ECE 1247: Semiconductor Device Theory

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OFFICE HOURS: Thu.: 14:00 – 16:00, Fri.: 12:00 – 16:00 or by appointment
LECTURES: Fri.: 8:15 – 11:00 AM, S202
TEXTBOOK: Simon M. Sze, Kwok K. Ng, Physics of Semiconductor Devices, Wiley-Interscience, ISBN: 9780471143239.
Donald A. Neamen, An introduction to semiconductor devices, Publishing House of Electronics Industry, ISBN: 9787121448973.
TEACHING ASSISTANT: Daoye Zheng
PREREQUISITE: Physics for Science and Engineering; Analytical Methods; Electromagnetics

DESCRIPTION:

This course is a required core course for undergraduates majoring in Electrical and Computer Engineering & Computer Science. The main content of this course can be divided into two parts: semiconductor physics and semiconductor devices.

The semiconductor physics part mainly includes electronic states in semiconductors, semiconductor material basis, carrier model, carrier transport and non-equilibrium carriers.

The semiconductor devices mainly includes the relevant contact phenomena and related device principles in semiconductor devices and introduces some special effects of semiconductors.

The task of this course is to reveal and study the microscopic mechanism of semiconductors and explain the macroscopic physical phenomena that occur in semiconductors from a microscopic perspective.

Through the study of this course, students can comprehensively understand and master the basic concepts, knowledge theories, basic models and analysis methods in semiconductor physics and devices, laying a good foundation for students to engage in theoretical and applied research on semiconductor materials and devices related to new optoelectronics devices in the future, and providing theoretical basis for further learning other courses in related disciplines.

COURSE OBJECTIVES:

1. Enable students to accurately explain the basic concepts, theories, basic models and analytical methods of semiconductors, and accurately describe the generation, recombination and motion laws of carriers in semiconductors.
2. Can accurately describe the device structure, basic principle and practical application field of pn junction diode, metal semiconductor contact Schottky diode and MOS transistor and can skillfully write and explain its current-voltage, capacitor-voltage relationship equations.
3. Skilled in summarizing various special effects of semiconductors, and able to use theoretical knowledge to analyze the properties of semiconductor materials.
4. Can give accurate interpretation of the test data of semiconductor materials and devices and judge the performance of devices according to the data.
5. Be able to attend class on time and actively participate in class interaction.

LEARNING OUTCOMES FOR THIS COURSE:

1. Knowledge objective: master the basic concepts of semiconductor physics and the basic principles of semiconductor devices.
2. Ability objective: Ability to independently carry out the performance analysis of semiconductor materials and devices, and judge the performance of semiconductor devices according to the test results.

3. Quality and emotional values objective: to lay a solid theoretical foundation for subsequent professional course learning, scientific research and engineering practice.
4. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
5. 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.
6. An ability to communicate effectively with a range of audiences.
7. 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.
8. An ability to function effectively on a team whose members together provide leadership, create a collaborative environment, establish goals, plan tasks, and meet objectives.
9. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
10. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

GRADE DETERMINATION:

Usual Performance	20%
Homeworks	20%
Midterm Exam	30%
Final Exam	30%

Letter grades will be determined from accumulated point totals and assigned according to the scale below.

A: 90 – 100	**A-: 85 – 90**	**B+: 80 – 85**	**B: 76 – 80**	**B-: 73 – 76**
C+: 70 – 73	**C: 66 – 70**	**C-: 63 – 66**	**D: 60 – 63**	**F: < 60**

Note: Usual performance up to 20% points could be granted to the final grade based on the overall course performance (lecture attendance, homework submission punctuality, course engagement such as in-class question answering and discussion, etc.).

EXAMS: There will be one midterm exam and one final exam. Exact exam dates will be announced at least two weeks ahead of time.

QUIZZES: In-class quizzes will be arranged generally prior to the exams. Each quiz will have up to a few questions or problems related to the learned content and help the preparation for exams. The lowest one quiz grade will be dropped when calculating final grades. Each student must complete the quizzes individually.

GRADE REBUTTAL: For any quiz or exam, you have one week to request correction if you feel your answer might be mis-graded. No correction will be made a week after the quiz or exam grade is posted.

HOMEWORK: Homework problems will be assigned throughout the semester. All finished homework needs to be submitted online by the specified due date. Homework will be graded and solutions for all homework problems will be posted 48 hours after the submission due date. The lowest one homework grade will be dropped when calculating final grades. While discussion between students is allowed for solving homework problems, each student must write and submit the homework individually.

ATTENDANCE: Less than 60% attendance might be failed for this course. Students will be given excused absences only in cases of a certified medical excuse, or a family emergency. Students missing homework because

of an excused absence must submit the completed assignments after they return. Students missing an exam because of an excused absence will take the exam at another time arranged by the instructor.

MAKE-UP POLICY: Late homework submission will be accepted up to 48 hours after the initial due date with a 20% penalty, unless an extension request is approved **prior to the homework due date**. Extensions are granted at the instructor's discretion. In general, **no** make-ups for quizzes and exams will be allowed. Exceptions will only be made for special circumstances such as a medical emergency. If you cannot attend a quiz or an exam, you must contact the instructor prior to the quiz and exam. Failure to do so will result in a zero grade on that quiz or exam.

MATERIAL COVERED: The sequence of the sections covered in this class is:

Week	**Contents**	**Descriptions**
1 (02/28)	Chapter 0	Introductions
2 (03/07)	Chapter 1	Electronic States in Semiconductors
3 (03/14)	Chapter 1	Electronic States in Semiconductors
4 (03/21)	Chapter 2	Impurity and Defect Levels in Semiconductors
5 (03/28)	Chapter 2	Impurity and Defect Levels in Semiconductors
6 (04/04)	Chapter 3	Statistical Distribution of Equilibrium States of Semiconductor Carriers
7 (04/11)	Chapter 3	Statistical Distribution of Equilibrium States of Semiconductor Carriers
8 (04/18)	Mid-Term Exam	
9 (04/25)	Chapter 4	PN Junction and PN Diode
10 (05/02)	Chapter 4	PN Junction and PN Diode
11 (05/09)	Chapter 5	Contact Between Metals and Semiconductors
12 (05/16)	Chapter 5	Contact Between Metals and Semiconductors
13 (05/23)	Chapter 6	Bipolar Junction Transistor (BJT)
14 (05/30)	Chapter 6	Bipolar Junction Transistor (BJT)
15 (06/06)	Chapter 7	Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET)
16 (06/13)	Chapter 7	Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET)
17 (06/20)	Final Exam	