Lecture-4

2. P-n Junction

2.0 Introduction: If a junction is formed between a p-type and a n-type semiconductor this combination is known as p-n junction diode and has the properties of a rectifier.

2.1 Formation of P-n Junction: p-n junction diode can be formed by different methods and according are known as

(a) Grown- Junction (b) Alloyed Junction or

(C) Diffused Junction type

(a) Grown- Junction : If donor impurities are introduced into one side and acceptor impurities into the other side of a single crystal at the time of crystal growing from a melt of silicon or germanium then a grown junction is formed . (See Fig. 2.1)

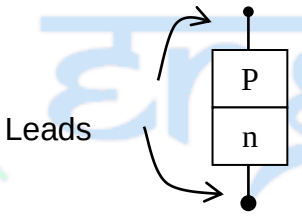


Fig. 2.1 Grown Junction

(b) Alloyed Junction: Allow type is made by melting a small pellet of induction on a slice of n-type germanium (or silicon). The molten indium (trivalent) is produced a p-type material. The area where pellet of indium is in contact (see Fig. 2.2) n-type material is the alloy junction (see Fig. 2.2)

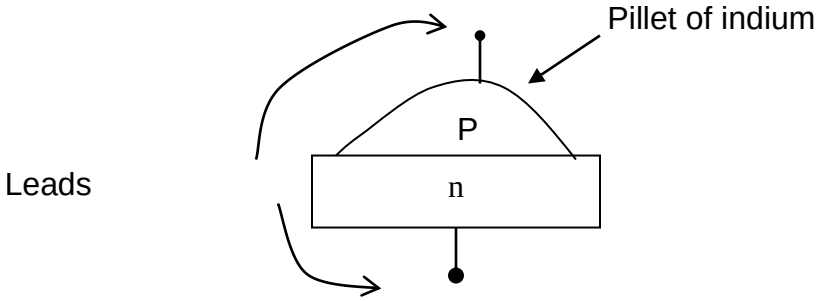
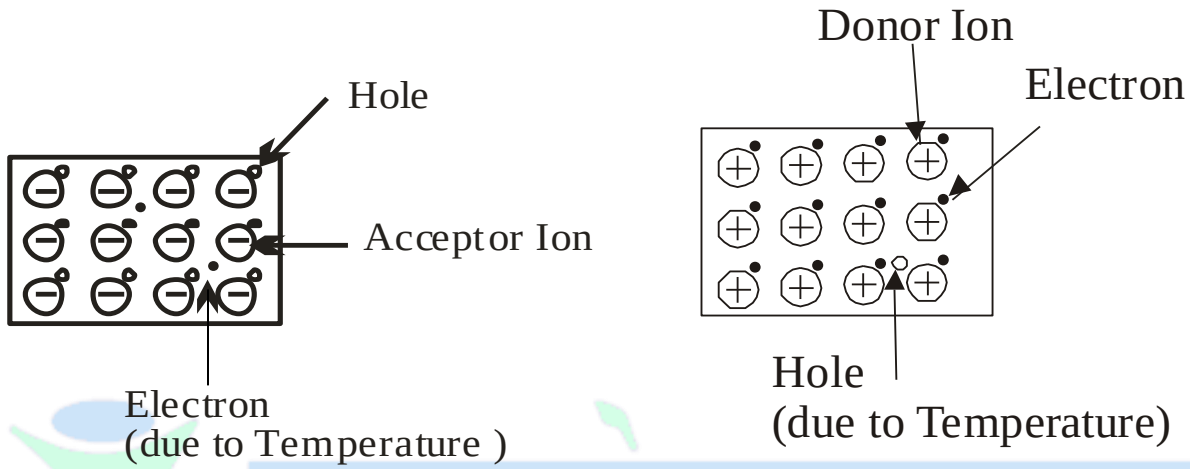


Fig. 2.2 Alloyed Junction

(C) Diffused type: In diffusion process a wafer of semiconductor material (say p-type) is exposed to a gas of impurity material (say n-type). The atoms of the impurity material diffuse into the semiconductor material to from a p-n junction.

2.2 Open –circuited P-n junction :

As we know in p- type semiconductor material the possible charge particles are holes due to doping of acceptor ions, may be electrons due to temperature (see Fig. 2.3a)



(a) p-type **(b) n-type**

Fig. 2.3

Similarly n-type semiconductor consist of electrons due to doping of Donor Ions and holes due to temperature (see Fig. 2.3 b) On formation of P-n junction on one side of the P-n junction, there is the P-type and on the other side is the n-type material.

Fig 2.4 shows a P-n junction “Just formed” where the P-side of the junction shows the holes and the acceptor ions and the n-side of the junction shows the electron and the donor ions.

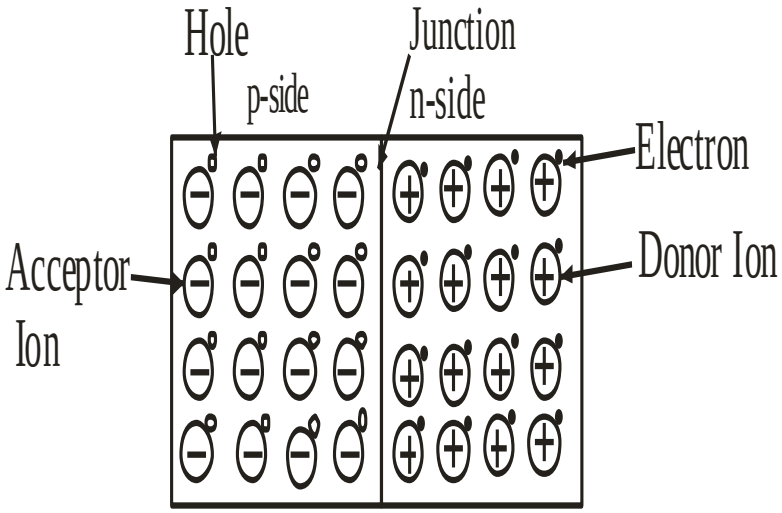


Fig. 2.4 A P-n Junction, "just formed"

1 2.2.1 Space Charge Region :

Since initially there exist large concentration of holes on the left hand side of the junction and very little of them on the right hand side, the holes will initially diffuse across the junction from L.H.S. to R.H.S. similarly electron will diffuse to the L.H.S. from R.H.S. These diffused holes and electron will recombine, and as a result the ions next to the junction will not have their accompanying mobile charges. Thus these ions will be uncovered charges. Fig 2.5 shows the situation after the initial diffusion has taken place.

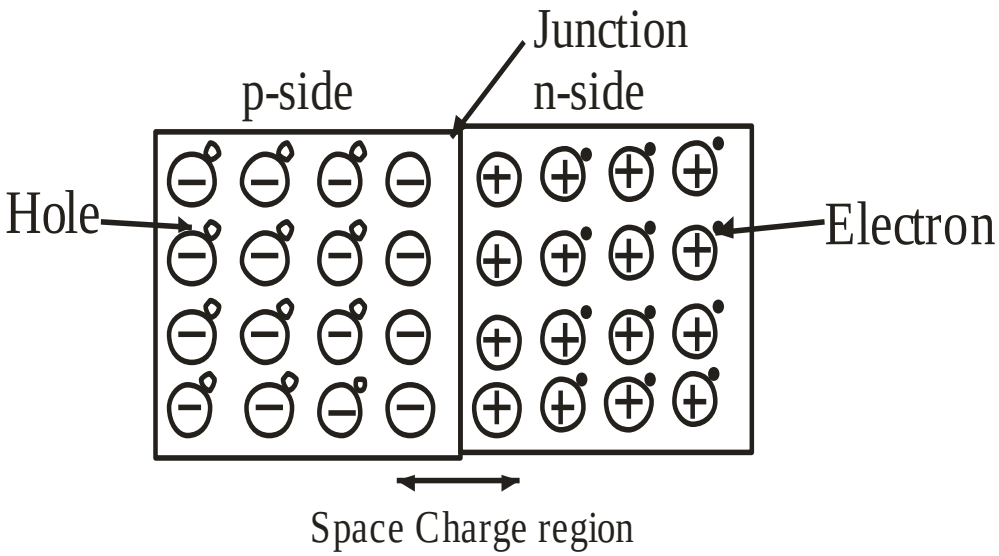


Fig 2.5 after Initial Diffusion

We note that on immediate either side of the junction there exist uncovered charges. This region is called depletion region (since is depleted of mobile charges) or space charge region or transition region. Due to uncovered ions at the junction, potential barrier will be developed. The movement of holes from p to n side will be blocked by uncovered donor ions on n side and movement of electron will be blocked by uncovered acceptor ions on p-side.

Thus, under open circuit condition, there is no more flow of holes or electrons across the junction and hence current through the junction (and hence through the diode) is zero.

2.3 P-n Junction Diode Under Biasing Condition:

Biasing of any device means application of voltage source across it to perform in required manner. If we have to made a diode in conducting manner we bias a diode in forward bias condition otherwise in reverse bias condition.

2.3.1 Forward Bias: Forward biasing of diode means application of higher voltage to p-type semiconductor and lower voltage to n-type semiconductor. A important point to be noted is that the applied voltage across diode should be in the range of its cutin voltage.

On application of forward biasing voltage across p-n junction Diode the holes available near the ohmic contact starts drifting towards junction, velocity of holes start decreasing due to repulsive force by donor ions on n-side at the junction.

On reaching near the junction the velocity of hole may be reduced to zero, it depends on applied voltage. But definitely at any voltage velocity of hole at junction will be lower than velocity at ohmic contact.

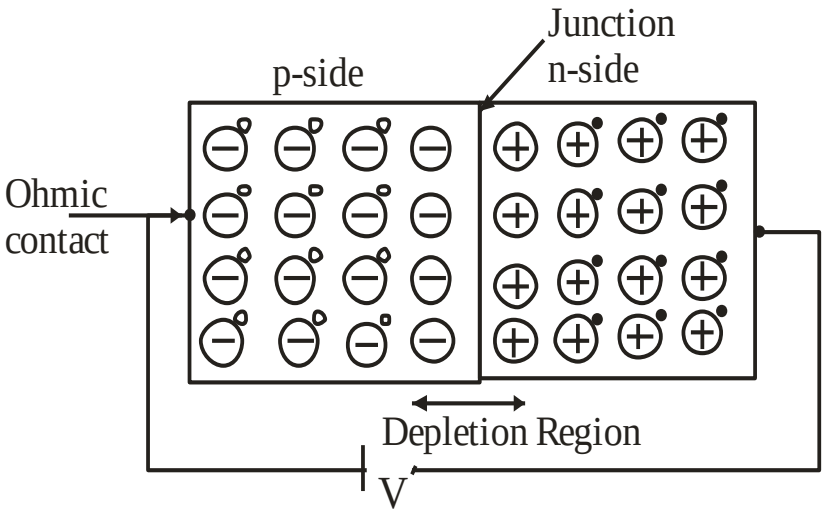


Fig 2.6 (Forward Biasing of Diode)

It means on application of voltage source V. across diode the holes available in P-side will start drifting from ohmic contact to junction. But the velocity of drifting will decrease from ohmic contact to p-n junction. Hence we can say the drift current will be maximum at ohmic contact but will be decreasing on moving towards junction. At the junction, all holes drifted from the ohmic contact, will be collected. Hence width of depletion region will be reduced on p-side and holes collected at the junction will start diffusion due to concentration gradient from p to n-side.

Similarly due to negative terminal electrons available on n-side will start drifting from ohmic contact to junction and will be collected at the junction due to repulsive force by the acceptor ion. It means drift current due to electron will be maximum at ohmic contact on n-side and will be decreasing on moving towards junction. Hence width of depletion region on n-side will also be decreased and electrons collected at junction will start diffusion from n-side to P-side.