Transport Phenomena in Solid State Devices – EE 471

School of Engineering and Science

Fall 2021

Meeting Times:	M 2:00-2:50, Fri 11:00-1:50
Instructor:	Dr. Rob Pastore
Contact Info:	Burchard 707 precovid-19,now on zoom rpastore@stevens.edu (732) 763-2109
Office Hours:	Thur 12-1
	Other times by appt. or just stop by my office
Prerequisite(s):	E 232 – Design IV
	E 245 – Circuits and Systems
Corequisite(s):	None
Cross-listed with:	None

COURSE DESCRIPTION

This course provides an introduction to the underlying phenomena and operation of solid state electronic and optical devices essential to the functioning of computers, communications and other electronic systems. Semiconductor properties are explained and analyzed in terms of charge carrier concentrations and quantum energy band diagrams. Concepts of carrier drift (due to electric fields) and carrier diffusion (due to density gradients) are combined with those of carrier generation and recombination to produce continuity and diffusion equations for the analysis of solid state devices. Optical energy absorption and emission is related to band gap energy levels in solid-state materials. Explanations and models of the operation of PN and metal-oxide-semiconductor junctions are used to describe the operation of devices including diodes, MOS transistors, photodiodes and lasers.

LEARNING OBJECTIVES

After successful completion of this course, students …

- Understand the difference between conductors, insulators and semiconductors and how very small levels of dopant impurities can drastically change the electrical properties of semiconductor materials.
- Understand the concepts of valence and conduction bands, holes and electrons, band gap, Fermi level and majority and minority carrier densities and how these affect device behavior.
- Understand the role of electric fields and density gradients in the transport of charge in semiconductors; the dependence of resistivity on carrier mobility and carrier density and the relationships between charge, electric field and potential in semiconductor devices
- Understand the development of device models for the PN junction diode from the underlying physical laws governing carrier generation and recombination.
- Understand the interaction of photons with atoms and carriers and how these interactions lead to the development of photodiodes, solar cells, LEDs and semiconductor lasers.

- Understand the band structure and behavior of the MOS capacitor and the concepts of carrier accumulation, depletion and inversion.
- Understand the derivation of simple models that describe the operation of the MOS transistor in the cut-off, linear and saturation regions, and the impact of short-channel effects on the performance of these devices.
- Understand the basic principles underlying the fabrication of semiconductor devices.

FORMAT AND STRUCTURE

This course is comprised of two lectures (one 50 minute and one 150 minute) per week.

COURSE MATERIALS

Textbook(s): (1) Semiconductor Physics and Devices, 4th edition, D. Neaman, McGraw Hill, ISBN 978-0-07-352958-5, 2012.

Materials: Stand-alone scientific calculator

COURSE REQUIREMENTS

Homework There will be homework assigned at the end of class and the solutions uploaded to canvas, this will include in class work. There also be work on exploring semiconductor devices using pspice.

Exams There will be 3 to 4 exams in this course. The final exam is cumulative. All the exams will be take home exams posted on canvas with the solutions to be uploaded to canvas.

GRADING PROCEDURES

Grades will be based on:

Homework and in class work	(20 %)
exams	(30 %)
Final	(30 %)

ACADEMIC INTEGRITY

Undergraduate Honor System

Enrollment into the undergraduate class of Stevens Institute of Technology signifies a student's commitment to the Honor System. Accordingly, the provisions of the Stevens Honor System apply to all undergraduate students in coursework and Honor Board proceedings. It is the responsibility of each student to become acquainted with and to uphold the ideals set forth in the Honor System Constitution. More information about the Honor System including the constitution, bylaws, investigative procedures, and the penalty matrix can be found online at http://web.stevens.edu/honor/

The following pledge shall be written in full and signed by every student on all submitted work (including, but not limited to, homework, projects, lab reports, code, quizzes and exams) that is assigned by the course instructor. No work shall be graded unless the pledge is written in full and signed.

"*I pledge my honor that I have abided by the Stevens Honor System*."

Reporting Honor System Violations

Students who believe a violation of the Honor System has been committed should report it within ten business days of the suspected violation. Students have the option to remain anonymous and can report violations online at www.stevens.edu/honor.