

# ECE 4/515: Fundamentals of Semiconductor Devices

## Catalog Description

Solid-state electronic devices; operation, fabrication and applications; single crystal growth, p-n junction, diodes, bipolar junction transistors, MOS capacitor, FETs. Course provides students with a sound understanding of existing devices and gives the necessary background to understand the problems and challenges of the micro-electronic manufacturing. Also offered as ECE 515 and may be taken only once for credit.

Credit hours: 4

## Goals

Students will attain solid physical understanding of operation of basic semiconductor devices and will be able to apply this knowledge in the areas of device characterization, modeling and device design. Students will be able to do independent study of relatively simple existing or novel devices or novel modes of operation.

## Course Coordinator and Committee

Malgorzata Chrzanowska-Jeske (coordinator)  
Branimir Pejčinović

## Textbooks

*Solid State Electronic Devices* 7th edition, B.G. Streetman & S.K. Banerjee, Pearson/Prentice Hall 2014, ISBN-13 978-0-13-335603-8 or ISBN-10 0-13-335603-5

*Semiconductor Physics and Devices: Basic Principles*, 4th edition, Donald A. Neaman, McGraw-Hill 2012, ISBN-978-0-07-352958-5

The course instructor may choose to use a different textbook. Please check with your instructor before purchasing.

## Prerequisites

PH 319, ECE 322

## Course Learning Outcomes

At the end of this course, students will:

1. Understand and be able to analyze performance of intrinsic and extrinsic semiconductors.

2. Understand and be able to analyze operation of p-n junction.
3. Understand and be able to analyze performance of MOS capacitor, FET and MOS transistor.
4. Be able to model semiconductor devices and to examine accuracy and limits of models.
5. Understand trade-off device design parameters based on device operation and design goals.
6. Understand and be able to analyze bipolar transistors for DC and AC operation.
7. Understand and be able to analyze performance of MOS devices fabricated in sub-micron technology.
8. Be able to write concise, accurate and complete technical reports.
9. Understand the impact of engineering solutions in economic and global contexts.
10. Be able to collaborate, function effectively and contribute to a team working on engineering goals.

## Topical Outline

- Semiconductors: Energy Bands
- Semiconductors: Density of states, Fermi levels
- Semiconductors: Extrinsic semiconductors
- Semiconductors: Transport phenomena
- Semiconductors: Non-equilibrium (excess carriers)
- P-N Junctions: Equilibrium, bias
- P-N Junctions: Currents, breakdown, transients & AC
- P-N Junctions: Metal-semiconductor/hetero-junctions
- MOSFET: MOS capacitor
- MOSFET: MOSFET operation & characteristics
- MOSFET: Frequency limits, (project), non-ideal, sub-threshold
- MOSFETs: Substrate bias, scaling, short channel, etc.
- BJTs: Operation, minority carrier, CB
- BJTs: Non-ideal, models, switching
- Introduction to FinFET

## Course Structure and Grading Criteria

Two 110 minute or three 75 minute weekly lectures.

Grade based on homework, exams and projects. For details of the grading criteria, please see the syllabus provided by your instructor. Note that grading criteria may vary with the individual instructor.

## Relevant Student Outcomes

The following student outcomes are supported by this course:

- (1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- (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.

Prepared By: Malgorzata Chrzanowska-Jeske

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