EP-505 Semiconductor Devices

L T P	Credits
3 1 0	4

UNIT I:

Introduction to the Quantum theory of solids: Allowed and forbidden Energy bands, Electrical conduction in solids, density of state function, Semiconductor in Equilibrium: Equilibrium carrier concentration, intrinsic semiconductor, extrinsic semiconductor, Position of Fermi energy level.

UNIT II:

Carrier transport phenomenon: Random motion, Drift and diffusion, Graded Impurity distribution, Excess carriers: Injection level, Lifetime, Direct and indirect semiconductors, P-N Junction: Device structure and fabrication, Equilibrium picture, DC forward and reverse characteristics, Small-signal equivalent circuit, Generation – Recombination currents, Junction Breakdown, Tunnel diode

UNIT III:

Bipolar Junction Transistor: History, Device structures and fabrication, Transistor action and amplification, low frequency, common- base current gain, Small-signal Equivalent circuit, Ebers-Moll model MOS Junction: C-V characteristics, threshold voltage, body effect Metal Oxide Field Effect Transistor: History, Device structures and fabrication, Common source DC characteristics

UNIT IV:

Small-signal equivalent circuit, Differences between a MOSFET and a BJT Junction FET and MESFET: Basic pn JEFT & MESFET operation, Device characteristics, Recent Developments: Hetero-junction FET, Hetro-junction bipolar transistor Optical Devices: Solar Cells, Photodectectors, LEDs

Text Books/Reference Books

1. Physics of Semiconductor Devices by Ben G. Streetman
2. Physics of Semiconductor Devices by M.Shur
3. Semiconductor Devices by Kittel
4. Integrated Electronics by Millman and Helkias

Electrical conduction in Solids.

- Classical free electron theory (Drude & Lorentz 1900)
- Quantum free electron theory (Sommerfeld 1928).
- Zone theory (Band theory of Solids)
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  Block in 1928.

Classical free electron theory

postulates

- Electrons moves around the nucleus of an atom and a metal is a composition of such atoms.
- Collection of valance electrons forms a gas called electron gas and electrons can move at random in electron gas
- Such electron collision with other electrons (or) Lattice atoms comes under elastic and there is no loss in energy.
- The motion of such electrons obeys classical (i) Kinetic theory of gases
  (ii) Maxwell's - Boltzmann distribution
- Such free electrons moves in a completely uniform potential field produced by ions of the lattice.
- When subjected to an electric field, free electrons moves/ accelerates in opposite direction of the applied electric field.

Electrical conduction.

e^- $\qquad \xleftarrow{\quad E \quad}$

According to Newtons 2nd law $F_R = F_{accelerate} - F_{Retention}$

$$m\frac{dv}{dt} = -eE - \frac{mv}{\tau}.$$

under steady-state condition $\frac{dv}{dt} = 0$

$$\Rightarrow -eE = \frac{mv}{\tau}$$

$$\Rightarrow v_d = \frac{-e\tau E}{m}. \qquad (v = v_d).$$

where v_d is called drift speed.

If 'n' is no. of conduction electrons per unit volume, then charge per unit volume $= ne$.

Charge crossing per unit area & unit time is called current density 'J'.

$$\therefore J = (ne)v_d. = (ne)\left(\frac{-e\tau E}{m}\right)$$

$$\boxed{J = \frac{ne^2\tau E}{m}}$$

We know that $J = \sigma E$

$$\boxed{\therefore \sigma = \frac{J}{E} = \frac{ne^2\tau}{m}.}$$

Success of classical free electron theory

- It explains Ohm's law
- It explains electrical and thermal conductivity of metals.
- It explains optical properties of metals.

Failures:

- photoelectric effect, compton effect & Black body radiation can not be explain
- Specific heat of metals cannot be explained
- conductivity of semiconductor's and Insulator's can not be explained.
- Ferromagnetism cannot be explained.