EC808 Semiconductor Physics Devices and Circuits 3-0-0-3

Learning Objectives

LO1: To enable understanding of the fundamental concepts of Solid-State Physics and Quantum Mechanics that govern semiconductors

LO2: To provide fundamental knowledge on electron transport and working principes of PN junctions and three terminal devices such as BJT and MOSFETs

LO3: To enable analysis and design of semiconductor devices (electrostatics and current-voltage characteristics) from fundamental principles.

Course Outcomes

CO1 Ability to demonstrate knowledge in Solid State Physics and Quantum Mechanics

CO2 Ability to apply concepts of device physics on the working principles of devices.

CO3 Ability to analyze device characteristics in detail using concepts from quantum mechanics and solid-state physics.

CO4 Ability to evaluate the device performance vis-à-vis suitable selection and optimization of Nano-electronic Materials.

Skills Acquired: Design, apply, analyze, and optimize the electrical and electronic characteristics of. Novel Semiconducting Nanomaterials towards advancement of two-terminal and three-terminal Electronic Devices

<u>Syllabus</u>

Unit 1: (15 hours)

Introduction to Semiconductor materials, Crystal Structure of Silicon and GaAs – Planes – directions - planes and planar atomic densities - Unit cell characteristics - Review of Quantum Mechanics – Dual Nature of Light and Electrons - Bohr model of atom, Uncertainty Principle - Time dependent and Time independent Schrodinger Wave equation - Infinite Potential well problem - Step Potential Function - Tunneling. Introduction to Energy Bands; Fundaments of Band Structure; Band Structure and Fermi-Dirac Distribution; Density of States.

Unit 2: (15 hours)

Doping and Intrinsic Carrier Concentration; Equilibrium Carrier Concentration; Temperature Dependence of Carrier Concentration; Doping Effects and Incomplete Ionization; Carrier Scattering and Mobility; Low-field and high-field Transport; Introduction to Diffusion; Drift diffusion and Trap statistics; Current Continuity Equation. Introduction to p-n Junction; Application of p-n Junction; Breakdown of Junction and CV Profiling; p-n junction under Equilibrium and under Bias; Generation and Recombination currents in p-n junction;

Unit 3:
Introduction to Schottky junction under Equilibrium and Bias; Introduction to Transistors - BJT; Working of BJT; Introduction to MOS: Capacitance-Voltage; MOSFET: An Introduction; Channel Approximation and Derivation of I-V Characteristics; Short Channel Effects in MOSFETS; Introduction to Compound Semiconductors; Basics of Heterojunctions; Band Diagram of Heterojunctions; Heterojunction Transistors; Basics of Nano-Electronic Materials and Devices.

References

1. Ben G. Streetman and Sanjay Kumar Banerjee, *"Solid State Electronic Devices",* Prentice Hall India, Sixth Edition, 2009.
2. Donald A. Neamen*, "Semiconductor Physics and Devices: Basic Principles",* McGraw-Hill International, Third Edition, 2003.
3. S. M. Sze and Kwok K. NG, *"Physics of Semiconductor Devices"*, John Wiley and Sons, Inc., Third Edition, 2007.
4. R S Muller and Theodore I Kamins with Chan, "*Device Electronics for Integrated Circuits*" Third Edition, John Wiley & Sons, 2002.
5. Parasuraman Swaminathan, *Semiconductor Materials*, *Devices, and Fabrication*, Wiley 2019.

Evaluation Pattern

Internal Component: 50

Periodical 1 – 15 marks

Periodical 2 – 15 marks

Continuous Assessment – 20 marks - Quizzes and Assignments

External Component: 50 marks

End Semester Examination – 50 marks