EI-27003: Electronics Devices and Circuits

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LECTURE - 1

Year: 2020-21

Scheme of Examination

- Theory:

CW	Max	Min	End Sem	Max	Min
	30	--		70	22

CW (30)= Avg. of two test (15) + five Assignments (10) + Attendance (5)

- Practical:

SW	Max	Min	End Sem	Max	Min
	40	--		60	18

SW (40)= Performance of 8 experiments (20)+ Journal(10)+Viva(10)

Syllabus

- ## Unit-I: Basics of Semiconductor:

  Types, Mobility, current densities, EK-diagram, Hall effect, Continuity equation, drift, diffusion current, generation and recombination, minority charge carriers.

  pn junction diode, VI characteristics, diode current equation, resistance and capacitances of diode, Types of diodes: Zener, tunnel, Varactor, Schotky, LED, Photodiode.

- ## Unit-II: Diode and Transistor Circuits:

  Clippers, Clampers, Rectifiers and filters, Models of diode, Bipolar junction transistor (BJT), Potential profile in PNP & NPN structures, Current components, Configurations, Early Effect, Eber's Moll Model, Transistor as an amplifier, Biasing & Thermal Stabilization, The Q point stability, Stabilization against variation of I_{CO}, V_{BE}& β, Bias compensation, Millers theorem and its dual, Thermal runway, Schottky and Photo-transistors.

- ## Unit-III:BJT Modeling and Introduction to FET:

  Hybrid model, Simplified model, Common emitter with emitter resistor, high i/p impedance circuits, Emitter follower, comparison of CB, CE, CC configuration, Darlington pair, Bootstrapping, Cascode Amplifier, Field effect transistors(FET), JFET, pinch off, V-I Characteristics, Small signal model, MOSFET, Derivation for drain current I_D for E-MOSFET, Threshold voltage and body effect, CS & CD amplifiers, Biasing techniques, FET as VDR,

Syllabus ….

- Unit-IV: MOS Structure and Effects….

  Band diagram for a MOS junction under accumulation, Depletion & inversion, MOS capacitor, C-V of an ideal & non- ideal capacitors, Characterization of MOS capacitors, MOS field effect transistor (MOSFET) V-I characteristics in three regions of operation & equivalent circuit. Short channel MOSFET: Effect of scaling of MOSFET, Short & narrow channel effects on V-I characteristics, Hot electron effect in MOSFET, **Modeling of MOS transistor level-I, BISIM3**

- Unit-V: Silicon Processing :

  Silicon Planar technology, Oxidation, Diffusion, Metallization, Ion-Implantation & chemical vapor deposition, Lithographic process, Typical Bipolar & MOS IC process sequence, Silicon controlled Rectifier, Holding and Latching current, di/dt triggering and other triggering methods &**Unijunction Transistor (UJT) and UJT relaxation oscillator.**

Text and Reference Books

1. Jacob Millman& Christos C. Halkias Electronic Devices & Circuits McGraw-Hill 1967.
2. Robert L. Boylestad, Electronic devices and Circuits, PHI.
3. Ben G. Streetman, Solid State Electronics Devices, Prentice Hall of India, 5th edition.
4. S. M. Sze, Physics of Semiconductor Devices, Wiley-Interscience, 1969.
5. Sedra& Smith L, Electronic circuits, McGraw Hill.

Unit-I:Basics of Semiconductors

- Definition
- Basic def. : is one whose conductivity lies between conductor and insulator

- One step Up : Is one in which Band Gap is greater than conductor but less than insulator.

- Alternately and more correctly : is one whose valence is four

Types of Semiconductors

- 1. Elemental Semiconductors
- 2. Compound Semiconductors

➢ Semiconductor materials are found in column IV and neighboring columns of periodic table

- Column IV semiconductors, Silicon (Si) and Germanium (Ge) are called ***Elemental*** semiconductors as they are composed of single species of atom.

- Compounds of column III and column V atoms as well as column II and column VI, make up ***intermetallic*** or ***compound*** semiconductors.

Portion of Periodic Table - semiconductors occur

Sr. No	**II**	**III**	**IV**	**V**	**VI**
1		B	C		
2		Al	Si	P	S
3	Zn	Ga	Ge	As	Se
4	Cd	In		Sb	Te

Elemental and Compound Semiconductors

Elemental	IV compound	Binary III-V compound	Binary II-VI compounds
Si	SiC	AlP	ZnS
Ge	SiGe	AlAs	ZnSe
		AlSb	ZnTe
		GaP	CdS
		GaAs	CdSe
		GaSb	CdTe
		InP	

Elemental Semiconductors

- Intrinsic Semiconductors
- Extrinsic Semiconductors

- Semiconductors in its purest form are Intrinsic Semicond. Si and Ge are intrinsic semiconductors.

OR

- Semiconductor with no impurities or lattice defects is called intrinsic semiconductor.
- In such materials there are no charge carriers at 0K, since valence band is filled with electrons and conduction band is empty.
- For intrinsic semiconductors

$$n=p=n_i$$

Elemental Semiconductors

- Intrinsic Semiconductors
- Extrinsic Semiconductors

- Extrinsic Semiconductors: Semiconductors doped with specific impurities.
- Doping: Process of adding impurities to intrinsic semiconductors is called Doping.
- Extrinsic Semiconductors are also called as doped semiconductors.
- Commonly used dopants: Trivalent atoms and Pentavalent

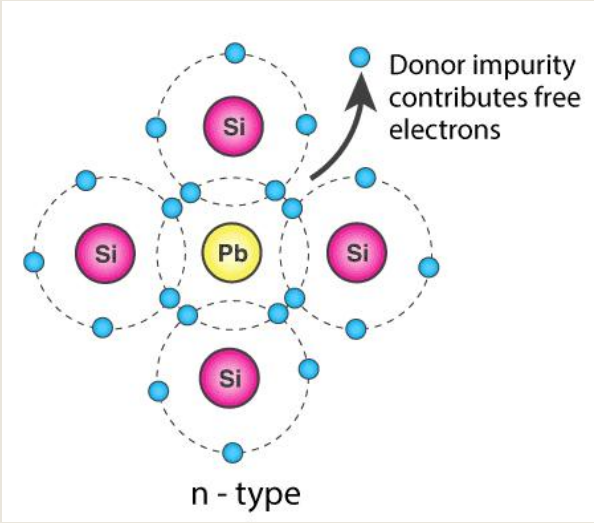
Trivalent Impurities: Indium(In), Aluminium(Al) and Boron(B)

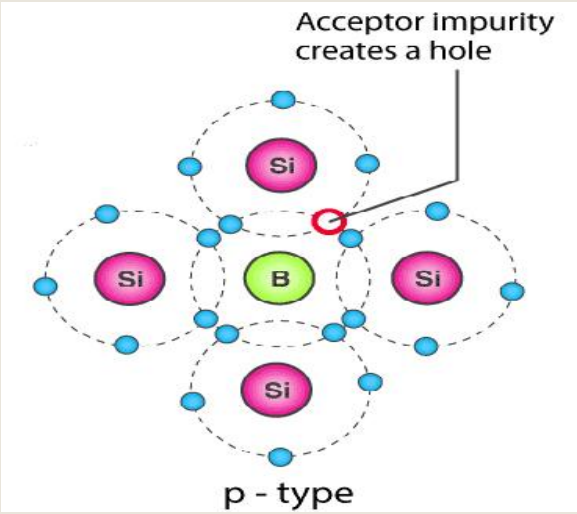
Pentavalent Impurities: Arsenic(As), Phosphorous(P), Antimony(Sb).

Extrinsic Semiconductors -Types

- N-type semiconductor
- P-type semiconductor

- N-type: When Si or Ge is doped with pentavalent impurities like As, P, Sb
- P-type: When Si or Ge is doped with trivalent impurities like Al, In, B



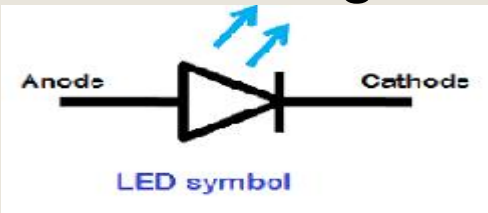


Applications

- Elemental Semiconductors Si and Ge are used in transistors, rectifiers and Integrated circuits.
- Compound semiconductors are widely used in high speed devices and devices requiring the emission or absorption of light.
- Binary III-V compounds such as GaAs and GaP are commonly used in light emitting diodes (LEDs).
- Binary II-VI compounds such as ZnS commonly used as Fluorescent materials in TV Screens
- Light detectors are commonly made with InSb, CdSe or other compounds such as PbTe and HgCdTe.

LED and Photodiode

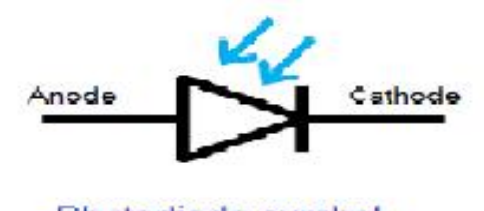
- Important characteristics of Semiconductor is its: energy band gap
- This property determines among the other things, the wavelength of light that can be absorbed or emitted by semiconductor.
- Semiconductor compounds from III-V, when operated in proper biasing condition emits light. E.g. LED



LED symbol

- Semiconductor compounds from II-VI, when operated in proper biasing condition absorbs light and generate electric current.

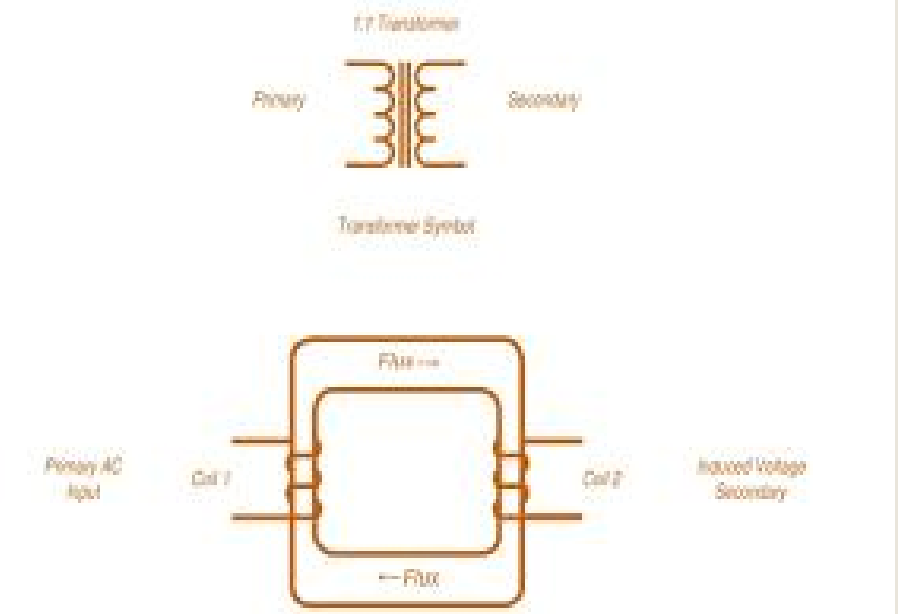
  e.g. Photodiode



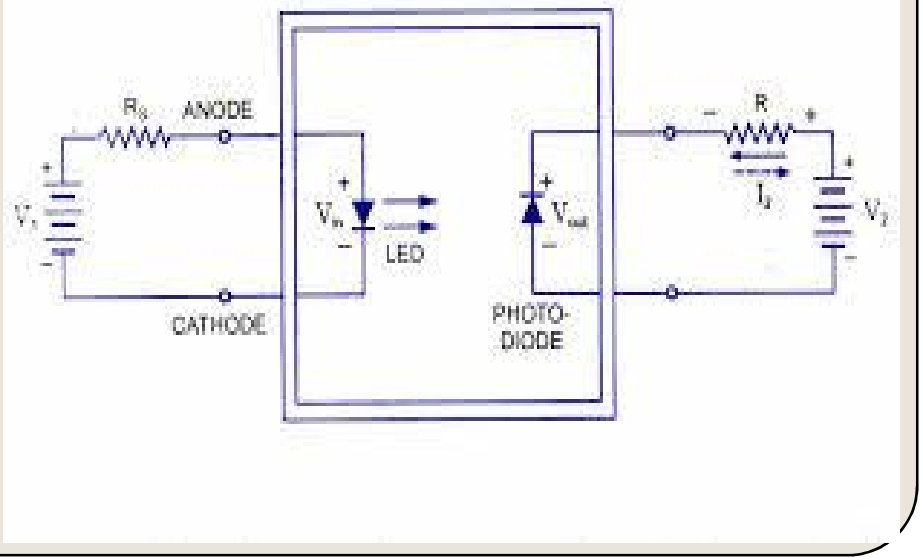
Photodiode symbol

Applications continued…

- Pulse Transformer:
  - Called as Electrical isolator
  - Used to isolate low voltage output from high Voltage input.
  - Turns ratio of unity (1).



- Opto-Isolator:



Next Lecture…

- Semiconductors can further be classified as:

- Direct Semiconductors
- Indirect Semiconductors

Thank You