



Physical Electronics – EEE 325

Department of Electrical & Electronics Engineering

Faculty of Engineering

1. Basic Details

Programme: B.ENG

Year: 2014/2015

Total Units: 3

Level: 300L

Taught Semester: First Semester

Instructor:

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Office Hours: Mondays and Thursdays, 4-5pm, or by appointment

Reading Materials:

<http://eee.fuoye.edu.ng/300l-s-semester/f-semester/177-eee-325-physical-electronics-3-units.html>

Department: Electrical and Electronics Engineering

Prerequisites: EEE204 (Fundamental of Electrical and Electronics Engineering)

Prior Knowledge:

- An understanding of the physics of semiconductor materials.
- Basic understanding of the differential calculus and differential equations.
- Transistors fundamentals.
- Understanding of the nature of signals in information transfer.

Lecture Time: Mondays, 11am - 12pm, & 2pm – 4pm

Total Learning Hours: 30

Course Delivery: Blended/Face to Face

Lecturers: Engr. Dr. A.M. Zungeru & Mr. H.U. Ezea

2. Course Overview

Physical Electronics (EEE325) examines the physics of silicon-based microelectronic semiconductor devices. Topics covered are: Energy bands and charge carriers in semiconductors, excess carriers in semiconductors, pn junctions, and metal-oxide semiconductor field-effect transistors (MOSFETs). The course emphasizes physical models for semiconductor electronic devices and understanding of device operation through energy band diagrams. The application of these models to the analysis and design of the devices are also outlined.

3. Course Objectives

This course is taught to students for the following aims:

- To introduce the student to the role of electronics in modern communications, computation and entertainment system.
- To introduce the student to the physical models for semiconductor electronic devices and to the application of these models to the analysis and design of these devices.
- To obtain a detailed understanding of the physical principles underlying a number of modern semiconductor devices.
- To obtain a detailed understanding of depletion capacitance due to dopant charges, and diffusion capacitance due to mobile charges.
- To have a detailed understanding of second-order effects-high level injection, generation, recombination in depletion region, series resistance, and graded junctions.
- To be able to explain and apply basic concepts of semiconductor physics relevant to devices.
- To be able to describe, explain, and analyze the operation of important semiconductor devices in terms of their physical structure.
- Develop their skills in critical thinking and problem solving.
- Increase confidence in the ability to explaining scientific contents and ideas orally.
- Increase confidence in the ability to prepare and orally present original results and be able to analyze them.

4. Intended Learning Outcomes (ILO)

Students completing this course will be able to:

- Understand and apply the physical laws relating to carrier statistics in semiconductor to analyze the density of states, the Fermi function, and the equilibrium distribution of carriers.
- Understand and apply the physical laws relating to currents in semiconductors to analyze drift, diffusion, and recombination-generation processes
- Understand and apply the physical laws relating to a pn junctions. Schottky junctions and heterojunctions in thermodynamic equilibrium and their ideal behavior under reverse bias.
- Understand and apply the physical law to analyze the electrostatic properties of MOS capacitors.
- Understand and apply the physical laws to analyze the DC characteristics of a MOSFET.
- Understand and apply the small-signal equivalent circuit of a MOSFET to analyze the AC response.
- Understand and apply the physical laws relating to pn junctions under forward bias and their ideal DC current voltage characteristics.
- Design a pn junction in order to obtain a desired DC current-voltage characteristic.
- Understand and identify the major deviations from ideal diode behavior that occur in pn junctions.

5. Course Content

- Semiconductor: bands in semiconductor, basic quantum mechanics, effective mass, doping, density of states, Fermi function, carrier concentration, drift, diffusion, absorption, recombination lifetime, device fabrication.
- pn junctions: electrostatics, depletion width, built-in potential, qualitative operation, ideal diode equation, Sah-Noyce-Shockley equation, high injection, avalanche breakdown, tunneling, AC analysis, Schottky barriers, heterojunctions.
- MOSFETs: MOS capacitor, DC characteristics of MOSFETs, transient properties.

6. Course Schedule

Week	Topics	Reading Assignment
1.	▪ Review of Diodes; Semiconductors and their types	1.1-2.2
2.	▪ Energy Band Diagrams and Doping; Basic Integrated Circuit processing	2.3-2.5
3.	▪ Planar Diode Fabrication; Doping Profiles and 1D approximations in the Diode Structure	2.6-2.7
4.	▪ Generation, Recombination and Diffusion; Diode Operation	2.8-2.10
5.	▪ Depletion Region and Parasitic Resistance; Diode Model Parameter Extraction	2.8, 3.1-3.4
6.	▪ Quiz 1	
7.	▪ pn Junction Electrostatics and Reverse Breakdown	4.1-4.7
8.	▪ Diode Small Signal Modelling and Switching	4.1-4.7
9.	▪ MOSFET Structure and Processing, Operation, and Threshold Voltage	6.1-7.4
10.	▪ The MOSFET Square law model; Channel Shortening and dc Parameter Extraction; Short Channel Threshold Voltage	7.3-7.6
11.	▪ MOSFET Small Signal Modelling, scaling and Velocity Saturation; Process Variation, Testing, Packaging and Reliability	7.6-7.7
12.	▪ Quiz 2	
13.	▪ Revision	

7. Course Learning & Teaching Methods

- Lecture 1: 1hr (Monday, 11:00am)
- Lecture 2: 2hrs (Monday, 2:00pm)
- Formative phase tests and Group tutorials/discussions

8. Learning & Teaching Activities

Activity Type	Percentage	Hours
Lectures & Class Exercises	26%	30
Group Tutorials/Discussions	9%	10
Guided independent study	65%	75
Total	100%	115

9. Course Assessment Method

Requirement:	3 Hours Exam
Status:	Compulsory Course
Written Examination:	60%
Quiz/Test:	20% (Two Quizzes)
Homework:	10%
Attendance:	10%

Level of Performance	Grade	Rating (credit points per unit)
70-100%	A = Excellent	5.0
60-69%	B = Very Good	4.0
50-59%	C = Good	3.0
45-49%	D = Satisfactory	2.0
40-44%	E = Poor	1.0
0-39%	F = Failure	0.0

10. Industry Relevance

- Semiconductor Industry: this involves the design of walkman, television, automobiles, washing machines, computers, microprocessors, and memory circuits;
- Instrumentation engineering;
- Aircraft.

11. Required Text

- An introduction to semiconductor devices, By Donald A. Neamen, McGraw Hill publisher, 2006.
ISBN: 0071116273, 9780071116275

12. Recommended Texts

- R.T. Howe and C.G. Sodini, “Microelectronics: An Integrated Approach, Published by: Pearson Education, Inc, 2008. (H & S)
- Semiconductor device fundamentals by Robert F. Pierret, Addison Wesley
- Semiconductor Physics and devices, 2ed, Donald A. Neamen, McGraw-Hill [This could be a nice reference book for those who intend to learn more about the semiconductor device physics]
- Device Electronics for ICs, 3rd Edition, by Richard S. Muller. (Especially for MOS capacitor and devices)
- Solid State Electronic Devices, (6th Ed) By Streetman and Banerjee, Prentice-Hall.
ISBN-13: 978-0131497269.

13. Attendance Policy

Attendance is strictly mandatory. The University policy stipulates that in order to be eligible for a course examination, a student shall be expected to attend a minimum of 65% of the lecture, tutorials, practical and classes for the course in which he/she is registered [**Ref. Students’ Handbook of Information, pg. 52**]. Any student, therefore, whose attendance rating falls below the required 65% shall not be eligible to write the course exam. In this regard, students will be notified of their eligibility status for a course examination prior to the exam.

14. Calculator Policy

Programmable calculators will not be allowed in the quizzes or final exam. The University policy prohibits the use of mobile phone, electronic programmable calculator, information storage devices, etc. in the quizzes or final exam [**Ref. Students’ Handbook of Information, Pg. 49**]. A “programmable calculator” is one that can store program steps or text at any level of sophistication and the rule applies irrespective of whether or not there appears to be anything stored. If you are in any doubt as to the eligibility of your calculator, please see me well before the quiz/exam.

15. Exemption from Quizzes/Exam

Dated medical documentation is required for exemption from a quiz; in this case the weighting will be moved to the final. Makeup quizzes will not be offered under any circumstances. The University policy prohibits a student from absenting from exam except on acceptable medical grounds, and in consultation with the HOD and the Dean of the faculty. Any student absent on the ground of illness must produce a certified medical report, and students who absent from quizzes/exams for reasons other than illness, accident or some exceptional circumstances shall be deemed to have failed the course [**Ref. Students’ Handbook of Information, Pg. 52**].

16. Ethical and Unethical Conduct

The preliminary purpose of Homework is to help students learn and gain practical experience in the subject matter. Allowing and encouraging collaborations with fellow students best serves this purpose. Modern engineering is, after all, almost exclusively a team effort. However, fairness requires us to be able to assess your *own* contribution. Therefore, the written material that you hand in *must* be your *ownwork*, and any discussions or collaborations with fellow students must be identified in writing on your solution (e.g. noting “the solution to problem #5 was worked out together with Mark Davison”, or “the solution to problem #2 was benefited from discussions with Ruth Peters”). Nearly identical solutions from different students who do not cross-reference each other will be viewed as statistically “unlikely”, thus worthy of further examination.

This policy is intended to help you make the most out of the course by allowing you to freely work with your classmates. If you are in any doubt as to what constitutes ethical or unethical conduct, please see any member of staff for assistance. Violations of this policy will be handled with maximum severity.

<http://www.sciencedirect.com/science/jrnllallbooks/sub/energy/a>