University of California, Berkeley Extension

Integrated Circuit Semiconductor Technology Programs

EL ENG X481.1: Introduction to Semiconductor Devices

(1 semester unit in EL ENG, Online Format)

Course Syllabus

A. Course Description

Working from the essential knowledge of semiconductors, the instructor illustrates some industry jargons, such as energy bandgap and minority carriers, and transforms them to powerful concepts that unveil the mysterious behaviors of semiconductor devices. Topics include: intrinsic and extrinsic semiconductors, carrier transport, and PN junction. An individual research project covers controversial subjects: ultimate limits of integrated electronics, and integrated strategy for confronting commoditization in the foundry industry. You can apply those concepts to many applications, including CMOS, BJT, LED and sensors.

B. Prerequisite

You should possess a basic knowledge on science/chemistry/physics at the high school level, such as

- *Atoms, ions, electrons, and charge*
- *Electric field and potential*

You should possess a basic on math/calculus at the college freshman level, such as

- *Single-variable derivative*
- *Single-variable integration*

C. Timeline

Timeline	Course events	Lecture pace
Day 30	**Homework 1**	30% of lectures done
Day 60	**Homework 2**	60% of lectures done
Day 90	**Homework 3**	100% of lectures done
Day 90	Final exam setup	
Day 120	**Midterm exam**	
Day 120	Final exam date confirmed	Review
Day 150	**Proctored final exam**	
Day 180	Course ends	

- Pacing yourself well is one of the key factors to succeed in this course. *Mark your calendar* for the timeline and course events.
- The course registration date (Day 1) is the date you receive the login information and welcome email.
- *It is strongly suggested you reserve the last month (Day 151-180) for contingency.*
- *You final exam request/setup process normally takes up to a couple of months to finalize.*

D. Required Readings

No textbook is required for this course.

E. Learning Objectives

Upon successful completion of the course, students will be able to

- Understand the vital concepts and essential characteristics pertaining to intrinsic and extrinsic semiconductors.
- Gain a comprehensive understanding of the device physics on the topics of energy band, carrier transport and their theoretical application on understanding the operation mechanism of a pn junction.
- Lay a strong foundation on semiconductor device physics to facilitate the study of BJT, MOS, and advanced VLSI devices.

F. Intended Audience

This course is intended for technical professionals new to the field, who want to learn the fundamentals of microelectronics, semiconductors and integrated circuits (ICs).

G. Course Content Outline

Session 1. Intrinsic Semiconductors

Starting from the introduction of semiconductor materials, the students will learn the important characteristics of representative elemental and compound semiconductors, crystal structure of silicon, the peculiar characteristics of the bipolar carriers. Plus, more abstract but much more powerful concepts derived from the energy bands can help students unveil the mysterious carrier behaviors of semiconductors.

- *Bond Model vs. Energy Bands (Semiconductor Basics)*

Session 2. Extrinsic Semiconductors

The students will learn to employ the concept of energy bands to understand the functions of donors and acceptors and differentiate the phenomenon between partial ionization and complete ionization. Combining the mass-action law with the charge neutrality, the students will be able to know the electron and hole concentrations in a doped semiconductor.

- *Doping of Semiconductors: Donors and Acceptors*
- *Principles for Analyzing Compensated Semiconductors*

Session 3. Carrier Transport Phenomenon

The students will understand the driving force of the drift current, how the carrier mobility affects this type of carrier transport process and how other factors like temperature, doping concentration, and electric field impact carrier mobility. On the other side, diffusion is the dominant transport process in the minority carrier

devices such as pn junction and bipolar junction transistor. The students will learn the formation, formulation, and diffusivity pertaining to the carrier diffusion.

- *Carrier Transport Phenomenon: Drift Current*
- *Carrier Transport Phenomenon: Diffusion Current*

Session 4. PN Junction

It's imperative to start from the equilibrium condition and gradually channel into non-equilibrium conditions, and minority-carrier distribution. The students will experience the detailed physical illustration and learn the essential concepts such as electrostatic potential distribution, built-in potential, energy barrier, and depletion layer—one of the essential keys to grasp the important characteristics of the semiconductor devices such as BJT and MOSFET. Furthermore, understanding the formation and physical meaning of the parasitic capacitances help the students understand the speed or frequency limitation of a digital or analog circuit and their relationships to the SPICE parameters.

- *Fundamental Physical Concepts of pn Junction*
- *Electrostatic and Quantitative Analysis of Depletion Region*
- *Minority Carrier Distributions: Concepts and Applications*
- *Electrostatics of Junction Capacitances*

H. Course Length

- The 15-hour course length covers not only the audio runtime but also the time to catch up by rewinding and replaying video. It also includes the time to take notes and to communicate/discuss with the instructor.
- Other than the 15-hour course length, you are expected to spend additional 30 hours studying the lectures, digesting the materials, working on the assignments, and preparing for the exams.
- Most students watch the lecture video or read PDF slides two or three times before they can fully grasp the concepts, cultivate problem-solving skills, and have a good grade on the final exam.

I. Course Grade Weighting (Grading)

The student's cumulative grade in the course will be based on the following criteria:

- Discussion Participation: 10 points
- Progress Updates: 10 points
- Written Homework Assignments: 30 points
- Midterm Exam (Take-home exam): 20 points
- Final Exam: 30 points

J. Credit Requirements

You must pass the final exam with a grade of at least 70 percent to pass the course.