RUTGERS
UNIVERSITY | NEW BRUNSWICK

16:332:583/14:332:465 – Semiconductor Devices I /Physical Electronics (Fall 2022)

Instructor: Sumati Sehajpal
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Office hours: Mondays and Thursdays from 11:45 am to 12:45 pm via zoom:
https://rutgers.zoom.us/j/94875998607?pwd=OTRMYjJRTkE5NG1VekwxSVlzalhEdz09

Pre-Requisite courses: 14:332:361

Course Description: This course will cover the physics of semiconductor devices (energy bands, charge carriers, doping, conductivity, mobility, and velocity saturation), which will help you to understand PN junctions, Bipolar Transistors, Schottky diodes, MOS Capacitors, and MOSFETs. This course will also cover the general principle of Solar cells, LEDs, Photodetectors (applications of PN junction).

Primary Textbook: Robert F. Pierret, *Semiconductor Device Fundamentals*, Addison-Wesley, 1996.

Supplemental Books:

- R. S. Muller & T. I. Kamins, *Device Electronics for Integrated Circuits*, 3rd Edition, John Wiley & Sons, Inc., 2003.
- Y. Taur & T. H. Ning, *Fundamentals of Modern VLSI Devices*, 2nd Edition, Cambridge University Press 1998.
- C. Hu, *Modern Semiconductor Devices for Integrated Circuits*, Pearson/Prentice Hall, 2010.
- B. L. Anderson & R. L. Anderson, *Fundamentals of Semiconductor Devices*, McGraw-Hill, 2005.

Grading Policy:

Quizzes	30%
Midterm	30%
Final Exam	40%

Important Dates (Tentative):

Quiz 1	09/22/22
Quiz 2	10/06/22
Quiz 3	10/20/22
Quiz 4	11/14/22
Midterm	10/27/22
Final exam	TBD

Notes:

1. There will not be given any Make-Up Exam or Quiz, except for medical emergencies, jury duty, or other documented special circumstances.
2. The homework assignments will be given for practice and will not be collected.
3. It is your responsibility to look at the announcements and the material uploaded on course website on timely manner.

Course Outline:

Semiconductor Fundamentals:

- Crystal structure, Bohr's atom, valence-bond model of solid and the energy-band model of solid.
- Effective mass, intrinsic & extrinsic semiconductors, free carrier and carrier concentration and Fermi-level.
- Scattering and Drift, Mobility, Hall Effect, excess carriers.
- Surface recombination, electrostatic field and built-in electric field, Quasi-Fermi level, basic governing equations.

Metal Semiconductor Contacts (Schottky and Ohmic):

- Schottky diodes and Ohmic contacts, energy band diagram, mathematical models for Schottky and ohmic contacts

PN Junction Diode:

- PN junction electrostatics, equilibrium and depletion approximation, Energy band diagrams.
- Reverse bias transition capacitance and breakdown in PN junctions.
- PN junction under forward bias, minority carrier injection, DC current-voltage characteristics, and Temperature effect.
- Non-ideal diodes, tunneling diodes, AC Analysis, charge storage and transient characteristics, applications.

MOS Capacitor:

- MOS capacitors, flatband and threshold voltages.

Metal Oxide Semiconductor Transistor:

- MOS transistor equivalent circuit, ideal MOS structure, cutoff frequency, and body effect.
- Solving Poisson's equation and deriving governing equations, short channel Effects, mobility degradation

Bipolar Junction Transistor:

- Bipolar transistors, derivation of I-V and current gain expressions, equivalent circuits, frequency response, transistor as a switch, and breakdown voltage.