1.3. *p-n* Junction Imp

When a *p*-type semiconductor is brought in close contact to *n*-type semiconductor by suitable means, the arrangement of both the semiconductors is known as *p-n* junction. Thus, a single piece of a semiconductor material (either Si or Ge) whose one portion is doped with *n*-type impurity and the other portion is doped with *p*-type impurity behaves as *p-n* junction (Fig. 9). In fact, the boundary dividing the two halves of such a semiconductor is called a junction and the arrangement is known as ***p–n* junction diode.**

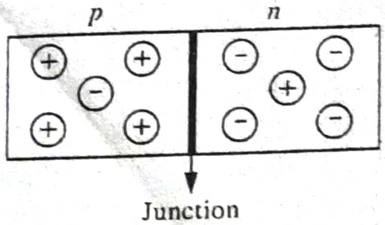
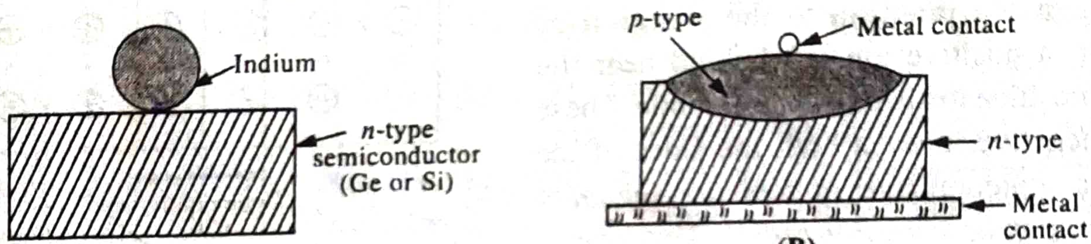


Fig. 9.

Formation of p-n Junction.

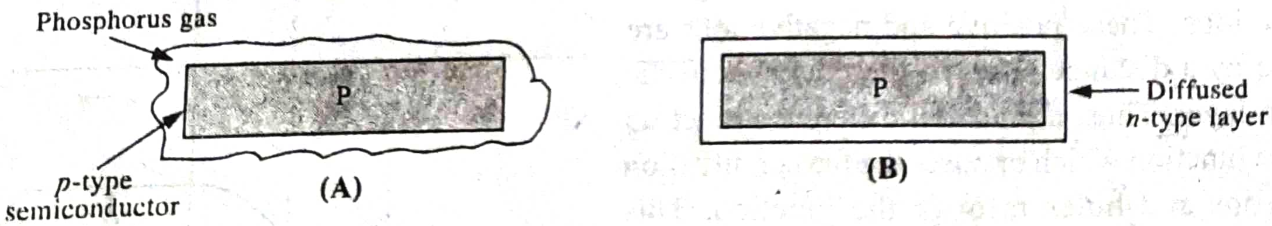
A small sphere of *trivalent impurity say indium* is pressed on a thin ***wafer*** of *n*-type germanium or silicon slab. The system is heated so that the indium fuses to the surface of germanium and produces *p*-type germanium just below the surce of contact (Fig. 10A). This *p*-type alongwith the *n*-type germanium wafer form a *p-n* junction (Fig. 10B). Both the upper and lower portions of the system have metallic contacts. Surface



(A) (B)

Fig. 10.

Similarly a *p-n* junction can be made by diffusion of a pentavalent impurity like phosphorous into a *p*-type semiconductor. In this process, *p*-type semiconductor is heated in phosphorus gas to result into diffused *n*-type layer on the semiconductor (Fig. 11).



(A) (B)

Fig. 11.

Formation of depletion Layer in a p-n junction

There is high concentration of holes in the *p*-region and high concentration of electrons in the *n*-region of *p-n* junction. The holes from *p*-region and electrons from *n*-region diffuse through the junction. The electrons which diffuse through the junction to *p*-region recombine with holes. As a result of this recombination, holes disappear and an excess negative charge appears in *p*-side of the junction.

When holes diffuse through the junction, an excess positive charge appears in n-side of the junction (Fig. 12). The thin region around the junction containing immobile positive and negative charges is known as **depletion layer.**

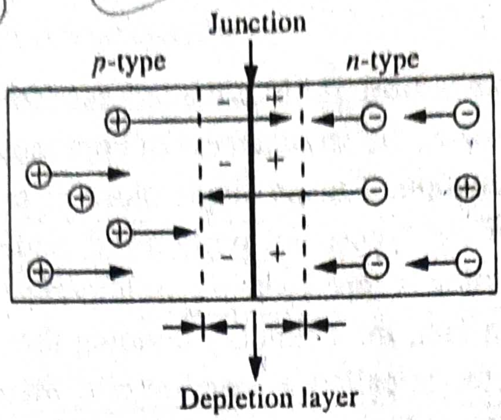


Fig. 12.

In fact, on the p side of a p-n junction, there are negative ions fixed in their positions in the crystal lattice surrounded by holes. When a hole diffuses through the junction to the n-region of semiconductor, a negative ion is left behind near the junction. This negative ion is fixed or immobile. Similarly, on the n side of the p-n junction, there are positive ions fixed in their respective positions in the crystal lattice surrounded by free electrons. When an electron diffuses through the junction to the p-region of semiconductor, a positive ion left behind near the junction. This positive ion is fixed or immobile. These positive and negative ions on both the sides of the junction form a depletion layer or *depletion region* or *space charge region* or *transition region.* This layer is known as depletion layer because it is depleted of free and mobile charge carriers. The thickness of depletion layer is about 10^{-3} mm or 10^{-6} m.

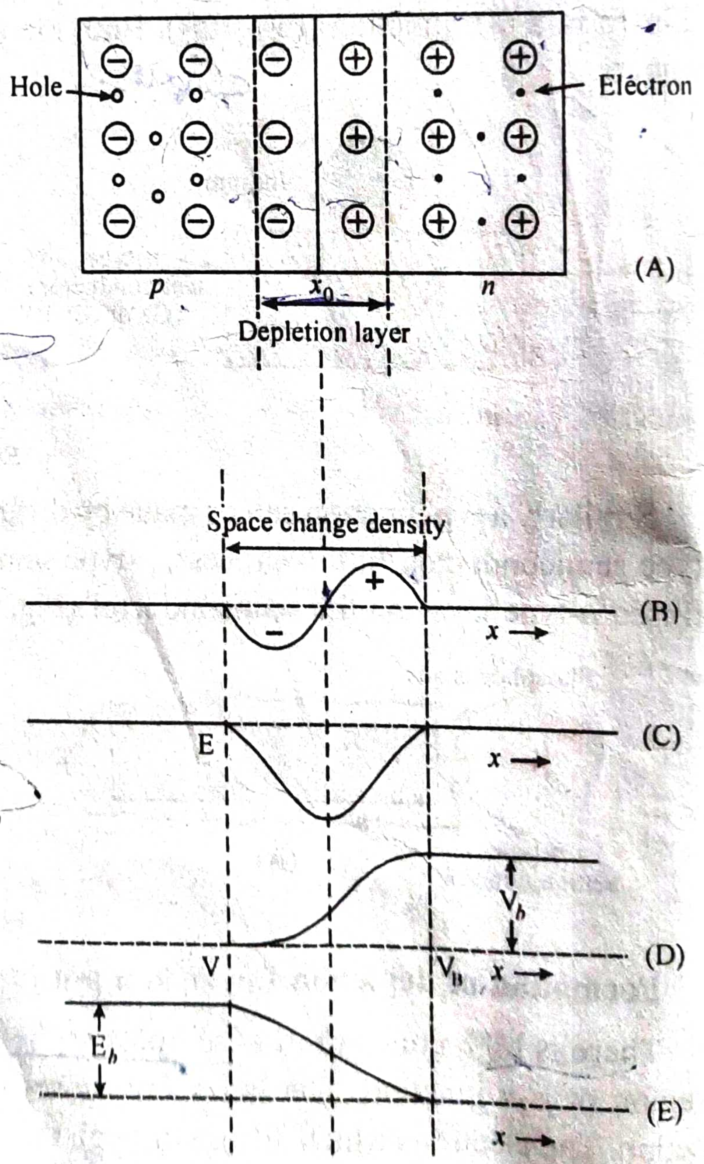


Fig. 13.

Junction Barrier *i.e.* Barrier Potential

The depletion layer contains positive and negative immobile ions. These positive and negative ions are separated by a distance equal to the thickness of the depletion layer. Thus, a potential difference is set up across the junction which opposes the further diffusion of electrons and holes through the junction. This potential difference is called **potential barrier** (V_b) (Fig. 13 A).

Thus, electric field ($\vec{E}$) appears across the junction. This electric field is also known as *barrier field* and it is directed from +ve ions to –ve ions in the