MATERIALS SCIENCE AND ENGINEERING, PH.D.

Meeting many of the most critical challenges facing modern society requires advances in the materials that underpin new technologies. Examples include providing carbon-free and renewable energy, clean water, advanced medical treatments and devices, and sustainable materials manufacturing. New materials are also required for continued economic growth in areas as diverse as aerospace, computing, and sensors.

Materials scientists and engineers at UW–Madison work toward solutions to these problems via research in a wide variety of areas. Research areas include ceramics, computational material science; composites; corrosion; electrical, optical, magnetic materials; growth and synthesis; joining; materials for energy; metals; materials characterization and microscopy; nanomaterials; phase transformations; photonics; polymers and biomaterials; materials for nuclear energy; quantum computing; self-assembly; semiconductors; structural materials and mechanical properties; surfaces and interfaces; sustainability; thin films; and wear.

More broadly, the field of materials science and engineering is in the middle of a revolution in how we design and deploy new materials. The old way is by trial and error, which involves laboratory testing of hundreds or thousands of candidate materials, which is costly and can take decades to develop a new material and deploy it in practical technologies. The emerging new method leverages advances in computational materials science; materials databases, data science, and machine learning; and high throughput materials synthesis and characterization to achieve true design of materials. The goal is to develop and deploy new materials much more quickly and much lower cost than ever before. Materials design is a major theme of materials research on campus, organized around the areas of materials design via atomically controlled thin film systems, modular design of nanomaterials, and integrated experimental and computational materials engineering. Materials design and these themes cut across the research and application areas list above.

Materials research extends across campus, well beyond the boundaries of the Department of Materials Science and Engineering, so graduate students in materials can pursue research with a large number of affiliate faculty. Faculty emphasize the cross-cutting, interdisciplinary nature of materials research, which is also reflected by the diverse undergraduate backgrounds of the student body, many of whom do not have undergraduate degrees in materials.

Materials research benefits from major campus facilities, including the Materials Science Center, the Wisconsin Microscopy and Characterization Center, Wisconsin Center for Applied Microelectronics, and the Soft Materials Laboratory. Research is supported by major centers, including the National Science Foundation Materials Research Science and Engineering Center and the Grainger Institute for Engineering.

Materials graduates from Wisconsin find long-term success in careers in private industry, national laboratories, and academia in the US and around the world.

ADMISSIONS

Applicants normally are expected to have a B.S. in the physical sciences or engineering. Undergraduate studies normally would include mathematics through differential equations, at least one year each of general physics and chemistry, a course in physical chemistry or modern physics, and an elementary course in properties of materials. Applicants may be admitted with deficiencies. These must be made up as soon as possible after entering the program.

Admission to the University of Wisconsin–Madison Graduate School (http://grad.wisc.edu) is a prerequisite for admission to study materials science. A minimum GPA of 3.0/4.0 is required. Graduate Record Examinations (http://www.ets.org/gre) scores on the General Test are required. Admission is highly selective. Most admitted students have an undergraduate GPA above 3.5. Mean GRE scores in the most recent admission cycle were quantitative: 166, verbal: 163, and analytical writing: 3.5. However, full consideration will be given to all students meeting the UW–Madison graduate school requirements. Please use institution code: 1846; no department code is necessary.

Foreign students must submit satisfactory results on the TOEFL (http://www.ets.org/toefl) or another acceptable English Language Test. Please use institution code: 1846; no department code is necessary. Information about these exams can be obtained from the Educational Testing Service, Princeton, New Jersey 08540 or Berkeley, California 94704.

Please use the online application (https://apply.grad.wisc.edu/Account/Login?ReturnUrl=%2f) to begin your application. To be considered for fellowships, all application materials are due by January 1. If you have questions about the application or admissions process, please do not hesitate to send an email to msaegradadmission@engr.wisc.edu.

The graduate school offers a limited number of application fee grants (waivers of all or part of the application fee) that are available in a few specific circumstances. Further information is available here. (https://grad.wisc.edu/admissions/feegrants)

APPLICATION DEADLINES:

Spring semester: October 1
Fall semester: January 1

GRADUATE SCHOOL ADMISSIONS

Graduate admissions is a two-step process between academic degree programs and the Graduate School. Applicants must meet requirements of both the program(s) and the Graduate School. Once you have researched the graduate program(s) you are interested in, apply online (https://grad.wisc.edu/admissions).

FUNDING

GRADUATE SCHOOL RESOURCES

Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding) is available from the Graduate School. Be sure to check with your program for individual policies and processes related to funding.
PROGRAM RESOURCES
FINANCIAL ASSISTANCE
Please note that most funding is available for Ph.D. students and there is limited resources for M.S. students. International students must prove one year of funding before requesting assistance. Financial assistance is not available for students enrolled in the named option M.S. in Nanomaterials and Nanoengineering (http://guide.wisc.edu/graduate/materials-science-engineering/materials-science-engineering-ms/materials-science-engineering-nanomaterials-nanoengineering-ms).

Various types of financial assistance are available for entering graduate students, including research assistantships, teaching assistantships, fellowships and special grants. Decisions regarding financial support are made on the basis of letters of recommendation, grades, GRE general test scores, and, for research assistantships, the matching of the interests or experience of the applicant to the research programs of individual faculty members. January 1 is the deadline for receipt of fellowship applications. Foreign students are generally not eligible for university fellowships. Applications for other types of support are accepted until mid-February.

RESEARCH AND TEACHING ASSISTANTSHIPS
Research assistantships (RAs) are available in any materials science area. These appointments are under the supervision of the major professor directing the research. Students interested in research assistantships in a particular area are encouraged to contact professors whose work is of special interest. The faculty’s research interests are given in the Department of Materials Science And Engineering faculty section. An RA permits the most rapid progress toward a degree. Research assistantships in materials science graduate students are comparable to similar stipends from other institutions. Information about stipends can be obtained from the director of graduate studies, dgs@mse.wisc.edu.

Teaching assistantships involve teaching rather than research experience. They pay approximately the same as research assistantships. Teaching experience is especially desirable for students considering an academic career. The Department of Materials Science and Engineering supports a limited number of teaching assistantships, which are allocated after admissions. Applications for teaching assistantship positions for the 2018-2019 academic year are available here (https://docs.google.com/document/d/1-L8U7xhNQ9i-FOJbk0qJA67h8lZzC09qRylIDeGZ_Jo/edit).

FELLOWSHIPS
Herb Fellowships in Materials Science are given out each year. The Herb Fellowship is a one-year full-ride fellowship for incoming graduate students. It is intended to provide especially strong students extra flexibility and independence in formulating their graduate research program.

Fellowships supporting graduate education are also offered on a competitive basis by organizations such as the National Science Foundation (http://www.nsf.gov), the Hertz Foundation (http://www.hertzfdn.org), UW-Madison Graduate School (http://www.wisc.edu/grad), the U.S. Department of Defense and a number of industries and foundations. Because some of these fellowships have fall application deadlines, early application is necessary. GRE scores for the General Test are required for fellowship applications.

OTHER FUNDING INFORMATION
If you choose to attend UW–Madison and plan to pursue funding on your own, the following sites could be very helpful:

- Graduate School Funding Resources (https://grad.wisc.edu/studentfunding/prospective)
- Graduate School Costs and Funding (https://grad.wisc.edu/studentfunding/currentstudents)
- Tuition & Fees (https://Registrar.wisc.edu/tuition_fees.htm)

REQUIREMENTS
MINIMUM GRADUATE SCHOOL REQUIREMENTS
Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduateschool/policiesandrequirements/studenttext), in addition to the program requirements listed below.

MAJOR REQUIREMENTS
MODE OF INSTRUCTION

<table>
<thead>
<tr>
<th>Face to Face</th>
<th>Evenings/Weekends</th>
<th>Online</th>
<th>Hybrid</th>
<th>Accelerated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Mode of Instruction Definitions

**Evenings/Weekend:** These programs are offered in an evening and/or weekend format to accommodate working schedules. Enjoy the advantages of on-campus courses and personal connections, while keeping your day job. For more information about the meeting schedule of a specific program, contact the program.

**Online:** These programs are offered primarily online. Many available online programs can be completed almost entirely online with all online programs offering at least 50 percent or more of the program work online. Some online programs have an on-campus component that is often designed to accommodate working schedules. Take advantage of the convenience of online learning while participating in a rich, interactive learning environment. For more information about the online nature of a specific program, contact the program.

**Hybrid:** These programs have innovative curricula that combine on-campus and online formats. Most hybrid programs are completed on-campus with a partial or completely online semester. For more information about the hybrid schedule of a specific program, contact the program.

**Accelerated:** These on-campus programs are offered in an accelerated format that allows you to complete your program in a condensed time-frame. Enjoy the advantages of on-campus courses with minimal disruption to your career. For more information about the accelerated nature of a specific program, contact the program.

CURRICULAR REQUIREMENTS

<table>
<thead>
<tr>
<th>Minimum Requirement</th>
<th>51 credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit Requirement</td>
<td>32 credits</td>
</tr>
<tr>
<td>Minimum Residence</td>
<td></td>
</tr>
<tr>
<td>Credit Requirement</td>
<td></td>
</tr>
</tbody>
</table>
Minimum Graduate Coursework Requirement
Half of degree coursework (26 credits out of 51 total credits) must be completed graduate-level coursework; courses with the Graduate Level Coursework attribute are identified and searchable in the university’s Course Guide (http://my.wisc.edu/CourseGuideRedirect/BrowseByTitle).

Overall Graduate GPA Requirement
3.00 GPA required.

Other Grade Requirements
The Graduate School requires an average grade of B or better in all coursework (300 or above, not including research credits) taken as a graduate student unless conditions for probationary status require higher grades. Grades of Incomplete are considered to be unsatisfactory if they are not removed during the next enrolled semester.

Assessments and Examinations
Students entering without a previous master’s degree:
• Students must pass a qualifying exam in Materials Science and Engineering. The exam must be attempted within 13 months of the start of the student’s first semester enrolled. If the first attempt is not passed, a second attempt is required within four months.
• Students must pass a preliminary exam / thesis proposal exam. This exam is typically undertaken by the end of the fourth semester enrolled and must be undertaken by the end of the fifth semester. If the first attempt is not passed, a second attempt is required within three months.
• Students must prepare a doctoral dissertation, present it in a public seminar, defend it in closed examination by their doctoral committee, and deposit it with the Graduate School.

Students entering with a master’s degree:
• Students on this track must pass the qualifying exam, thesis proposal exam, and thesis defense as described above, on the same schedule with respect to their matriculation date. Students who fail one of these exams will have the opportunity to earn a terminal Master’s degree in M S & E, even if they have been granted a course substitution.

Language Requirements
None.

Doctoral Minor/Breadth Requirements
All doctoral students are required to complete a minor. If students choose a distributed minor (Option B), they must select a topic or theme and three courses around that theme. At least one course must be graduate level. There are no other restrictions on the course department or topic.

REQUIRED COURSES
Courses for Students Starting from a Bachelor's Degree and Enrolling Directly in the Ph.D. Program
The Graduate School requires that a Ph.D. student earn at least 51 total credits, at least half of which must be at the graduate level. Thus, M S & E graduate students are required to take at least 25 additional credits of research study (51 credits - 24 course credits - 2 credits for M S & E 900 Materials Research Seminar) beyond the required lecture or laboratory courses. These credits may be research credits, additional courses, or a combination of both. For research credits, students should register for the following courses:

1. Before earning the Master's degree, students should register for M S & E 790 Master's Research or Thesis.
2. After earning the Master's degree, they should register for M S & E 890 Pre-Dissertation's Research.
3. Once they have achieved dissertator status, they should register for M S & E 990 Research and Thesis.

All course requirements are subject to modification or substitution to better serve the research needs of the student. To request a change, submit a letter to the department graduate secretary signed by the student and advisor proposing a change and explaining how the change will better suit the student's needs, especially as it pertains to their research. Course substitutions and other curriculum variances are decided by the department's director of graduate studies, subject to appeal to the department's Graduate Governance Committee and the grievance procedure.

Materials Elective Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>M S &amp; E 401</td>
<td>Special Topics in Materials Science and Engineering</td>
<td>1-3</td>
</tr>
<tr>
<td>M S &amp; E/CHEM 421</td>
<td>Polymeric Materials</td>
<td>3</td>
</tr>
<tr>
<td>M S &amp; E/N 423</td>
<td>Nuclear Engineering Materials</td>
<td>3</td>
</tr>
<tr>
<td>M S &amp; E/N E 433</td>
<td>Principles of Corrosion</td>
<td>3</td>
</tr>
<tr>
<td>M S &amp; E 434</td>
<td>Introduction to Thin-Film Deposition</td>
<td>3</td>
</tr>
<tr>
<td>M S &amp; E 441</td>
<td>Deformation of Solids</td>
<td>3</td>
</tr>
<tr>
<td>M S &amp; E 445</td>
<td>Crystallography and X-Ray Diffraction</td>
<td>3</td>
</tr>
</tbody>
</table>
Courses for Students Starting from a Master's Degree and Enrolling Directly in the Ph.D. Program

These requirements cover students who (1) have already earned a master's degree in M S & E or a related field and (2) do not wish to earn an M S & E master's from UW.

Students must enroll in the introductory seminar, M S & E 900 Materials Research Seminar, for their first two semesters of enrollment.

Students must satisfy all of the course requirements for the Ph.D. given in the preceding section. However, they may request that courses taken as part of a previous master's degree at another institution serve to satisfy a portion of the requirements. Students will have one month after matriculation to identify that they wish to follow this track to their Ph.D. and to submit all their course substitution requests. Course substitutions will not be considered later in the student's Ph.D. studies.

To make such a request, the student should submit a request to the department graduate secretary describing (1) the course from a previous institution; (2) the UW course equivalent; (3) the M S & E course requirement that will be satisfied. The request must include sufficient information to determine if the courses are equivalent. Typically, a syllabus listing the course textbook and lecture topics is sufficient. A course catalog description is typically insufficient. Courses taken while enrolled as an undergraduate student at another institution will not be considered for substitution. This includes courses at the graduate level taken while the student is enrolled as an undergraduate.

If a request is not approved, the student must fulfill the corresponding requirement at the University of Wisconsin–Madison.

If one or more course substitutions are accepted, the student will not earn a master's degree in Materials Science and Engineering from UW–Madison as part of their Ph.D. studies.

**POLICIES**

**GRADUATE SCHOOL POLICIES**

The Graduate School's Academic Policies and Procedures (https://grad.wisc.edu/acadpolicy) provide essential information regarding general university policies. Program authority to set degree policies beyond the minimum required by the Graduate School lies with the degree program faculty. Policies set by the academic degree program can be found below.

**MAJOR-SPECIFIC POLICIES**

**GRADUATE PROGRAM HANDBOOK**

The Graduate Program Handbook (https://www.engr.wisc.edu/app/uploads/2016/01/MSE-Graduate-Curriculum-adopted-01_26_16-corrected-7-12-17.pdf) is the repository for all of the program's policies and requirements.

**PRIOR COURSEWORK**

**Graduate Work from Other Institutions**

With program approval, students are allowed to count graduate coursework from other institutions toward the minimum graduate degree credit requirement and the minimum graduate coursework (50%) requirement. No credits from other institutions can be counted toward the minimum

| M S & E 451 | Introduction to Ceramic Materials | 3 |
| M S & E 456 | Electronic, Optical, and Magnetic Properties of Materials | 3 |
| M S & E 461 | Advanced Metal Casting | 3 |
| M S & E/M E 462 | Welding Metallurgy | 3 |
| M S & E 463 | Materials for Elevated Temperature Service | 3 |
| M S & E 465 | Fundamentals of Heat Treatment | 3 |
| M S & E 521 | Advanced Polymeric Materials | 3 |
| M S & E 530 | Thermodynamics of Solids | 3 |
| M S & E/M A 541 | Heterogeneous and Multiphase Materials | 3 |
| M S & E 551 | Structure of Materials | 3 |
| M S & E 553 | Nanomaterials & Nanotechnology | 3 |
| M S & E 560 | Fundamentals of Atomicistic Modeling | 3 |
| M S & E 570 | Properties of Solid Surfaces | 3 |
| M S & E 748 | Structural Analysis of Materials | 3 |
| M S & E 750 | Imperfections and Mechanical Properties | 3 |
| M S & E 752 | Advanced Materials Science: Phase Transformations | 3 |
| M S & E 756 | Structure and Properties of Advanced Electronic Materials | 3 |
| M S & E 760 | Molecular Dynamics and Monte Carlo Simulations in Materials Science | 3 |
| M S & E 803 | Special Topics in Materials Science | 1-3 |
| B M/E/PHM SCI 430 | Biological Interactions with Materials | 3 |
| B M/E/M E 615 | Tissue Mechanics | 3 |
| BIOCHEM/ CHEM 704 | Chemical Biology | 2 |
| CBE 540 | Polymer Science and Technology | 3 |
| CBE 747 | Advanced Colloid and Interface Science | 3 |
| CHEM 652 | Chemistry of Inorganic Materials | 3 |
| CHEM 653 | Chemistry of Nanoscale Materials | 3 |
| CHEM 664 | Physical Chemistry of Macromolecules | 2-3 |
| CHEM 664 | Physical Chemistry of Macromolecules | 2-3 |
| E C E 745 | Solid State Electronics | 3 |
| GEOSCI 765 | Crystal Chemistry | 3 |
| PHYSICS 415 | Thermal Physics | 3 |
| PHYSICS 551 | Solid State Physics | 3 |
| PHYSICS 715 | Statistical Mechanics | 3 |
| PHYSICS 751 | Advanced Solid State Physics | 3 |

Additionally, the student's research advisor must sign a form available from the department graduate secretary approving the five courses taken to fulfill the materials core and materials electives requirements.
graduate residence credit requirement. For additional requirements, consult the program.

UW–Madison Undergraduate

With program approval, students are allowed to count up to 7 credits numbered 300 or above toward the minimum graduate degree credit requirement when taken in excess of the undergraduate degree requirements; if that coursework is numbered 700 or above it may be used to satisfy the minimum graduate coursework (50%) requirement. No credits can be counted toward the minimum graduate residence credit requirement.

UW–Madison University Special

Typically, no UW-Madison University Special student credits may be counted toward graduate program requirements. However, with program approval, students are allowed to count up to 15 credits of coursework numbered 300 or above taken as a UW–Madison Special student toward the minimum graduate residence credit requirement, and the minimum graduate degree credit requirement; if that coursework is numbered 700 or above it may satisfy the minimum graduate coursework (50%) requirement.

PROBATION

The Graduate School regularly reviews the record of any student who earned grades of BC, C, D, F, or Incomplete in a graduate course (300 or above), or grade of U in research credits. This review could result in academic probation with a hold on future enrollment or in being suspended from the Graduate School.

ADVISOR / COMMITTEE

Every graduate student is required to have an advisor. An advisor is a faculty member, or sometimes a committee, from the major department responsible for providing advice regarding graduate studies. An advisor generally serves as the thesis advisor. In many cases, an advisor is assigned to incoming students. To ensure that students are making satisfactory progress toward a degree, the Graduate School expects them to meet with their advisor on a regular basis.

Students without a researcher advisor at the end of their first year enrolled are in danger of failing to make adequate progress towards their degree. Students can be suspended from the Graduate School if they do not have an advisor.

CREDITS PER TERM ALLOWED

15 credits

TIME CONSTRAINTS

The Ph.D. is typically completed within six years. A candidate for a doctoral degree who fails to take the final oral examination and deposit the dissertation within five years after passing the preliminary examination may be required to take another preliminary examination and to be admitted to candidacy a second time.

Doctoral degree students who have been absent for ten or more consecutive years lose all credits that they have earned before their absence. Individual programs may count the coursework students completed prior to their absence for meeting program requirements; that coursework may not count toward Graduate School credit requirements.

OTHER

n/a

PROFESSIONAL DEVELOPMENT

GRADUATE SCHOOL RESOURCES

Take advantage of the Graduate School’s professional development resources (https://grad.wisc.edu/pd) to build skills, thrive academically, and launch your career.

PROGRAM RESOURCES

Find information about professional development from the College of Engineering at the following webpage: https://epd.wisc.edu/.

LEARNING OUTCOMES

1. Demonstrate an ability to synthesize knowledge from a subset of the biological, physical, and social sciences to help frame problems critical to the future of their discipline.
2. Conduct original research.
3. Demonstrate an ability to create new knowledge and communicate it to their peers.
4. Fosters ethical and professional conduct.

PEOPLE

FACULTY:

Professors:
Mike Arnold, Sue Babcock, Chang-Beom Eom, Paul Evans, Padma Gopalan, Sindo Kou, Max Lagally, Rod Lakes, Dane Morgan, John Perepezko, Ian Robertson, Don Stone, Izabela Szlufarska, Paul Voyles, and Xudong Wang.

Assistant Professors:
Jason Kawasaki and Jamian Hu.

AFFILIATE FACULTY: