, performance requirements, evaluation criteria, conceptual design evaluation; introduction to systems engineering; parametric and risk analysis, failure analysis, material selection and manufacturability; cost and life cycle issues, project management; topics from sponsored research or an industry-sponsored design project.
Prerequisites: MSEN 281, MSEN 340 and MSEN 400.

MSEN 402 Materials Research and Design II
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Continuation of MSEN 401; development of innovative solutions to research or industry-provided design challenges; structured framework and methodology for design activities; innovation, computational materials science, synthesis/processing and analysis/characterization of material components; project definition, management, customer interaction and effective team participation; presentations and design reviews.
Prerequisite: MSEN 401.

MSEN 410 Materials Processing
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Synthesis, properties and processing of technologically important inorganic materials (metals and ceramics); includes thermodynamics and kinetics of different materials processing methods, casting, deformation processing, heat treatments, powder processing and sintering, coating and thin films processing, etc.
Prerequisite: MSEN 201, MSEN 222/MEEN 222, AERO 413, BMEN 343, CHEN 313, CVEN 306, ENTC 206, or NUEN 265, or approval of instructor.

MSEN 415 Defects in Solids
Credits 3. 3 Lecture Hours.
Overview of point, line and surface defects in solids; relates defect properties to diffusion, deformation, phase transformations; focuses on atomic defects in crystals, with additional examples from liquid crystals, superconductors and ferromagnets; incorporates atomistic modeling to examine defect structure.
Prerequisite: MSEN 310 or approval of instructor.

MSEN 420 Polymer Science
Credits 3. 3 Lecture Hours.
Types of polymerization; molecular characteristics of polymer chains; single chain statistics and rubber elasticity; phase transitions, glass transition, viscoelasticity and time-temperature superposition; polymer structure at the molecular, microscopic and macroscopic level; polymer mesosets, thermoplastics, elastomers, fibers, and advanced nanoparticle-filled composites.
Prerequisite: PHYS 208, CHEM 102 and CHEM 112; or approval of instructor.

MSEN 426 Polymer Laboratories
Credits 3. 2 Lecture Hours. 3 Lab Hours.
Laboratory to prepare those interested in polymer research with necessary experimental and analytical skills to conduct and analyze experimental work.
Prerequisite: MSEN 250 or approval of instructor.

MSEN 430 Nanomaterials Science
Credits 3. 3 Lecture Hours.
Nanotechnology and nanomaterials; types, fabrication, characterization methods and applications; current roles in technology and future impact of such systems on industry targeting.
Prerequisite: MSEN 310, junior or senior classification; or approval of instructor.

MSEN 440 Materials Electrochemistry and Corrosion
Credits 3. 3 Lecture Hours.
Survey of thermodynamic and kinetic fundamentals of electrochemistry; multiscale materials corrosion mechanisms; details of interfacial aqueous electrochemical mechanisms and the environmental effects when materials are exposed to different conditions.
Prerequisite: MSEN 220/CHEM 220 or approval of instructor.
MSEN 444 Corrosion and Electrochemistry Lab  
**Credits 3. 2 Lecture Hours. 3 Lab Hours.**  
Laboratory practice and principles for corrosion and electrochemistry methods; design, carry out and analyze a series of labs illustrating the most important techniques in the field; builds to an open-ended corrosion engineering problem resulting in preparation of a technical report for a hypothetical client.  
**Prerequisite:** MSEN 440.

MSEN 446 Corrosion Prevention and Control Methods  
**Credits 3. 3 Lecture Hours.**  
Cathodic protection and coatings; functional engineering approach to controlling and preventing aqueous corrosion; impressed current, galvanic anodes, organic, inorganic and hybrid coatings; case studies in oil and gas, energy, automotive and different industries.  
**Prerequisites:** MEEN 360 and MSEN 444.

MSEN 458 Fundamentals of Ceramics  
**Credits 3. 3 Lecture Hours.**  
Structure-property relationships of ceramics and ceramic composites; atomic bonding in ceramics; crystalline and glassy structures; phase equilibria and ceramic reactions; mechanical, electrical, thermal, dielectric, magnetic and optical properties; ceramic processing; different properties of ceramics will be related to their underlying structure.  
**Prerequisite:** MSEN 310 or approval of instructor.

MSEN 460 Properties of Functional Materials  
**Credits 3. 3 Lecture Hours.**  
Origins of functional materials properties from their electronic and molecular structure; electron theory in solids; electronic transport and dielectric behavior; optical and magnetic properties; current applications of functional materials.  
**Prerequisite:** MSEN 201, MSEN 222/MEEN 222, AERO 413, BMEN 343, CHEN 313, CVEN 306, ENTC 206, or NUEN 265, or approval of instructor.

MSEN 462 Advanced Materials Characterization  
**Credits 3. 2 Lecture Hours. 3 Lab Hours.**  
Principles and techniques used in characterization of different materials, including metals, ceramics, polymers, composites and semiconductor systems; microstructural, chemical/compositional and surface analysis methods; interpretation and analysis of the characterization results.  
**Prerequisites:** MSEN 220/CHEM 220, MSEN 250, and MSEN 310; or approval of instructor.

MSEN 472 Atomistic Simulation of Materials  
**Credits 3. 3 Lecture Hours.**  
Modern methods of computational modeling and simulation of materials properties and phenomena at the atomistic scale; quantum, classical and statistical mechanical methods, including semi-empirical atomic and molecular-scale simulations, and other modeling techniques using macroscopic input.  
**Prerequisite:** MSEN 370 or approval of instructor.

MSEN 474 Materials Modeling of Phase Transformation and Microstructural Evolution  
**Credits 3. 2 Lecture Hours. 3 Lab Hours.**  
Computer modeling and simulation of microstructural evolution during various phase transformation processes in solid materials, including spinodal decomposition, ordering, martensitic transformation, ferroelectric and ferromagnetic domain evolution, nucleation, growth, and solidification.  
**Prerequisite:** MSEN 370 or approval of instructor.

MSEN 476 Multi-Scale Computational Materials Science  
**Credits 3. 2 Lecture Hours. 3 Lab Hours.**  
Advanced and problem-based; illustrating elements of challenges associated with multi-scale simulations; examination of multi-scale modeling of elastic response of a multi-phase microstructure; elements of uncertainty quantification and propagation.  
**Prerequisite:** MSEN 370 or approval of instructor.

MSEN 480 Communicating Materials Science and Engineering  
**Credit 1. 1 Lecture Hour.**  
Effective communication of technical topics in materials science and engineering to technical and non-technical audiences; emphasis on oral and visual presentations.  
**Prerequisite:** MSEN 401 or concurrent enrollment.

MSEN 484 Internship  
**Credits 0 to 4. 0 to 4 Other Hours.**  
Practical experience working in a professional materials science and engineering setting offered on an individual basis. Must be taken on a satisfactory/unsatisfactory basis.  
**Prerequisites:** Junior or senior classification and approval of instructor.

MSEN 485 Directed Studies  
**Credits 0 to 4. 0 to 4 Other Hours.**  
Directed study of selected problems in the area of materials science and engineering. May be taken four times for credit.  
**Prerequisite:** Approval of instructor.

MSEN 489 Special Topics In...  
**Credits 1 to 4. 1 to 4 Lecture Hours. 0 to 4 Lab Hours.**  
Selected topics in an identified area of materials science and engineering. May be repeated for credit.  
**Prerequisite:** Approval of instructor.

MSEN 491 Research  
**Credits 0 to 4. 0 to 4 Other Hours.**  
Research conducted under the direction of a faculty member in materials science and engineering. May be taken four times for credit.  
**Prerequisites:** Junior or Senior classification or approval of instructor.