

ECE 441
Physics and Modeling of Semiconductor Devices

Professor Wenjuan Zhu

Spring Semester 2021

Course Overview

This course focuses on the derivation of models for the terminal currents of the semiconductor devices used in integrated circuits, specifically, the MOSFET and bipolar junction transistor. Our objective will be to represent the device's steady-state response; however, we will also discuss how to extend the models to the transient case. On an as-needed basis throughout the semester, we will study semiconductor physics, focusing on topics such as drift and diffusion, generation and recombination, and avalanche multiplication. In the latter part of the semester, we will explore the motivations behind recent modifications to the basic transistor structures, such as the adoption of high-k gate dielectrics for MOSFETs.

Lectures

MWF 10:00–10:50 AM

Important Dates

Midterm 1: March 3rd, Wednesday (tentative)

Midterm 2: April 7, Wednesday (tentative)

Final Exam: TBD

Grading

Assignments 30% (weekly homework 25%, TCAD project 5%)

Midterm Exams 30% (15% each)

Final Exam 40%

Instructor Office Hours

Tuesday 4:00 pm – 5:00pm

Textbook

R. Muller and T. Kamins, *Device Electronics for Integrated Circuits*, 3rd edition, John Wiley & Sons, 2003.

Homework Policy

Please upload your homework on Compass 2g before the deadline.

If a piece of homework misses the submission deadline, then the following grading policy will apply:

0 day < delay time < 1 day (24 hours), 25% of the assignment's maximum credits will be deducted.

1 day < delay time < 2 days, 50% of the assignment's maximum credits will be deducted.

2 days < delay time < 3 days, 75% of the assignment's maximum credits will be deducted.

3 days < delay time < 4 days, 100% of the assignment's maximum credits will be deducted.

The submission time stamp is based on the record on Compass 2g.

For example, if a homework is due on October 1st 5 pm and the full score of the homework is 100 points. If the homework is submitted on Compass on October 2nd 9 am and has 90% of the answers correct, then it will receive 90 points -25 points = 65 points.

Any homework past deadline by more than 4 days will not be accepted.

Each student's lowest homework grade of the semester will be dropped before the semester total score is calculated. A student who is seriously ill for more than 7 consecutive days should contact the instructor so that s/he is not unduly penalized for missing multiple homework. Homework is to be the student's own work, not a collaborative or plagiarized work. However, students are permitted and encouraged to help one another by engaging in discussion of the course material and approaches to solving the homework problems.

Course Policy on Absences

If you miss an exam, or homework assignment the following procedures apply:

- 1) Absences for job interviews or for specific university-sponsored events must be pre-arranged with the course instructor. Upon verification that the excuse is valid and complies with the UIUC Student Code, the course coordinator will issue an excused absence in the event a quiz is given. Pre-arranged excused absences will not be given for exams except in the case of specific university-related events as described in the UIUC Student Code.
- 2) Excused absences are not given for missed homework assignments for any reason, as only the top 9 of the 10 assigned homework assignments count towards the course grade.
- 3) In the event of illness, you must receive an Excused Absence Form from the Undergraduate College Office, Room 207 Engineering Hall, indicating what work you have missed and the reason for the absence. This form must be signed by a physician or medical official for a medical excuse, or by the Office of the Dean of Students (Emergency Dean) for a personal excuse due to personal illness, family emergencies, or other uncontrollable circumstances. The office may be reached at 333-0050. **Note that Excused Absence Forms in the case of illness are now only given out by the office for the case of serious illness lasting more than 3 days. Excused absences are not granted for minor illness.**

For missed classes or hour exams, present the completed form in person to the course instructor as possible after you return.

Scores on hour exams missed due to excused absences **will not be made up**. Your grade will be determined based on the average of the grades that you have completed. Specifically, the average of your completed scores will be used to determine the total, homework or hour exam score and the final total score.

Class Website and Web-board

<http://courses.engr.illinois.edu/ece441>. Homework and exam solutions will be posted on the class website, as will copies of any slides shown in class. If you have a question regarding a homework assignment or an exam, post the question on the class web-board; you may link to the ECE 441 web-board from the class homepage. The web-board is the **primary** means for student-staff communication

outside class and office hours. Email should be used only for matters of a personal nature. The web-board will be checked on a daily basis.

List of Topics

We will cover the following topics. Relevant sections of the textbook are noted in parentheses. Exact reading assignments will be given on the weekly homework sheets.

- Semiconductor Physics (1.1, 1.2)
- Metal-Semiconductor Contacts (3.1-3.6)
- PN junctions (4.1-4.5, 5.1-5.4)
- MOS Capacitor (8.1-8.7)
- MOSFET (9.1-9.4, 10.2, 10.5)
- Bipolar Transistor (6.1-6.4, 7.1-7.2)

Some of the lectures will cover material that is not in the textbook, so attendance is expected. Smart-phones and other communication devices must be turned off while you are in my classroom.