<table>
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<tr>
<th>Course</th>
<th>ECE 5550 Fall 2015: Solid State Electronics</th>
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| Instructor  | Pai-Yen Chen  
Office: 3137 Engineering Bldg.  
Email: pychen@wayne.edu  
Phone: 313-577-3758 |
| Credits     | 4 |
| Times       | M W 05:30PM - 07:20PM |
| Class Dates | Aug 28 to Dec 11 |
| Location    | 0015 Manoogian Hall |
| Office Hours| M 7:30-9 PM, W4-5:20PM |
| WSU Catalog Description: | ECE 3300, PHY 3300, MAT 2150 for non-ECE students. From these courses, students should be familiar with 1) basic electrical circuits, 2) modern physics and Maxwell’s equation, 3) partial differential equations. Open only to students enrolled in professional engineering programs |
| Course Content | This course explicitly deals with the graduate-level fundamental physics of operation of electronic devices, and expounds on the practical aspects of common semiconductor devices, including diodes, bipolar junction transistors (BJTs), and field-effect transistors (FETs). The objective is to help students understand semiconductors devices commonly used in RF/analog/digital circuits and optoelectronics. In addition to learning the device physics fundamentals, the course will feature broad-based discussions regarding the ongoing state-of-the-art research concerning semiconductor devices, microfabrication, and integrated circuits (ICs). |
| Topics      | • Solid-state physics and quantum mechanics  
 o Crystal structure of solids  
 o Crystal growth  
 o Atomic structure and Bohr model  
 o Schrodinger’s wave equation  
 o Quantization effects  
 • Energy band and carriers in semiconductors  
 o Electrons and holes  
 o Effective mass and density of states  
 o Mobility, drift and diffusion  
 • P-N junctions  
 o Energy band diagram  
 o Forward and reverse bias  
 o Generation and recombination  
 o Heterojunctions  
 • Schottky diode and metal-semiconductor Ohmic contact  
 • Metal oxide field effect transistor (MOSFETs)  
 o MOS capacitors  
 o Surface charge  
 o CV characteristics  
 o Low and high frequency capacitance  
 o Gradual channel approximation and constant mobility model  
 o Threshold voltage  
 o Velocity saturation effect  
 • MOSFET scaling  
 o Short channel effect  
 o Subthreshold current |
Charge sharing model
- Drain induced barrier lowering
- Bipolar junction transistor
  - Operation principle
  - Ebers-Moll Model
  - Heterojunction BJT
- Introduction to VLSI fabrication technologies

Text and Sources

Learning Objectives
- After completing this course, students should be able to do the following:
  - Define and describe semiconductor materials, crystal lattices, periodic structures, cubic lattices, crystal planes, crystal directions and diamond lattice.
  - Define and describe semiconductor crystal growing methods.
  - Calculate physical quantities using classical and quantum models of the atom.
  - Define terms such as bonding force, energy band, metal, semiconductor, insulator, direct and indirect semiconductors, charge carriers in semiconductors, effective mass, intrinsic and extrinsic materials and Fermi-Dirac function.
  - Calculate electron and hole concentrations, and the temperature dependence of carrier concentrations.
  - Discuss drift of carriers in electric and magnetic fields and the effects of temperature and doping on mobility.
  - Discuss mechanisms due to excess carriers in semiconductors and calculate excess carrier concentrations and lifetimes under given conditions.
  - Define and discuss methods for fabricating p-n junctions in semiconductors.
  - Derive the two-sided step-junction model for the p-n junction and calculate junction variables.
  - Discuss deviations from the simple model of the p-n junction.
  - Discuss the operation of the field-effect transistor and derive a model for
its operation. Use the model to explain and calculate characteristics of the field-effect transistor.

- Discuss the operation of the bipolar-junction transistor and derive a model for its operation. Use the model to explain and calculate characteristics of the bipolar-junction transistor.

**ABET Outcome Coverage**

ABET is responsible for accrediting engineering degree programs throughout the USA. This course has coverage in the following ABET objectives ([www.abet.org](http://www.abet.org)).

(a) An ability to apply knowledge of mathematics, science, and engineering.
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The principles of semiconductor physics will be used to understand the operating mechanisms behind solid-state electronic devices, including pn/Schottky diodes, BJT, JFETs, MESFET, and MOSFETs, which are commonly used in the electronic circuits. Principles in mathematics will be used to derive some of the important relationships.

(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(e) An ability to identify, formulate and solve.

In the final project and exams, student will need to design semiconductor devices for integrated circuits that must meet certain specifications. The final project will help students develop the analytical and modeling skills, and build on research and knowledge about the building blocks of the microelectronic technology.

**Attendance Policy**

Students are required to attend class, and attendance will be taken if necessary. 4 absences are allowed for documented personal/medical reasons. Please email the lecturer in advance if you know you will miss a class. Attendance is, however, mandatory on the exam dates listed in the course calendar. Makeup exams is not allowed. Please email me within the second week of classes if you have a conflict on these dates.

**Grading Policy**

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<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Homeworks</td>
<td>10%</td>
</tr>
<tr>
<td>Midterm exam I</td>
<td>25%</td>
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<tr>
<td>Midterm exam II</td>
<td>25%</td>
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<tr>
<td>Final exam</td>
<td>35%</td>
</tr>
<tr>
<td>Attendance</td>
<td>5%</td>
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Homeworks: 10% (HW will be assigned approximately every two weeks)

**Grading scale (subject to change)**

- A 94-100
- A- 90-93
- B+ 85-89
- B 80-84
- B- 75-79
- C+ 70-74
- C 65-69
- C- 60-64
- D 50-59
- E 0-49
| Cheating Policy and Penalty for Cheating | Cheating is defined by the University as “intentionally using or attempting to use, or intentionally providing or attempting to provide, unauthorized materials, information, or assistance in any academic exercise.” This includes any group efforts on assignments or exams unless specifically approved by the professor for that assignment/exam. Evidence of fabrication or plagiarism, as defined by the University in its brochure Academic Integrity, will also result in downgrading for the course. Students who cheat on any assignment or during any examination will be assigned a failing grade for the course. |
| Blackboard | We will use the WSU blackboard website extensively in this course. Please log on to [http://blackboard.wayne.edu](http://blackboard.wayne.edu) and make sure you have access to ECE 5550 course website. The WSU blackboard will be used to post lecture slides, course information, announcement, homeworks and answers. You will be able to access your current grades in the blackboard. Please also feel free to give your anonymous feedback and constructive criticism about how the course can be improved. |