Lahore University of Management Sciences

EE528/PHY 537: Semiconductor Device Fundamentals

Fall 2023

Course Catalog Description
This course is about basic semiconductor physics and its applications on important devices such as PN junctions and the metal-oxide-semiconductor field-effect transistor (MOSFET). The course is divided into three parts. The first part is an introduction to solid-state physics (energy bands, electrons and holes, the Fermi function), doping and carrier densities, carrier transport and generation-recombination, and the so-called semiconductor equations, which provide a complete, semi-classical, mathematical description of electrons and holes in semiconductors, subject to some important simplifying assumptions. The second part of the course applies these concepts to the dominant electronic device today, i.e., PN junctions and the third part covers metal-oxide-semiconductor field-effect transistor (MOSFET). The course provides the device fundamentals needed for those interested in photovoltaic solar cells, integrated circuits (ICs), and a starting point for those who intend to focus on semiconductor devices and nanoelectronics.

COURSE OBJECTIVES
The goal of this course is to stimulate interest of semiconductor devices in students and to teach them fundamental background to pursue further research and advanced course work in this area. In addition, the course aims to provide a solid background to students who wish to work in today's solar cell and integrated circuits industry.

Course Details	
Credit Hours	3
Core	
Elective	Elective course for EE/PHY undergraduate and graduate students
Open for Student Category	EE/PHY/CHEM/BIO/CS/MATH Senior and Junior students and Graduate students;
Closed for Student Category	Freshman, Sophomore

Course Prerequisite(s)/Co-Requisite(s)
Pre-requisites: SSE standing at following levels: Junior, Senior, MS, PhD; EE340 for EE undergraduate students; PHY204 for PHY undergraduate students. Basic programming knowledge/experience in Matlab. Co-requisites: None

Course Offering Details						
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 min	Timings and Venue	
Recitation (per week)	Nbr of Rec (s) Per Week	x	Duration			
Lab (if any) per week	Nbr of Session(s) Per Week	x	Duration			
Tutorial (per week)	Nbr of Tut(s) Per Week	x	Duration			

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Secretary/TA	
TA Office Hours	
Course URL (if any)	LMS

Course Learning Outcomes	
EE528-	The students should be able to:
CLO1:	(i) To predict the observable properties of semiconductors as a function of various parameters.
CLO2:	(ii) To analyze and understand PN junction diodes suitable for current rectification and solar power production
CLO3:	(iii) To analyze and evaluate the performance of metal-oxide-semiconductor field effect transistors (MOSFETs)
CLO4	(iv) To design and evaluate the performance of devices based on PN junctions and MOSFETs.

Relation to EE Program Outcomes

EE-412 CLOs	Related PLOs	Levels of Learning	Teaching Methods	CLO Attainment checked in
CLO1	PLO1	Psy-4	Instruction, Tutorial, Assignments	Assignments
CLO2	PLO2	Cog-4	Instruction, Tutorial, Assignments	Midterm, Final
CLO3	PLO3	Cog-4	Instruction, Tutorial, Assignments	Midterm, Final
CLO4	PLO4	Cog-5	Instruction, Tutorial, Assignments	Course Project

Grading Breakup and Policy

Assignments (5 – 6): 10%
Guided Term Project (1): 15%
Quizzes (5 – 6): 10%
Midterm Exam: 30%
Final Exam: 35%

Attendance in lectures is strongly recommended for understanding of the course material.

COURSE OVERVIEW

Week/ Lecture/ Module	Topics	Recommended Readings	Related CLOS and Additional Remarks
Module 1: Semi-classical Fundamentals			
Week 1 – 6	Introduction / Geometry of Crystals, Quantum Mechanics / Schrodinger	https://nanohub.org/courses/PSF/fall 2018	CLO1

	Equation, Energy Bands / Energy Bands in 3D Crystals, Density of States / Fermi-Dirac Statistics, Doping / Equilibrium Statistics / Carrier Conc.	SDF (ch. 1 – 3) + Notes ADF (ch. 1 – 6), Mostly used as reference	
Module 2: PN junctions			
Week 7 - 8	PN Diode Electrostatics / I-V Characteristics	SDF (ch. 5, 6) + Notes	CLO2, CLO4
Module 3: Classical MOSFET			
Session 9-11	MOS Electrostatics, MOSFETS: Ideal, MOSFETS: Non ideal	SDF (ch. 16 – 18) + Notes	CLO3, CLO4
Module 4: Modern (nano) MOSFET			
Session 12-15	Landauer Approach for Ballistic MOSFET, Virtual Source Model, Transmission theory of NanoMOSFET , Fundamental/Practical Limits of MOSFET Scaling, Course Wrap-up	SDF (ch 16, 17) + FN + Notes	CLO3, CLO4

Textbook(s)/Supplementary Readings
Text Books: 1) Advanced Semiconductor Fundamentals (ADF) By Robert Pierret (week 1 - 6) 2) Semiconductor Device Fundamentals (SDF) By Robert Pierret (week 7 - 11) 3) Fundamentals of Nanotransistors (FN) by Mark Lundstrom (week 12 - 14)

Examination Detail	
Midterm Exam	Yes/No: Yes Combine Separate: Combine Duration: 90 minutes Preferred Date: TBA Exam Specifications: TBA

Lahore University of Management Sciences

Final Exam	Yes/No: Yes Combine Separate: Combine Duration: 180 minutes Exam Specifications: TBA

Prepared by:	**Nauman Zafar Butt**
Date:	**29 July, 2023**