ANALOG ELECTRONICS [redacted]

PN JUNCTION DIODE

⇒ When a P-type semiconductor is joined to a N-type semiconductor, the contact surface is called PN junction or PN diode.

⇒ The voltage across PN junction can be applied in two ways.

i) Forward Biasing

ii) Reverse Biasing.

⇒ Formation of PN junction

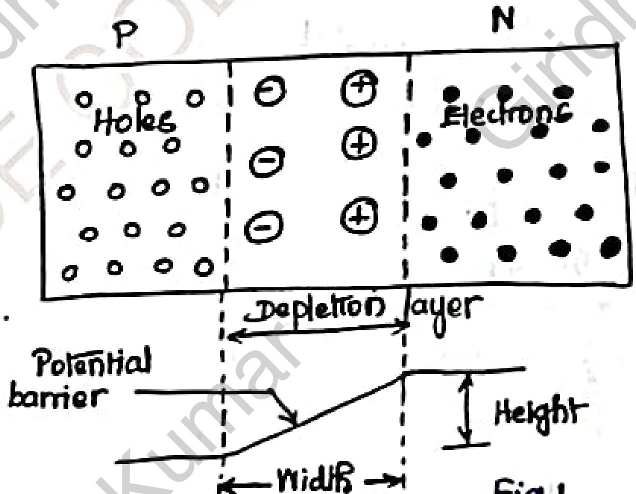


Fig 1

The n-type material has high concentration of free electrons and p-type material has high concentration of holes.

⇒ At the junction, there is a tendency for the free electrons of the n-type to diffuse over to the P-side and holes from the P-side to the N-side.

⇒ This process is called diffusion.

⇒ A barrier is set up against further movement of charge carriers (holes and free electrons) - called Potential barrier or Junction barrier (V_B)

⇒ V_B is of the order of 0.1 V to 0.3 V

⇒ As the mobile charges have been depleted in this region it is called depletion layer

i) ZENER BREAKDOWN

⇒ The breakdown using heavily doped P and N regions, direct rupture of covalent bonds takes place because of the strong electric field at the junction of the PN diode.

⇒ The new electron-hole pairs so created increase the reverse current in a reverse biased PN diode.

⇒ Due to heavy doping of p and n regions, the depletion region width becomes very small and for an applied reverse bias of 6V or less.

⇒ The field across the depletion region becomes very high of the order of 2×10^7 V/m.

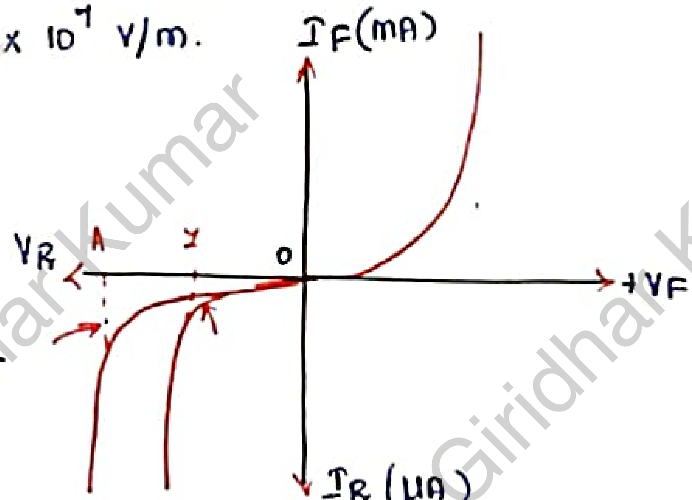


Fig 2: Breakdown in PN junction diode.

ii) AVALANCHE BREAKDOWN

⇒ In reverse biased diode, a thermally generated carriers falls down the junction barrier and acquires energy from the applied voltage.

⇒ The sufficient kinetic energy to disrupt a covalent bond, at this carrier collides with crystal. - known as impact ionization.

⇒ A new electron-hole pair created, in addition to the original carrier. - The new carriers in turn, acquire enough energy from the applied field - collide with another crystal ion and create still another electron-hole pair. - this is a cumulative process and is known as avalanche multiplication.

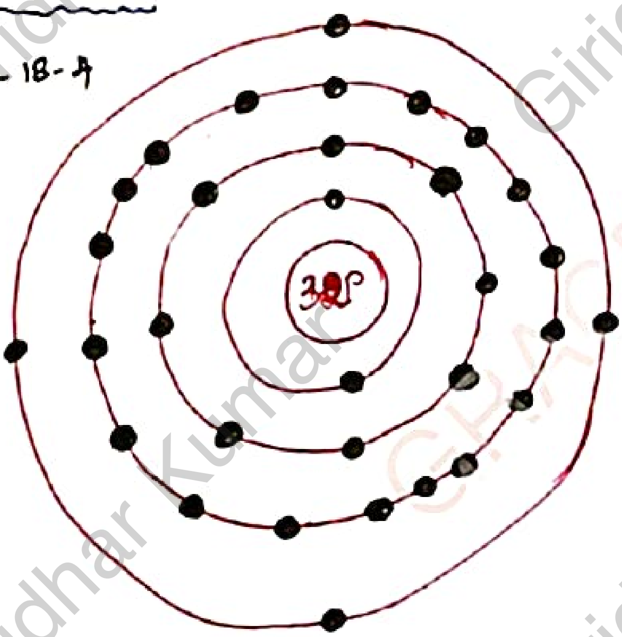
Types of Materials

- Conductor
  - eg: silver, copper, Gold, Aluminium.
- Semiconductor
  - conductivity changed by adding impurities
  - Si, Ge, GaAs.
- Insulator.
  - eg: Wood, Glass, Teflon.

Silicon - 14 electrons are arranged in the order $2n^2$. n - orbit number.

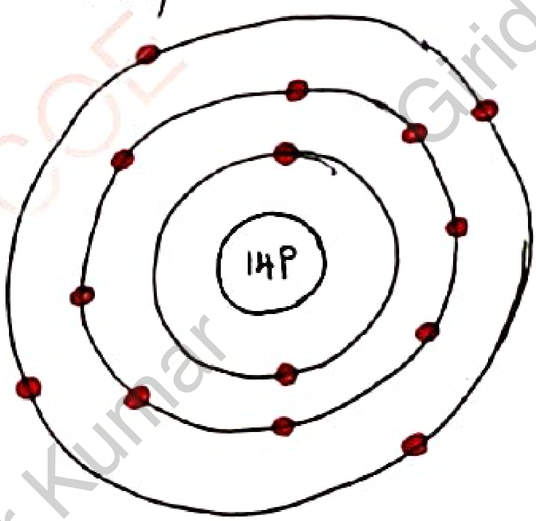
Germanium - 32

2-8-18-4



Silicon - 4

2-8-4



Two types of flow in semiconductor

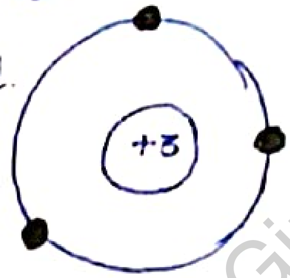
1) Flow due to electrons
2) Flow due to holes

Semiconductor

- Intrinsic
- Extrinsic
  - → p-type
  - → n-type

Doping - process of adding impurities.

⇒ can change the electrical properties of material.

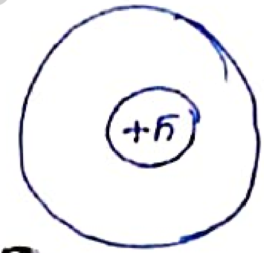


Trivalent atoms → Aluminium, Boron, Gallium

- p-type semiconductor

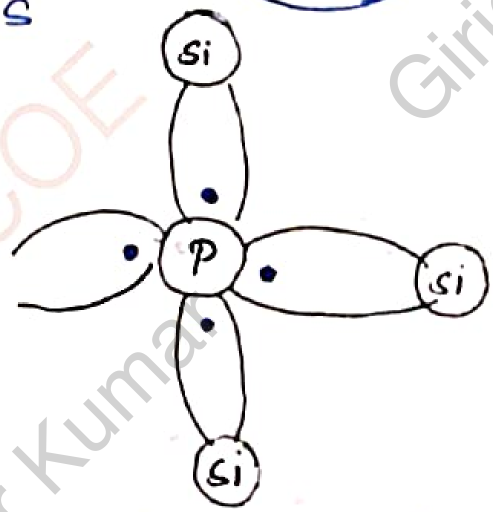
⇒ every trivalent atom creates 1 hole.

⇒ those trivalent atoms → acceptor atom.



Pentavalent atom → Arsenic, Antimony, Phosphorus

n-type semiconductor.



⇒ This process creates excess unbond electrons in conduction band.

Energy level - range of energies that an electron may possess in an atom.

Energy band - The electrons in the same orbit exhibit different energy levels. The grouping of this different energy levels is known as energy band.

Types of energy bands

1) Valence band $E_g = 0$

2) conduction band $E_g \approx 4V - 8eV$

3) Forbidden band $E_g > \cancel{5eV}$

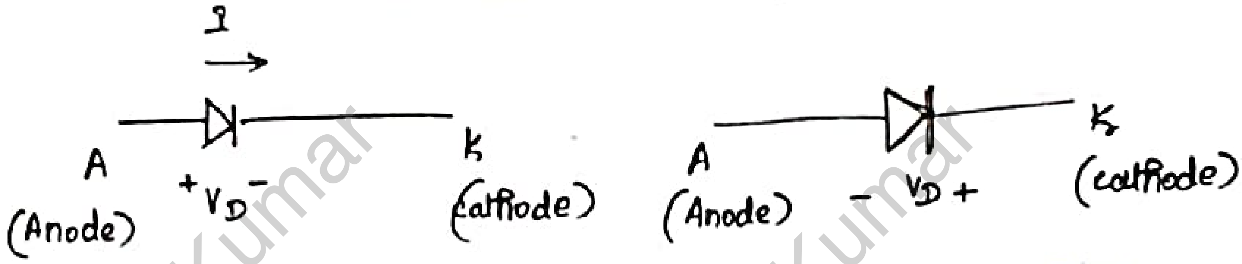
Conductor

Insulator

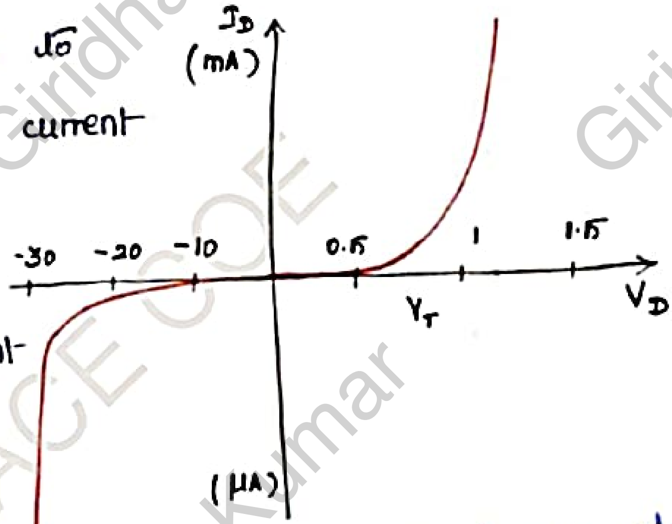
Semiconductor 0.1 - 3eV

The result is a large reverse current at an almost constant voltage drop and avalanche breakdown takes place.

4.2. V-I CHARACTERISTICS OF A DIODE



a) Forward Bias b) Reverse Bias



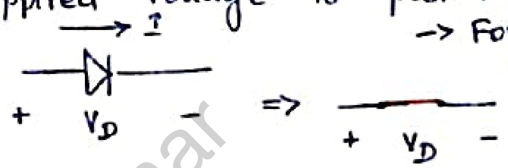
=> V-I characteristics helps to analyze the voltage and current in the diode.

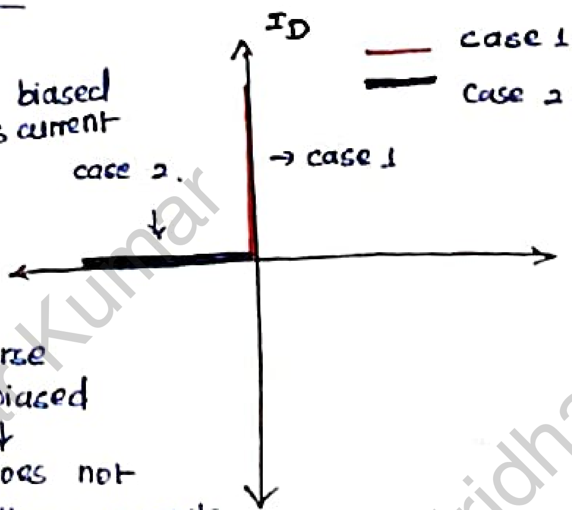
=> We know that the resistor is a linear element and hence the V-I characteristic is also linear.

=> Unlike, the resistor, the diode is a non-linear element and hence the V-I characteristic is also non-linear.

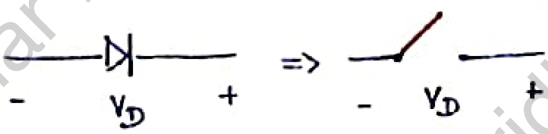
=> V-I characteristic of Ideal diode

case 1: Applied voltage is positive
→ Forward biased
allows current





case 2: Applied voltage is negative,
→ Reverse biased
↓
does not allow current.



=> Ideal diode starts conducting current in the Forward bias condition even when a very small voltage of 0.1 V is applied