# SEMICONDUCTOR ENGINEERING

**Emphasis areas at Bachelor of Science level in semiconductor device engineering and semiconductor process engineering.**

Semiconductors are at the heart of today's technology-driven world, powering everything from smartphones and computers to groundbreaking innovations in quantum computing, artificial intelligence, healthcare, and renewable energy. By pursuing a degree in semiconductor engineering, you will be at the forefront of shaping future technologies and solutions that impact virtually every aspect of modern life. This exciting field offers rewarding opportunities for students who are eager to solve complex problems, innovate cutting-edge technologies, and lead advancements in industries that significantly enhance everyday life and global connectivity.

The semiconductor engineering program at Missouri S\&T integrates engineering fundamentals with strong foundations in physical sciences, mathematics, and computer science, blending principles from materials science and engineering, electrical engineering, computer engineering, and chemical engineering. All program graduates will receive extensive hands-on training using state-of-the-art, cleanroom-based techniques and cutting-edge equipment. Through rigorous coursework and practical laboratory experiences, students gain the comprehensive skills needed to enter the semiconductor manufacturing workforce, as well as related scientific and technological fields.

This multidisciplinary program prepares graduates for career opportunities across diverse sectors, including microelectronics, nanotechnology, critical materials production, and high-purity specialty chemicals. The program also equips students to pursue advanced graduate degrees in semiconductor processing, device design and fabrication, intelligent manufacturing, and nano- or bio-device engineering.

Students specialize their education by choosing one of two emphasis areas: Semiconductor Device Engineering or Semiconductor Process Engineering. The Semiconductor Device Engineering emphasis area provides courses focused on the analysis and design of circuits and electronics, equipping students with in-depth knowledge for developing semiconductor-based devices. The Semiconductor Process Engineering emphasis area offers courses concentrating on chemical process analysis, reactor design, and large-scale manufacturing methods for semiconductor devices and associated critical materials supply chains.

Semiconductor engineering courses and laboratories are primarily located in V.H. McNutt Hall, Emerson Electric Company Hall, and James E. Bertelsmeyer Hall. Additional educational and research opportunities are available through various research centers across campus.

Students can enrich their academic experience by participating in faculty-led research projects, student organizations, and design competitions, fostering professional growth and networking opportunities. Cooperative education programs and internships with industry-leading companies and research institutions nationwide provide practical experience and career preparation. Additional academic pathways, such as dual majors and minors, offer further opportunities to customize their educational journey.

More information about the semiconductor engineering program and departmental activities can be found at http://mse.mst.edu/.

**Mission Statement**

The department will train the future industrial and academic leaders in semiconductor engineering by providing a comprehensive, forward-looking and broad-based curriculum, which emphasizes fundamental principles, practical applications, oral and written communication skills, and professional practice and ethics.

The program educational objectives of the semiconductor engineering program:

- Our graduates will be valued contributors in the science, technology, and management of semiconductor engineering
- Our graduates will serve their profession and society
- Our graduates will continually enhance their professional skills and educational background
- Our graduates will promote a diverse and inclusive professional culture that nurtures learning, innovation, and growth

The specific outcomes of the semiconductor engineering program are:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Bachelor of Science Semiconductor Engineering

For the Bachelor of Science degree in Semiconductor Engineering a minimum of 127 credit hours (Semiconductor Device Engineering emphasis area) or 128 credit hours (Semiconductor Process Engineering emphasis area) is required. A cumulative grade point average of at least 2.0 is required for all courses applied toward the degree, as well as for all required courses in the major field of study, defined as SEMI ENG, ELEC ENG, COMP ENG, and/or CHEM ENG.

### Semiconductor Device Engineering emphasis area

**First Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| ENGLISH 1120 | 3 | MECH ENG 1720 | 3 |
| CHEM 1310[1] | 4 | CHEM 1320[1] | 3 |
| CHEM 1319[1] | 1 | MATH 1215 or 1221[1] | 4 |

| | | | |
|---|---|---|---|
| MATH 1214 or 1211 | 4 | PHYSICS 1135 | 4 |
| FR ENG 1100 | 1 | SEMI ENG 1100 | 1 |
| General Education Elective[2] | 3 | | |
| | **16** | | **15** |

**Second Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| COMP SCI 1500 or 1972 ***and*** 1982 | 3 | MATH 2222[1] | 4 |
| ELEC ENG 2100[1] | 3 | SEMI ENG 2100[1] | 3 |
| ELEC ENG 2101[1] | 1 | ELEC ENG 2120[1] | 3 |
| MATH 3304 | 3 | COMP ENG 2210[1] | 3 |
| PHYSICS 2135[1] | 4 | COMP ENG 2211 | 1 |
| SEMI ENG 3230 | 3 | ENGLISH 1160, or 3560, or SPM S 1185[3] | 3 |
| | **17** | | **17** |

**Third Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| SEMI ENG 3019[1] | 1 | SEMI ENG 3101[1] | 3 |
| SEMI ENG 3100[1] | 3 | SEMI ENG 3410 | 3 |
| ELEC ENG 3100 | 3 | ELEC ENG 3250 | 3 |
| ELEC ENG 3101 | 1 | ELEC ENG 3600 | 3 |
| STAT 3115 or 3117 | 3 | General Education Elective[2] | 3 |
| HISTORY 1200, or 1300, or 1310, or POL SCI 1200 | 3 | | |
| General Education Elective[2] | 3 | | |
| | **17** | | **15** |

**Fourth Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| SEMI ENG 4096[1] | 3 | SEMI ENG 4097 | 3 |
| SEMI ENG 4100 | 3 | SEMI ENG 4200 | 3 |
| SEMI ENG 4101 | 3 | SEMI ENG 4400 | 3 |
| SEMI ENG 4300 | 3 | General Education Elective[2] | 3 |
| COMP ENG 5210 | 3 | Free Elective | 3 |
| | **15** | | **15** |

**Total Credits: 127**

1. A grade of "C" or better is required in the following courses to satisfy prerequisite requirements for subsequent coursework and to meet graduation criteria: CHEM 1310,CHEM 1319, CHEM 1320, COMP ENG 2210, ELEC ENG 2100,ELEC ENG 2101, ELEC ENG 2120, MATH 1215 or MATH 1221, MATH 2222, PHYSICS 2135, SEMI ENG 2100, SEMI ENG 3019, SEMI ENG 3100, SEMI ENG 3101, SEMI ENG 4096.
2. Gen. Ed. electives must fulfill the Missouri S&T general education requirements applicable to the student's catalog year.
3. Students may replace SP&M S 1185 with the ROTC sequence of MIL ARMY 4250 and MIL ARMY 4500 or MIL AIR 4110 and MIL AIR 4120.

## Semiconductor Process Engineering emphasis area

**First Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| ENGLISH 1120 | 3 | MECH ENG 1720 | 3 |
| CHEM 1310[1] | 4 | CHEM 1320[1] | 3 |
| CHEM 1319[1] | 1 | MATH 1215 or 1221[1] | 4 |
| MATH 1214 or 1211 | 4 | PHYSICS 1135 | 4 |
| FR ENG 1100 | 1 | SEMI ENG 1100 | 1 |
| General Education Elective[2] | 3 | | |
| | **16** | | **15** |

**Second Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| COMP SCI 1500 or 1972 ***and*** 1982 | 3 | CHEM ENG 2110[1] | 3 |
| PHYSICS 2135[1] | 4 | SEMI ENG 2100[1] | 3 |
| MATH 2222[1] | 4 | MATH 3304[1] | 3 |
| CHEM ENG 2100[1] | 4 | ELEC ENG 2100 | 3 |
| General Education Elective[2] | 3 | ELEC ENG 2101[1] | 1 |
| | | ENGLISH 1160, or 3560, or SPM S 1185[3] | 3 |
| | **18** | | **16** |

**Third Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| CHEM ENG 3111 | 3 | CHEM ENG 3150 | 3 |
| CHEM ENG 3101 | 4 | ELEC ENG 2200 | 3 |
| CHEM ENG 3120 | 3 | ELEC ENG 2201 | 1 |
| SEMI ENG 3019[1] | 1 | SEMI ENG 3101[1] | 3 |
| SEMI ENG 3100[1] | 3 | SEMI ENG 3410 | 3 |
| HISTORY 1200, or 1300, or 1310, or POL SCI 1200 | 3 | STAT 3113 or 3115 | 3 |
| | **17** | | **16** |

**Fourth Year**

| First Semester | Credits | Second Semester | Credits |
|---|---|---|---|
| CHEM ENG 4110 | 3 | SEMI ENG 4097 | 3 |
| CHEM ENG 4101 | 3 | SEMI ENG 4200 | 3 |
| SEMI ENG 4096[1] | 3 | General Education Elective[2] | 3 |
| SEMI ENG 4101 | 3 | General Education Elective[2] | 3 |
| SEMI ENG 4300 | 3 | Free Elective | 3 |
| | **15** | | **15** |

**Total Credits: 128**

1. A grade of "C" or better is required in the following courses to satisfy prerequisite requirements for subsequent coursework and to meet graduation criteria: CHEM 1310, CHEM 1319, CHEM 1320 CHEM ENG 2100, CHEM ENG 2110, ELEC ENG 2101, MATH 1215 or MATH 1221, MATH 2222, MATH 3304, PHYSICS 2135, SEMI ENG 2100, SEMI ENG 3019, SEMI ENG 3100, SEMI ENG 3101, SEMI ENG 4096.
2. Gen. Ed. electives must fulfill the Missouri S&T general education requirements applicable to the student's catalog year.
3. Students may replace SP&M S 1185 with the ROTC sequence of MIL ARMY 4250 and MIL ARMY 4500 or MIL AIR 4110 and MIL AIR 4120.

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***SEMI ENG 1100 Engineering in the Silicon Age*** (RSD 1.0)
An introductory seminar detailing the rise and impact of the Silicon Age on the modern world. Discussions will include: historical perspectives on the development and application of semiconductor materials; current and future major scientific, technological, and societal challenges; and career opportunities.

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***SEMI ENG 2100 Fundamentals of Semiconductor Materials*** (LEC 3.0)
A broad overview of elemental, compound, and wide-bandgap semiconductor materials covering chemical bonding, crystal structures, defects, interfaces, heterostructures, and structure-property relationships. Prerequisites: A grade of "C" or better in Chem 1320 and Physics 2135.

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***SEMI ENG 3019 Cleanroom Facilities and Practices Laboratory*** (LAB 1.0)
Introduction to cleanroom practices, cleanroom layout and systems, operations and hazards, microcontamination management, environmental control strategies, testing and inspection methods, and electronic cleaning procedures. Prerequisites: A grade of "C" or better in Chem 1319.

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***SEMI ENG 3100 Semiconductor Materials Processing*** (LEC 3.0)
Examination of semiconductor processing stages, including cleaning, oxidation, ion implantation, diffusion and thermal processing, deposition and epitaxy, etching, metallization, and lithography. Prerequisites: A grade of "C" or better in Semi Eng 2100 or with instructor permission.

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***SEMI ENG 3101 Semiconductor Materials Processing Laboratory*** (LAB 2.0 and LEC 1.0)
Front-end unit semiconductor process operations and testing, including cleaning, oxidation, ion implantation, diffusion and thermal processing, deposition and epitaxy, etching, metallization, and lithography. Prerequisites: A grade of "C" or better in Semi Eng 3019 and Elec Eng 2101; preceded or accompanied by Semi Eng 3100 or with instructor permission.

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***SEMI ENG 3230 Thermodynamics of Materials*** (LEC 3.0)
Basic thermodynamic concepts are applied to materials. Calculations involving enthalpy, entropy, and Gibbs' free energy are studied. Inter-relationships among properties are emphasized. Fundamental concepts of phase equilibria are presented. Prerequisite: A grade of "C" or better in either Met Eng 1210 or Chem 1320. (Co-listed with Cer Eng 3230 and Met Eng 3230).

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***SEMI ENG 3410 Characterization Of Inorganic Solids*** (LEC 3.0)
X-ray diffraction analysis is emphasized including lattice parameter determination, qualitative and quantitative analysis methods, and sources of error. In addition, the basic principles of other common characterization techniques including electron microscopy, thermal analysis, and energy dispersive spectroscopy are discussed. Prerequisite: A grade of "C" or better in Cer Eng 2110, Met Eng 2110, Semi Eng 2100 or a similar introductory course on structure of solids. (Co-listed with Cer Eng 3410).

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***SEMI ENG 4096 Materials Senior Design I*** (LEC 3.0)
Overview of the methods, approaches, and techniques required to execute materials related capstone senior design projects. Formation of teams, assignment of projects, review of department curriculum concepts and topics, and comprehensive project management skills needed to complete projects will be used as means to learn the design process. Prerequisites: A grade of "C" or better in Met Eng 3125 and Met Eng 2125, or Cer Eng 3315 or Semi Eng 3101. (Co-listed with Cer Eng 4096 and Met Eng 4096).

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***SEMI ENG 4097 Materials Senior Design II*** (LAB 3.0)
A continuation of the Materials Senior Design I. Students working in groups will complete a capstone design project including process and product simulation and/or fabrication, safety aspects, environmental impact and capital and operating economics. Prerequisite: A grade of "C" or better in either Cer Eng 4096 or Met Eng 4096 or Semi Eng 4096. (Co-listed with Cer Eng 4097 and Met Eng 4097).

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***SEMI ENG 4100 Semiconductor Device Simulation*** (LAB 1.0 and LEC 2.0)
Semiconductor device simulation concepts: conventional and advanced MOS devices, bipolar transistors, heterostructures. Modern simulation tools such as SPICE and TCAD will be employed. Prerequisites: Preceded or accompanied by Elec Eng 3250 or Semi Eng 4101.

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***SEMI ENG 4101 Semiconductor Device Fabrication and Testing Laboratory*** (LAB 2.0 and LEC 1.0)
Unit process operations, including back-end operations, inspection, and metrology for process control, are integrated into complete manufacturing sequences for fabrication and testing of semiconductor devices. Prerequisites: A grade of "C" or better in Semi Eng 3101 and preceded by Elec Eng 2200 or Elec Eng 3250.

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***SEMI ENG 4200 Semiconductor Process Simulation*** (LAB 1.0 and LEC 2.0)
Semiconductor process simulation using modern simulation tools. Concepts include ion implantation, diffusion, oxidation, deposition and epitaxy, etching, and photolithography. Prerequisites: A grade of "C" or better in Semi Eng 3100.

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***SEMI ENG 4300 Polymers for Semiconductor Devices and Processes*** (LEC 3.0)
Fundamentals of polymers for semiconductor device and process engineering. Roles in advanced semiconductor technology, optoelectronics, and organic electronics. Prerequisites: Semi Eng 3100.

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***SEMI ENG 4400 Microelectronics Packaging and Integration*** (LEC 3.0)
Materials selection, thermal management principles, manufacturing concepts, testing and reliability models for packaging and heterogeneous integration of semiconductor devices. Prerequisites: Semi Eng 4101 and Semi Eng 4300.

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