ELEG 4203, ELEG5203: Semiconductor Devices, Fall 2016

TTh 9:30-10:45 Location: Bell 2284

# Instructor: Dr. Shui-Qing (Fisher) Yu Office: Bell 3170, Nano211 Phone: 5-7265 Email: syu@uark.edu

**Text book:**

There is no required textbook for this course. The instructor will distribute class notes to be used for teaching purpose.

**References:**

1. *Semiconductor Device Fundamentals,* R.F. Pierret, Addison-Wesley, 1996.
2. *Semiconductor Devices,* Sima Dimitrijev, 2nd Edition, Oxford University Press 2012.

3. *Solid State Electronic Devices*, Ben G. Streetman, Sanjay Kumar Banerjee, 6th edition.

**Office Hours**: TTh 10:45pm-11:45 or any other time by prior email/phone appointment

**Goals:** This course is designed to provide junior and senior graduate students detailed background in semiconductors devices particularly for PN junction, MOSFET and Bipolar Transistors.

**Objectives:**

* Understand the operation of the basic semiconductor devices
* Understand device physics (energy bands, carrier statistics, recombination, and carrier drift and diffusion)
* After discussing these aspects of semiconductors, we will concentrate on:
* pn junctions
* Metal-semiconductor devices
* Metal-oxide semiconductor capacitors and transistors
* Bipolar junction transistors

**Prerequisites:** This is a required course for µEP students and a technical elective for Electrical Engineering senior undeergraduate students. Sufficient knowledge in Physics (such as basics of quantum mechanics), Mathematics (differential equation and numerical calculations), Materials, and Programming are needed. Please come to talk with the instructor to find out if you are eligible to take this course.

**Homework:**

Homework will be assigned by the end of class and collected one week after in class. Late homework will not be accepted. Use of software (e.g., MathCad, Matlab, Mathematica, Spreadsheet, TK Solver, etc.) to solve some homework problems is recommended. Homework should be written in a clean and clear manner with sufficient details so that the grader can follow the derivation logic to get the final answers. The final answer should be **clearly marked (underline or enclosed with a box)**. Simply listing the final answers without any derivation might end up with losing all points even though the answers are correct. Please always use **a separate page of paper to start a new question**. Each homework should include a **cover page** with student name, UArk ID number, homework number (#1, #2, #3,…), question number (for example, 5.1, 5.3, 5.5, …) and due date. Each page of answer sheet should be **properly numbered**. Homework does not follow the required format is subject to 20% penalty.

**Attendance**: Bring your textbook, calculator, pen/pencil, and paper to every class and be ready to use these anytime they are needed. Attendance is strongly recommended. Most students are graduate students or going to go to graduate school. This course will be the foundation for you to conduct research in the semiconductor field. Please make sure that you review the course materials timely and understand them thoroughly.

**Exam**: There will be three exams during the semester at an interval of approximately 7 weeks. In these exams you will be responsible for the subject matter taught during that 7-week period for the first two exams. The last exam is the final and will be comprehensive.

**Term papers**: Term papers are required for graduate students and those UG students who are taking this course for Honors Credit. They are to extend the knowledge gained in class about the physics of junction diodes and transistors to understand the working of other semiconductor devices, (such as, Photodetectors, Solar Cells, Light Emitting Diodes, Solid State Laser Diodes, Microwave Generators, such as, IMPATT and Gunn Diodes, Nuclear, X-ray and Gamma Detectors, Switching and Power Devices) and to submit a 5-page research paper. Please refer to IEEE Transaction Paper format for reference. All papers should be checked by Turn-it-in or other software with no report of plagiarism.

**Academic Integrity Policy**

As a core part of its mission, the University of Arkansas provides students with the opportunity to further their educational goals through programs of study and research in an environment that promotes freedom of inquiry and academic responsibility. Accomplishing this mission is only possible when intellectual honesty and individual integrity prevail.

Each University of Arkansas student is required to be familiar with and abide by the University’s ‘Academic Integrity Policy’ which may be found at http://provost.uark.edu/ Students with questions about how these policies apply to a particular course or assignment should immediately contact their instructor.

**Standard Grades**

A (90% - 100%), B (80% - 89%), C (70% - 79%), D (60% - 69%), F (below 60%)

Grade Breakdown:

For Undergrad Credit:

Homework: 20%

Exam I 20%

Exam II 20%

Final Exam 40%

For Graduate Credit and for Honors UG Credit:

Homework: 15%

Exam I 18%

Exam II 18%

Final Exam 34%

Term Paper 15%

**ELEG 4203, ELEG5203 Teaching schedule**

|  |  |  |
| --- | --- | --- |
| Week 1 | 8/23 | 8/25 |
|  | Introduction, Semiconductors, Miller Indices, Growth, Bonds | Carrier Statistics |
| Week 2 | 8/30 | 9/1 |
|  | Review of Quantum Mechanics | Review of Semiconductor Bandstructures |
| Week 3 | 9/6 | 9/8 |
|  | Energy, Potential, Drift, Diffusion, Recombination | Energy, Potential, Drift, Diffusion, Recombination |
| Week 4 | 9/13 | 9/15 |
|  | Continuity Equations-1 | Continuity Equations-2 |
| Week 5 | 9/20 | 9/22 |
|  | PN Junctions: Electric Field, Potential-1 | PN Junctions: Electric Field, Potential-2 |
| Week 6 | 9/27 | 9/29 |
|  | PN Junctions: Current-Voltage, Breakdown-1 | PN Junctions: Current-Voltage, Breakdown-2 |
| Week 7 | 10/4 | 10/6 |
|  | **Exam1** | PN Junctions: Switching, Schottky Diodes,  |
| Week 8 | 10/11 | 10/13 |
|  | MOS Band Diagrams | MOS Capacitor, Band Diagrams, Threshold Voltage-1 |
| Week 9 | 10/18 | 10/20 |
|  | **Fall break** | MOS Capacitor, Band Diagrams, Threshold Voltage-2 |
| Week 10 | 10/25 | 10/27 |
|  | MOS-C: Capacitance, MOSFET-1 | MOS-C: Capacitance, MOSFET-2 |
| Week 11 | 11/1 | 11/3 |
|  | MOSFET: Current-Voltage-1 | MOSFET: Current-Voltage-2 |
| Week 12 | 11/8 | 11/10 |
|  | MOSFET: Advanced Current-Voltage, Nonidealities-1 | MOSFET: Advanced Current-Voltage, Nonidealities-2 |
| Week 13 | 11/15 | 11/17 |
|  | CMOS, Bipolar Junction Transistor, Minority Carriers-1 | CMOS, Bipolar Junction Transistor, Minority Carriers-2 |
| Week 14 | 11/22 | 11/24 |
|  | **Exam2** | **Thanksgiving** |
| Week 15 | 11/29 | 12/2 |
|  | BJT: Current-Voltage-1 | BJT: Current-Voltage-2 |
| Week 16 | 12/6 | 12/8 |
|  | BJT: Ebers-Moll, Gain | BJT: Breakdown, Crowding |

Dead day: 12/9

Exam 1: 10/4, Exam 2: 11/22

Final: 12/15 8:00-10:00 AM