

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 materials 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

Please consult the table below for key information about this degree program's admissions requirements. The program may have more detailed admissions requirements, which can be found below the table or on the program's website.

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

Requirements	Detail
Fall Deadline	December 15
Spring Deadline	September 1
Summer Deadline	December 15
GRE (Graduate Record Examinations)	Not required.
English Proficiency Test	Every applicant whose native language is not English or whose undergraduate instruction was not in English must provide an English proficiency test score and meet the Graduate School minimum requirements (https://grad.wisc.edu/apply/requirements/#english-proficiency).
Other Test(s) (e.g., GMAT, MCAT)	n/a
Letters of Recommendation Required	3

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.

Required Application Materials:

- Academic transcripts
- English proficiency scores (<https://grad.wisc.edu/apply/requirements/#english-proficiency>), if applicable
- Three letters of recommendation
- Statement of purpose (<https://grad.wisc.edu/apply/prepare/>)
- Resume

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. Admission is highly selective. Most admitted students have an undergraduate GPA above 3.5. However, full consideration will be given to all students meeting the UW–Madison graduate school requirements.

International 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 December 15th. 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 (covers 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: September 1

Fall semester: December 15

Summer: December 15

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 restrictions related to funding.

PROGRAM RESOURCES

FINANCIAL ASSISTANCE

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. December 15th is the deadline for receipt of fellowship applications. International 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 Associate Chair of Graduate Studies, acgs@mse.wisc.edu (<http://guide.wisc.edu/graduate/materials-science-engineering/materials-science-engineering-phd/acgs@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.

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.hertzfndn.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/>)

REQUIREMENTS

MINIMUM GRADUATE SCHOOL REQUIREMENTS

Review the Graduate School minimum academic progress and degree requirements (<http://guide.wisc.edu/graduate/#policiesandrequirementstext>), in addition to the program requirements listed below.

MAJOR REQUIREMENTS

MODE OF INSTRUCTION

Face to Face	Evening/ Weekend	Online	Hybrid	Accelerated
Yes	No	No	No	No

Mode of Instruction Definitions

Accelerated: Accelerated programs are offered at a fast pace that condenses the time to completion. Students typically take enough credits aimed at completing the program in a year or two.

Evening/Weekend: Courses meet on the UW-Madison campus only in evenings and/or on weekends to accommodate typical business schedules. Students have the advantages of face-to-face courses with the flexibility to keep work and other life commitments.

Face-to-Face: Courses typically meet during weekdays on the UW-Madison Campus.

Hybrid: These programs combine face-to-face and online learning formats. Contact the program for more specific information.

Online: These programs are offered 100% online. Some programs may require an on-campus orientation or residency experience, but the courses will be facilitated in an online format.

CURRICULAR REQUIREMENTS

Requirement Detail	
Minimum Credit Requirement	51 credits
Minimum Residence Credit Requirement	32 credits
Minimum Graduate Coursework Requirement	26 credits must be graduate-level coursework. Details can be found in the Graduate School's Minimum Graduate Coursework (50%) policy (https://policy.wisc.edu/library/UW-1244 (https://policy.wisc.edu/library/UW-1244/)).
Overall Graduate GPA Requirement	3.00 GPA required. This program follows the Graduate School's GPA Requirement policy (https://policy.wisc.edu/library/UW-1203 (https://policy.wisc.edu/library/UW-1203/)).
Other Grade Requirements	n/a
Assessments and Examinations	<p>Students entering without a previous master's degree:</p> <ul style="list-style-type: none"> 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 may earn the M S & E Master's degree the semester they pass their preliminary exam. 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. <p>Students entering with a master's degree:</p> <ul style="list-style-type: none"> 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.
Graduate School Breadth Requirement	All doctoral students are required to complete a doctoral minor or Graduate/Professional certificate. 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 (numbered 700

or above or has Graduate Course Attribute). 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

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 Coordinator 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.

Code	Title	Credits
Materials research seminar ¹		2
M S & E 900	Materials Research Seminar	
Materials core courses ²		9
M S & E 521	Advanced Polymeric Materials	
M S & E 530	Thermodynamics of Solids	
M S & E 551	Structure of Materials	
M S & E 752	Advanced Materials Science: Phase Transformations	
Graduate level math course (students may only count one of the following as materials core course)		
E P/E M A 547	Engineering Analysis I	
CBE 660	Intermediate Problems in Chemical Engineering	
MATH 703	Methods of Applied Mathematics 1	
MATH 704	Methods of Applied Mathematics-2	
PHYSICS 721	Theoretical Physics-Electrodynamics	
Materials electives courses ³		6
Additional coursework and/or research credits ⁴		25
Breadth requirement		9
Total Credits		51

1

Take two consecutive semesters.

2

Take three materials core courses, chosen from these options.

3

Electives must be selected from the list of Materials Elective Courses.

4

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

Materials Elective Courses

Code	Title	Credits
M S & E 401	Special Topics in Materials Science and Engineering	1-3
M S & E/CHEM 421	Polymeric Materials	3
M S & E/N E 423	Nuclear Engineering Materials	3
M S & E/N E 433	Principles of Corrosion	3
M S & E 434	Introduction to Thin-Film Deposition Processes	3
M S & E 441	Deformation of Solids	3
M S & E 448	Crystallography and X-Ray Diffraction	3
M S & E 451	Introduction to Ceramic Materials	3
M S & E 456	Electronic, Optical, and Magnetic Properties of Materials	3
M S & E 460	Introduction to Computational Materials Science and Engineering	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/CIV ENGR/ G L E/GEOSCI 474	Rock Mechanics	3
M S & E 521	Advanced Polymeric Materials	3
M S & E 530	Thermodynamics of Solids	3
M S & E/E M A 541	Heterogeneous and Multiphase Materials	3
M S & E 550	Materials Fundamentals	3
M S & E 551	Structure of Materials	3
M S & E 553	Nanomaterials & Nanotechnology	3
M S & E 560	Fundamentals of Atomistic Modeling	3
M S & E 570	Properties of Solid Surfaces	3
M S & E 648	Advanced X-ray Scattering Methods in Materials Science and Engineering	3
M S & E 660	Mesoscale Modeling of Materials	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 Modeling of Materials	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	3
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 654	Materials Chemistry of Polymers	2-3
CHEM 664	Physical Chemistry of Macromolecules	2-3
CHEM 721	Instrumental Analysis	3-4
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 Coordinator approving the five courses taken to fulfill the materials core and materials electives requirements.

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 Coordinator 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

PRIOR COURSEWORK

Graduate Work from Other Institutions

With program approval, students are allowed to count up to 9 credits of 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 graduate residence credit requirement. For additional requirements, consult the program. Students who count credits of graduate coursework from other institutions toward their M S & E Ph.D. degree credit requirements cannot earn a M S & E Master's degree.

UW–Madison Undergraduate

Typically, no UW–Madison Undergraduate student credits may be counted toward graduate program requirements. However, 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

This program follows the Graduate School's Probation policy. (<https://policy.wisc.edu/library/UW-1217/>)

ADVISOR / COMMITTEE

This program follows the Graduate School's Advisor policy (<https://policy.wisc.edu/library/UW-1232/>) and the Graduate School's Committees policy (<https://policy.wisc.edu/library/UW-1201/>).

Students without an 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 LIMITS

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.

This program follows the Graduate School's Time Limits policy. (<https://policy.wisc.edu/library/UW-1221/>)

GRIEVANCES AND APPEALS

These resources may be helpful in addressing your concerns:

- Bias or Hate Reporting (<https://doso.students.wisc.edu/bias-or-hate-reporting/>)
- Graduate Assistantship Policies and Procedures (<https://hr.wisc.edu/policies/gapp/#grievance-procedure>)
- Hostile and Intimidating Behavior Policies and Procedures (<https://hr.wisc.edu/hib/>)
 - Office of the Provost for Faculty and Staff Affairs (<https://facstaff.provost.wisc.edu/>)
- Dean of Students Office (<https://doso.students.wisc.edu/>) (for all students to seek grievance assistance and support)
- Employee Assistance (<http://www.eao.wisc.edu/>) (for personal counseling and workplace consultation around communication and conflict involving graduate assistants and other employees, post-doctoral students, faculty and staff)
- Employee Disability Resource Office (<https://employeeabilities.wisc.edu/>) (for qualified employees or applicants with disabilities to have equal employment opportunities)
- Graduate School (<https://grad.wisc.edu/>) (for informal advice at any level of review and for official appeals of program/departmental or school/college grievance decisions)
- Office of Compliance (<https://compliance.wisc.edu/>) (for class harassment and discrimination, including sexual harassment and sexual violence)
- Office of Student Conduct and Community Standards (<https://conduct.students.wisc.edu/>) (for conflicts involving students)
- Ombuds Office for Faculty and Staff (<http://www.ombuds.wisc.edu/>) (for employed graduate students and post-docs, as well as faculty and staff)
- Title IX (<https://compliance.wisc.edu/titleix/>) (for concerns about discrimination)

MS&E Grievance Procedures

Students who feel they have been unfairly treated or otherwise have a grievance related to the policies and procedures for graduate study in the Materials Science and Engineering Department may choose to submit a formal grievance to the department. Before taking this step, however, students are encouraged to discuss their grievance directly with the person or persons involved. Respectful, professional, direct communication can often reach a more satisfactory resolution to an issue more quickly than a formal grievance procedure.

To pursue a formal grievance, the student should submit a letter describing the issue in detail to the department Associate Chair of Graduate Studies within 60 days of the precipitating incident. (Should the grievance involve the Director of Graduate Studies, the letter should be submitted to the department Chair.) The Director (or Chair) will convene a committee of not fewer than three department faculty. The committee will obtain a written response from the person or persons who are the subject of the complaint. The committee will then decide a course of action in response to the grievance. The response from the subject of the complaint and the committee course of action will be communicated in writing to the student within 15 working days of submission of the grievance. The course of action will be implemented no later than 10 working days of the communication.

If the departmental procedure does not resolve the grievance, the student may appeal to the College of Engineering or the Graduate School. The College grievance procedures are currently available at <https://>

engineering.wisc.edu/report-an-incident/academic-grievances-and-complaints/, and the Graduate School procedures are available at <http://grad.wisc.edu/acadpolicy/>. (<http://grad.wisc.edu/acadpolicy/>)

The Assistant Dean for Graduate Affairs (engr-dean-graduateaffairs@engr.wisc.edu) provides overall leadership for graduate education in the College of Engineering (CoE), and is a point of contact for graduate students who have concerns about education, mentoring, research, or other difficulties.

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://interpro.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

Professors:

Michael Arnold, Sue Babcock, Chang-Beom Eom, Paul Evans, Padma Gopalan, Sindo Kou, Rod Lakes, Dane Morgan, John Perepezko, Kumar Sridharan, Donald Stone, Izabela Szlufarska, Dan Thoma, Paul Voyles, and Xudong Wang

Associate Professors:

Jason Kawasaki

Assistant Professors:

Dawei Feng, Jiamian Hu, Fang Liu, Hyunseok Oh, Daniel Rhodes, and Jun Xiao

Assistant Teaching Professors:

Franklin Hobbs

See also Materials Science and Engineering Faculty Directory (<https://directory.engr.wisc.edu/mse/faculty/>).