VDPC2001 PHYSICS OF SEMICONDUCTOR DEVICES (3-0-0)

Course Objectives

1. To provide a foundational understanding of the physics and properties of semiconductors, including energy bands, carrier concentration, and mobility under varying conditions.
2. To explore the mechanisms of carrier transport, including drift, diffusion, and generation-recombination processes, along with their implications in device behavior.
3. To study the operational principles, characteristics, and modeling of p-n junctions, Schottky diodes, MOS capacitors, and MOSFETs.
4. To analyze the fundamentals and advanced aspects of Bipolar Junction Transistors (BJT), including their current equations, switching behavior, and design considerations.
5. To introduce the principles and design of photonic devices such as LEDs, solar cells, and photodetectors, emphasizing efficiency, response, and material properties.

Module 1 (8 Hrs)

Semiconductors: Energy Band and Charge Carriers in semiconductors, Types of semiconductors, Charge carriers, Intrinsic and extrinsic materials. Carrier concentration: Fermi Level, Electron and hole concentration equilibrium, Temperature dependence of carrier concentration, Compensation and charge neutrality. Conductivity and mobility, Effect of temperature, Doping and high electric field.

Module 2 (4 Hrs)

Excess Carriers in Semiconductor: Drift, Diffusion: Current equation, Einstein's Relationship, Continuity equation Generation & Recombination: Mechanisms, Minority Carrier Lifetime

Module 3 (6 Hrs)

P-N Junctions: Principles, DC model, Capacitance of Reverse bias PN junction, store charge effects, Metal Semiconductor contacts: Schottky diode, Ohmic Contact MOS Capacitor MOSFET: Principles, C-V Characteristics, Second order effects

Module 4 (6 Hrs)

Bipolar Junction Transistors (BJT): Fundamentals of BJT operation. Minority carrier distribution, Solution of diffusion equation in base region, Terminal current, Current transfer ratio, Ebers-Moll equations, Charge control analysis. BJT switching: Cut off, Saturation, Switching cycle.

Module 5 (6 Hrs)

Photonics: LED: Radiative transition, Emission spectra, Luminous efficiency and LED materials, Solar cell and photodetectors: Ideal conversion efficiency, Fill factor, Equivalent circuit, Voc, Isc and Load resistance, Spectral response. Reverse saturation current in photodetector

Course Outcomes:

After the completion of course, students will be able to

CO1: Explain the atomic structure of solids and the basic physics of semiconductor materials.

CO2: Describe various properties of semiconductor materials using mathematical equations.

CO3: Apply the knowledge of semiconductors to illustrate the functioning of the different electronic devices.
CO4: Evaluate the performance of the different electronic devices
CO5: Describe the working and design considerations for the various photonic devices.

Text Books:

1. Streetman, B. and Banerjee, S., Solid State Electronics, Prentice Hall India, (2006)
2. Sze, S.M., Physics of Semiconductor Devices, John Wiley, (1981)

Reference Books:

1. S. Dimitrijev,Principles of Semiconductor Devices, Oxford University Press,2005
2. M.S.Tyagi,Introduction to Semiconductor Materials and Devices, Wiley Student Edition