M3PHY04-ET02D: Semiconductor Physics and Devices

(Note: At the beginning of the semester, students must be provided: Detailed lecture schedule of topics to be covered in each lecture, tutorial topics, clearly defining chapters/ section of reference books followed, link to web resources etc. Examiners are expected to take into consideration the lecture schedule while setting the question papers to ensure questions are set within the scope of the syllabus)

External: 80 Marks Internal: 20 marks
Lectures: 40hrs Tutorials: 10hrs

Additional Contact Hours: 10 (seminars, quiz, assignments, group discussion etc.)

Unit-I (8L)

Semiconductor Concepts and Energy Bands; energy band diagram, semiconductor statistics, extrinsic semiconductors, compensation doping and degenerate and non-degenerate semiconductors, Direct and indirect bandgap semiconductors
Carrier Transport Phenomena: Carrier drift and diffusion. Graded impurity distribution
Semiconductor process technology; MBE and MOCVD

Unit-II (8L)

Non-equilibrium excess carriers in semiconductors: Carrier generation and recombination, Characteristics of excess carriers, Ambipolar transport, Quasi-Fermi energy levels, Excess carrier lifetime; Shockley-Read-Hall theory of recombination,
pn Junction Principles; open circuit, forward and reversed bias, Depletion layer capacitances Recombination lifetime
Metal-semiconductor junctions; ohmic and non-ohmic contacts

Unit-III (8L)

Bipolar Transistors: Bipolar transistor action and minority carrier distribution
Field Effect Transistors: JFET; concept and characterization, MOSFET; two terminal MOS structure, energy band diagrams, depletion layer thickness and work function differences
Light-Emitting Diodes: Principles and device structure, Homojunction and Heterostructure LEDs, LED characteristics

Unit-VI (8L)

Principle of the Laser diode, Heterostructure laser diodes, Elementary laser diode characteristics, Steady state semiconductor rate equations, Quantum well devices
Photodetectors: Principle of the pn Junction Photodiode, Quantum efficiency and responsivity, pin Photodiode, Avalanche photodiode, Phototransistors, Photoconductive detectors and Photoconductive gain

Unit-V (8L)

Photovoltaic Devices: Solar energy spectrum, Photovoltaic device principle, Photovoltaic I-V characteristics; photocurrent and quantum efficiency, dark current, open circuit voltage, short circuit current, Fill factor and efficiency, Effect on p-n junction characteristics; irradiation, temperature, band gap and parasitic resistance, Depletion approximation, Calculation of carrier and carrier densities, General solution for J (V), p-n junction in dark and under illumination

Tutorials (10 hrs)

Examples and problems from Text books will be listed in the Lecture schedule as Tutorials and assignments

Text books:

1. S. O. Kasap; Optoelectronics and Photonics: Principles and Practices, Pearson 2009
2. Donald A. Neamen and Dhrubes Biswas; Semiconductor Physics and Devices, 4th edition, McGraw Hill, 2003.
3. Jenny Nelson; The Physics of Solar Cells, 1st edition, Imperial College press, 2003.

Reference books:

4. S.M. Sze; Semiconductor Device Physics and Technology, John Wiley and Sons, 2002.
5. Ben. G. Streetman and Sanjay K. Banerjee, Solid Sate Electronics Devices, 7th edition, PHI, 2014.
6. T. Markvart and L. Castaner; Solar Cells: Materials, Manufacture and Operations, Elsevier, 2005.