Materials Science

Degrees Offered
- Master of Science (Materials Science; thesis option or non-thesis option)
- Doctor of Philosophy (Materials Science)

Program Description
The Departments of Chemistry and Geochemistry, Metallurgical and Materials Engineering, Physics, and Chemical and Biological Engineering jointly administer the interdisciplinary materials science program. This interdisciplinary degree program coexists along side strong disciplinary programs, in Chemistry, Chemical and Biochemical Engineering, Mechanical Engineering, Metallurgical and Materials Engineering, and Physics. For administrative purposes, the student will reside in the advisor’s home academic department. The student’s graduate committee will have final approval of the course of study.

The interdisciplinary graduate program in Materials Science exists to educate students, with at least a Bachelor of Science degree in engineering or science, in the diverse field of Materials Science. This diversity includes the four key foundational aspects of Materials Science – materials properties including characterization and modeling, materials structures, materials synthesis and processing and materials performance – as applied to materials of a variety of types (i.e., metals, ceramics, polymers, electronic materials and biomaterials). The Materials Science graduate program is responsible for administering MS (thesis and non-thesis) and PhD Degrees in Materials Science.

Fields of Research
- Advanced polymeric materials
- Alloy theory, concurrent design, theory-assisted materials engineering, and electronic structure theory
- Applications of artificial intelligence techniques to materials processing and manufacturing, neural networks for process modeling and sensor data processing, manufacturing process control
- Atomic scale characterization
- Atom Probe Tomography
- Biomaterials
- Ceramic processing, modeling of ceramic processing
- Characterization, thermal stability, and thermal degradation mechanisms of polymers
- Chemical and physical processing of materials, engineered materials, materials synthesis
- Chemical vapor deposition
- Coating materials and applications
- Computational condensed-matter physics, semiconductor alloys, first-principles phonon calculations
- Computer modeling and simulation
- Control systems engineering, artificial neural systems for senior data processing, polymer cure monitoring sensors, process monitoring and control for composites manufacturing
- Crystal and molecular structure determination by X-ray crystallography
- Electrodeposition
- Electro and ion microscopy
- Experimental condensed-matter physics, thermal and electrical properties of materials, superconductivity, photovoltaics
- Fuel cell materials
- Fullerene synthesis, combustion chemistry
- Heterogeneous catalysis, reformulated and alcohol fuels, surface analysis, electrophotography
- High temperature ceramics
- Intelligent automated systems, intelligent process control, robotics, artificial neural systems
- Materials synthesis, interfaces, flocculation, fine particles
- Mathematical modeling of material processes
- Mechanical metallurgy, failure analysis, deformation of materials, advanced steel coatings
- Mechanical properties of ceramics and ceramic composites
- High entropy alloys
- Mössbauer spectroscopy, ion implantation, small-angle X-ray scattering, semiconductor defects
- Nano materials
- Non-destructive evaluation
- Non-ferrous structural alloys
- Novel separation processes: membranes, catalytic membrane reactors, biopolymer adsorbents for heavy metal remediation of ground surface water
- Numerical modeling of particulate media, thermomechanical analysis
- Optical properties of materials and interfaces
- Phase transformations and mechanisms of microstructural change
- Photovoltaic materials and device processing
- Physical metallurgy, ferrous and nonferrous alloy systems
- Physical vapor deposition, thin films, coatings
- Power electronics, plasma physics, pulsed power, plasma material processing
- Processing and characterization of electroceramics (ferro-electrics, piezoelectrics, pyroelectrics, and dielectrics)
- Semiconductor materials and device processing
- Soft materials
- Solidification and near net shape processing
- Surface physics, epitaxial growth, interfacial science, adsorption
- Transport phenomena and mathematical modeling
- Weld metallurgy, materials joining processes
- Welding and joining science

Program Requirements
Each of the three degree programs require the successful completion of three core courses for a total of 9 credit hours that will be applied to the degree program course requirements. Depending upon the individual student’s background, waivers for these courses may be approved by the program director. In order to gain a truly interdisciplinary understanding of Materials Science, students in the program are encouraged to select elective courses from several different departments outside of the Materials Science program. Course selection should be completed in consultation with the student’s advisor or program director as appropriate.

Listed below are the three required Materials Science core courses:

- MLGN591 MATERIALS THERMODYNAMICS 3.0
an additional final examination be given during the mid-term break of
receives a grade of less than B- in a class, the student may request
the first Fall semester for all doctoral candidates. Students must obtain
Core Curriculum – The three required core classes must be completed in
additional coursework is required as part of a student's program, these
Committee may award credit for previous experience. In cases where
this background information. In these cases, the candidate's Thesis
examines before the Thesis Committee.
COURSEWORK Materials Science Courses 1 18.0
MLGN707 Thesis Research Credits 12.0
Total Semester Hrs 30.0
* Must include 9.0 credit hours of core courses.

Master of Science (Non-Thesis Option with a case study)
The Master of Science degree requires a minimum of 30.0 semester
hours of acceptable course work and case study credit including:
COURSEWORK Materials Science Courses 1 24.0
MLGN Case Study 6.0
Total Semester Hrs 30.0
* Must include 9.0 credit hours of core courses.

Doctor of Philosophy
The Doctor of Philosophy degree requires a minimum of 72.0 hours of
course and research credit including:
COURSEWORK Materials Science Courses (minimum) 1 24.0
MLGN707 Thesis Research Credits (minimum) 24.0
* Must include 9.0 credit hours of core courses.

Deficiency Courses
All doctoral candidates must complete at least 6 credit hours of
background courses. This course requirement is individualized for each
candidate, depending on previous experience and research activities to be pursued. Competitive candidates may already possess
this background information. In these cases, the candidate's Thesis
Committee may award credit for previous experience. In cases where
additional coursework is required as part of a student's program, these
courses are treated as fulfilling a deficiency requirement that is beyond
the total institutional requirement of 72 credit hours.

PhD Qualifying Process
The following constitutes the qualifying processes by which doctoral
students are admitted to candidacy in the Materials Science program.

Core Curriculum – The three required core classes must be completed in
the first Fall semester for all doctoral candidates. Students must obtain
a grade of B- or better in each class to be eligible to take the qualifying
examination at the end of the succeeding spring semester. If a student
receives a grade of less than B- in a class, the student may request
an additional final examination be given during the mid-term break of
the following spring semester. If the result of this examination is a B- or
better, the student will be allowed to take the qualifying examination. The
grade originally obtained in the course will not be changed as a result.
If not allowed to complete the qualifying examination at the end of the
spring semester, students will be discouraged from the PhD program and
encouraged, rather, to finish with a Masters degree.

Qualifying Examination – A qualifying examination is given annually
at the end of the spring semester under the direction of the Materials
Science Graduate Affairs Committee. All first-year Materials Science
students are expected to successfully complete the qualifying
examination within three semesters to remain in good standing in the
program. The examination covers material from the core curriculum plus
a standard introductory text on Materials Science, such as "Materials
Science and Engineering: An Introduction", by William Callister. If a
student performs below the expectations of the Materials Science faculty
on the written exam, they will be asked to complete a follow-up oral
examination in the subsequent fall semester. The oral examination will
be based on topics deemed to be deficient in the written examination.
Satisfactorily completing the oral exam will allow the student to proceed
with the PhD program. Students who perform below the expectations
of the Materials Science faculty on the oral exam will not be allowed to
continue with the PhD program.

Thesis Proposal – A student's thesis committee administers a Thesis
Proposal defense. The proposal defense should occur no later than the
student's fourth semester. While the proposal itself should focus on the
central topic of a student's research efforts, during the proposal defense,
candidates may expect to receive a wide range of questions from the
Committee. This would include all manner of questions directly related to
the proposal. Candidates, however, should also expect questions related
to the major concept areas of Materials Science within the context of a
candidate's research focus. The Committee formally reports results of the
proposal defense to the Materials Science Program Director using the
Committee Reporting form developed by the Office of Graduate Studies.

Upon completion of these steps and upon completion of all required
coursework, candidates are admitted to candidacy.

Following successful completion of coursework and the PhD qualifying
process, candidates must also submit a thesis and successfully complete
the Defense of Thesis examination before the Thesis Committee.

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<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tr>
<td>MLGN500</td>
<td>PROCESSING, MICROSTRUCTURE, AND PROPERTIES OF MATERIALS</td>
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<td>STRUCTURE OF MATERIALS</td>
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<td>SOLID STATE PHYSICS</td>
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<td>CHEMICAL BONDING IN MATERIALS</td>
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<td>MLGN506</td>
<td>TRANSPORT IN SOLIDS</td>
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<td>SOLID STATE CHEMISTRY</td>
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<td>SURFACE CHEMISTRY</td>
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<td>ELECTRICAL PROPERTIES AND APPLICATIONS OF MATERIALS</td>
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<td>PHASE EQUILIBRIA IN CERAMICS SYSTEMS</td>
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<td>APPLIED SURFACE AND SOLUTION CHEMISTRY</td>
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<td>GEL SCIENCE AND TECHNOLOGY</td>
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<td>INTRODUCTION TO POLYMER SCIENCE</td>
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<td>STATISTICAL PROCESS CONTROL AND DESIGN OF EXPERIMENTS</td>
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<td>BONDING, STRUCTURE, AND CRYSTALLOGRAPHY</td>
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<td>MLGN696</td>
<td>VAPOR DEPOSITION PROCESSES</td>
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<td>MLGN707</td>
<td>GRADUATE THESIS / DISSERTATION RESEARCH CREDIT</td>
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</table>

### Professors

- Colin Wolden, Department of Chemical Engineering, Weaver Distinguished Professor
- Stephen Liu, Department of Metallurgical and Materials Engineering, American Bureau of Shipping Endowed Chair of Metallurgical and Materials Engineering
- John R. Dorgan, Department of Chemical and Biological Engineering
- Mark Eberhart, Department of Chemistry and Geochemistry
- Thomas E. Furtak, Department of Physics
- Michael J. Kaufman, Department of Metallurgical and Materials Engineering, Dean of CASE
- Daniel M. Knauss, Department of Chemistry and Geochemistry
- Ryan P. O’Hayre, Department of Metallurgical and Materials Engineering
- Ivar E. Reimanis, Department of Metallurgical and Materials Engineering, Herman F. Coors Distinguished Professor of Ceramic Engineering
- P. Craig Taylor, Department of Physics
- Chester J. Van Tyne, Department of Metallurgical and Materials Engineering, FIERF Professor and Associate Department Head

### Associate Professors

- John R. Berger, Department of Mechanical Engineering
- Stephen G. Boyes, Department of Chemistry and Geochemistry
- Cristian V. Ciobanu, Department of Mechanical Engineering
- Brian P. Gorman, Department of Metallurgical and Materials Engineering
- Timothy R. Ohno, Department of Physics
- Ryan Richards, Department of Chemistry and Geochemistry, Materials Science Program Interim Director
- Neal Sullivan, Department of Mechanical Engineering

### Assistant Professors

- Geoff L. Brennecka, Department of Metallurgical and Materials Engineering
- Honjun Liang, Department of Metallurgical and Materials Engineering
- Corinne E. Packard, Department of Metallurgical and Materials Engineering
- Eric Toberer, Department of Physics
- Zhigang Wu, Department of Physics
- Yongan Yang, Department of Chemistry and Geochemistry

### Professors Emeriti

- John Moore, Department of Metallurgical and Materials Engineering
- Denis W. Readey, Department of Metallurgical and Materials Engineering, University Professor Emeritus

### Teaching Associate Professors

- Gerald Bourne, Department of Metallurgical and Materials Engineering
- John Chandler, Department of Metallurgical and Materials Engineering
Research Professors
Richard K. Ahrenkiel, Department of Metallurgical and Materials Engineering
William (Grover) Coors, Department of Metallurgical and Materials Engineering

Research Associate Professors
James E. Bernard, Department of Physics
Jianhua Tong, Department of Metallurgical and Materials Engineering

Research Assistant Professors
David Diercks, Department of Metallurgical and Materials Engineering
Jianliang Lin, Department of Metallurgical and Materials Engineering