Semiconductor

11/04/19

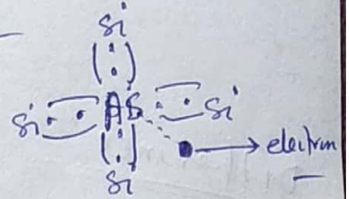
Q. What is n-type and p-type semiconductor give examples.

⇒ n-type semiconductor

If a small amount of pentavalent impurity is doped with pure Ge and Si crystal, then the conductivity increase appreciably, then it is called n-type semiconductor.

Example – Pentavalent arsenic (As) is doped with pure Si.

Explaination :– Doped As has five valence electron which make four co-valent bonds with four neighbouring Si and 5th extra electron is free.

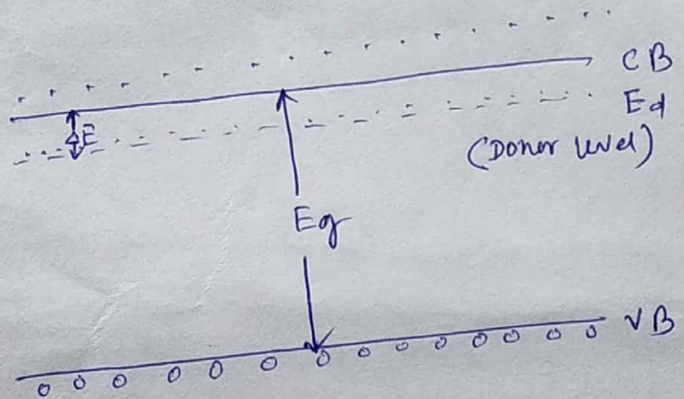


~~Hence electrons and holes~~

Here, Majority charge carriers are ⇒ 'electron'
Minority " " ⇒ "holes".

The impurity is called "donar ion" because the impurity atoms donate electrons to the crystal.

Band diagram

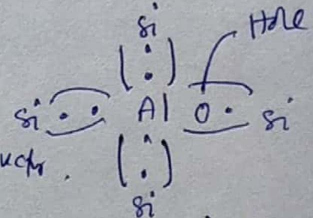


$\Delta E < E_g$

ΔE for Ge = .01 eV
ΔE " Si = .05 eV
E_g for Ge = 0.72 eV
E_g " Si = 1.2 eV

⇒ p-type semiconductor

If a small amount of trivalent impurity is doped with the pure Si or Ge crystal, then the conductivity increase appreciably, then it is called p-type semiconductor.

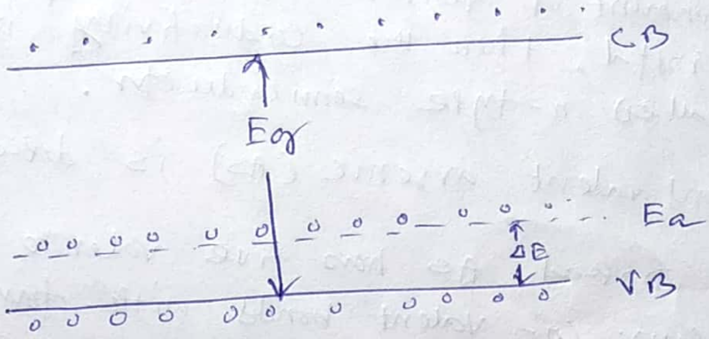


Example : Trivalent aluminium (Al) is doped with pure Si.

Explaination – Doped Al has three valence electrons which make three covalent bonds with 3 adjacent Si but there is a deficiency of electron to make 4th covalent bond with the 4th Si thus create a "hole".

Here majority charge carriers are ⇒ 'holes'
minority " " " ⇒ "electron"
The impurity is called an "acceptor" because the impurity atoms accept electrons from the crystal.

Band diagram



Difference.

p-type	n-type
1. Trivalent impurity is doped	1. Pentavalent impurity is doped.
2. Majority charge carriers – hole.	2. Majority – electron
3. minority — electron	3. minority – hole.
4. impurity is called - acceptor ~~ion~~ ion.	4. Impurity → donar ion.

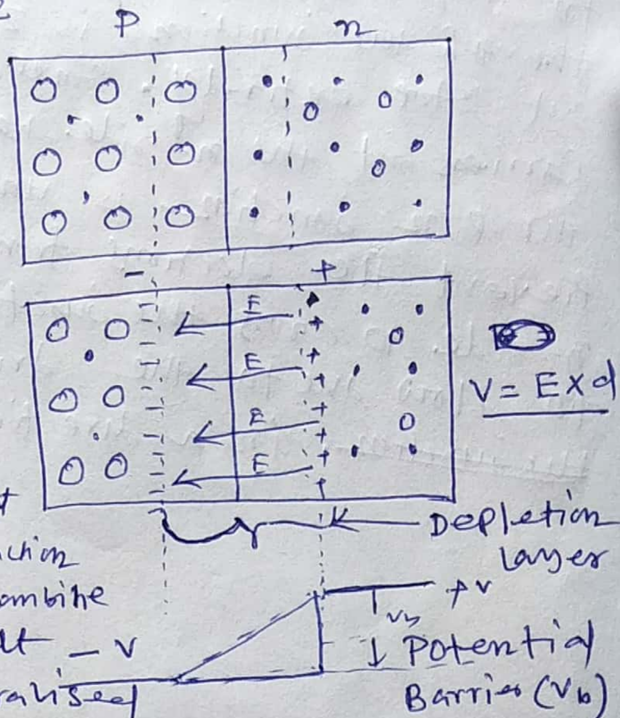
P-n Junction

A single piece of a semiconductor material (Si or Ge) whose one portion is doped with trivalent impurity and the other portion is doped with pentavalent impurity behaves as p-n junction.

Formation or fabrication of p-n junction

(1) Diffusion junction type (2) Growth junction type (3) Alloy junction (4) Epitaxial junction type.

Formation of depletion layer in a p-n junction:-



In the p-region of p-n junction, there are acceptor ions fixed in their positions in the crystal lattice surrounded by holes. In the n-region of p-n junction, there are donor ions fixed in their positions in the crystal surrounded by free electron.
~~In the region~~ The n-type has a large concentration of electrons and ~~a few holes whereas~~ the p-type has a large concentration of holes.
As soon as junction is formed, holes will diffuse through ~~through~~ the junction to the right side and electrons will diffuse through the junction to the left side. These electrons and holes combine with each other. ~~As a~~ ~~Hence,~~ As a result of these diffusing and recombinations unneutralised ions appear in the junction. Since the region around the junction which is depleted of mobile charged carriers, so this region is known as depletion region or space charge region or the transition region.

Potential Barrier:-

Potential Barrier

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). The potential barrier is about 0.7 V for Si and 0.38 V for Ge. The electric field is set up across the junction due to potential barrier. The electric field is given by $E = \frac{V_b}{d}$, where d is the thickness of the depletion layer. This electric field is directed from positive charge to negative charge. It is to be noted that in ~~the~~ equilibrium ~~condition~~ net current through the junction is zero but the electrons and hole flows do not stop entirely. Since, the p-side contains electrons as minority carriers and the n-side has holes as minority carriers. When the p-n junction is unbiased, the barrier field does not prevent the electrons from the p-side and the holes from the n-side to cross the junction. Thus, a drift current begins to flow due to the drifting of hole and ~~ectr~~ electron across ~~the junction~~. in a direction opposite to that of diffusion current