Semiconductor
Lecture 2

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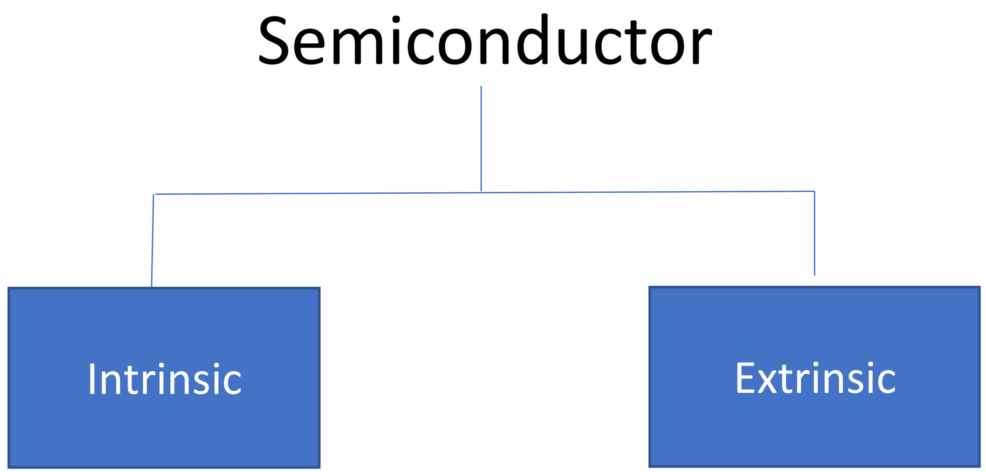
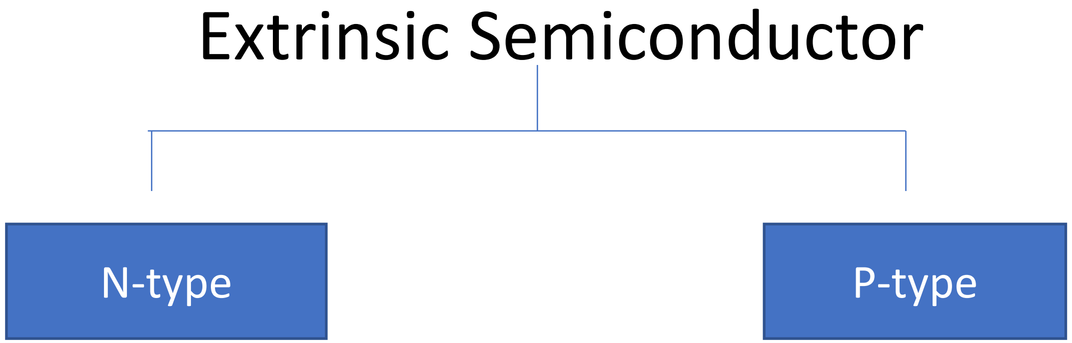


When impurities are added to the intrinsic form of semiconductor it change to extrinsic. The process of mixing impurities is known as doping.



In case of intrinsic form of semiconductor number of holes are equal to number of free electrons. Each electron when leaves the covalent bond contributes a hole in the broken bond. At a certain temperature always electron-hole pair are created by gaining thermal energy. But at the same time same number of electron-hole pair are lost due to recombination. It is known as equilibrium condition and at this condition $n_e = n_p$.

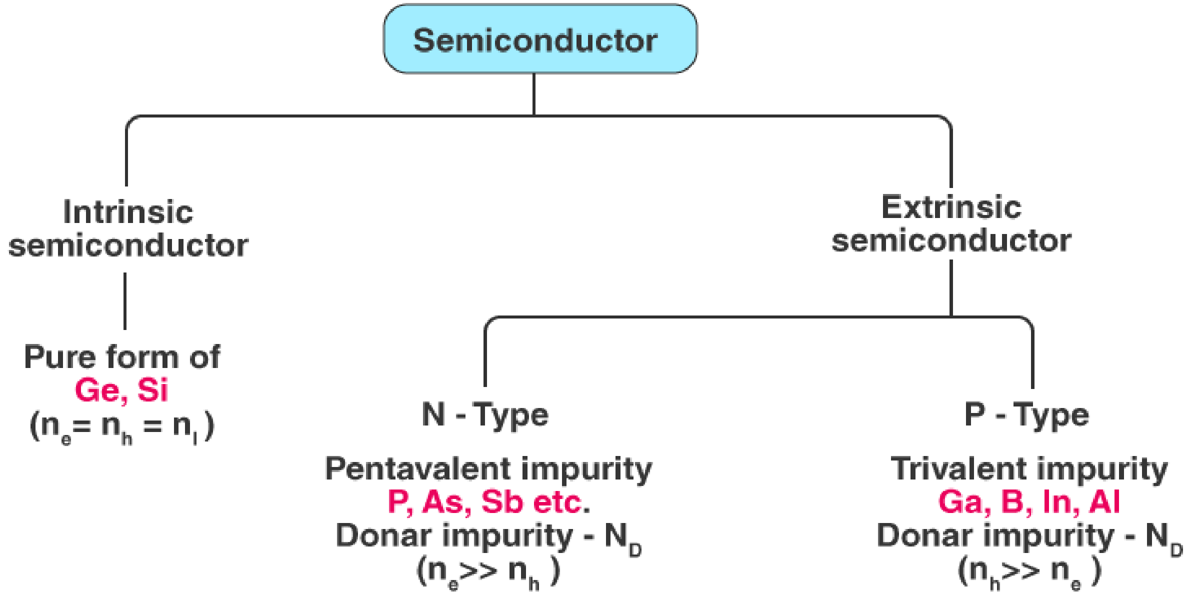


Fig 1

Intrinsic semiconductor turns into Extrinsic one, when it is doped with controlled manner with dopants. It is doped with donor atoms (*Group V Elements*) it becomes $n - type$ semiconductor and when it is doped with acceptor atoms (*Group III Elements*), it becomes $p - type$ semiconductor.

Now let a small amount of ***Group V*** elements, such as phosphorous(P), arsenic(As), antimony(Sb), bismuth(Bi) is added to intrinsic Si or Ge semiconductor. These ***Group V*** element five valance electron. When they displace a Si or Ge atom the four valance electron form covalent bonds with neighbouring atoms and the fifth electron which does not participate in formation of covalent bond is loosely attached with the parent atoms and can easily leave the atom as free electron.

In case of silicon the energy necessary that releasing that fifth electron is just $0.05\ ev$. So this kind of impurity is named as donor, because it contributes free electrons. This type of semiconductor is known as $n - type$ semiconductor, because it can donate free electrons. Fermi energy level move closer to conduction band in $n - type$ semiconductor. Here number of free electrons is increased over intrinsic concentration of electron. On the other hand number of holes are decreased over intrinsic hole concentration as there is more probability of recombination due to larger number of free electron concentration. Here electrons are majority charge carriers.

Now ***Group III*** elements such as aluminium(Al), boron(B), indium(In), which have three valance electron is added to intrinsic semiconductor they displaces a Si or Ge atom.

These three electrons make covalent bond with neighbouring atoms creating hole. These kind of impurity atoms known as acceptors. The semiconductor is known as $p - type$ semiconductor as holes assumed to be positively charged.

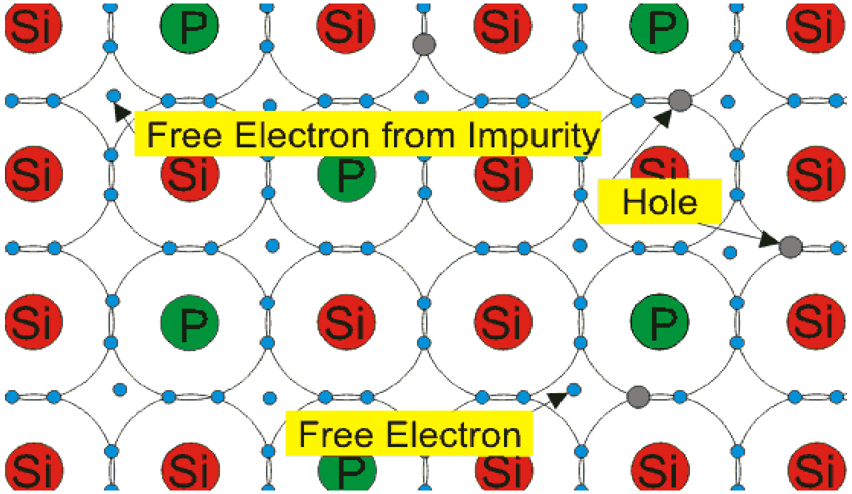


Fig 2

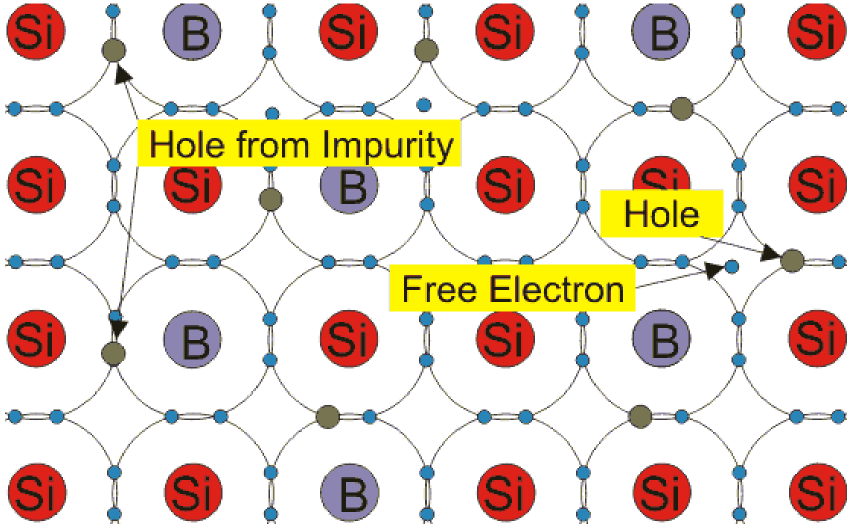


Fig 3

In this case Fermi energy level moves down closer to valance band in $p - type$ semiconductor. Here number of holes are increased and number of electrons are decreased over the intrinsic carrier concentration of Si or Ge, since here free electrons gets plenty of holes in the crystal. In $p - type$ semiconductors, holes are majority charge carriers.

Semiconductor Diode:

An electronic component made of semiconductor material that allows conduction of current in one direction is termed as Diode. It is two terminal device by fusing $p \,\&\, n\ type$ material.

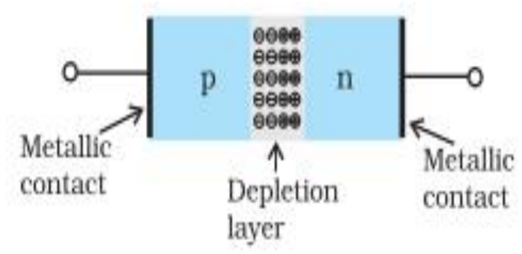


Fig 4

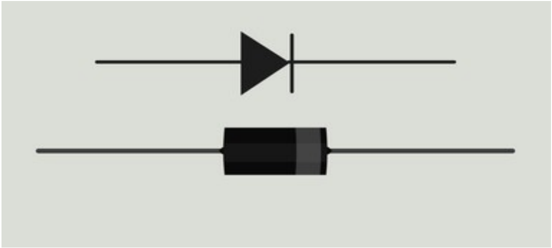


Fig 5

Here p-type material holds holes as its majority carrier and electrons in it minority carrier. On the other hand $n - type$ material has electrons as majority carrier and holes as minority carrier. The junction is nothing but a layer of immobile ions termed as depletion layer. When no proper potential is provided then the conducting and nonconducting states is noticed. Now operation of diode involved unbiased, forward biased and reversed biased condition.

At **unbiased condition** ie no voltage is applied across the diode the holes from $p - side$ and electron from $n - side$ get combined with each other at the junction. Due to this a depletion region is formed at the junction. It is noticed that a flow of charge carriers across the cross-sectional area is known as diffusion.

Hence current at no biased condition is known as diffusion current. The potential difference across the depletion region generate an electric field in it. Due to this electric field any further movement of majority charge carrier is allowed. This is the reason that the depletion region is fixed. The potential at depletion region acts as a barrier for further movement of majority charge carrier. However still minority carrier drift across the depletion region and a negligible current flows which is known as drift current.

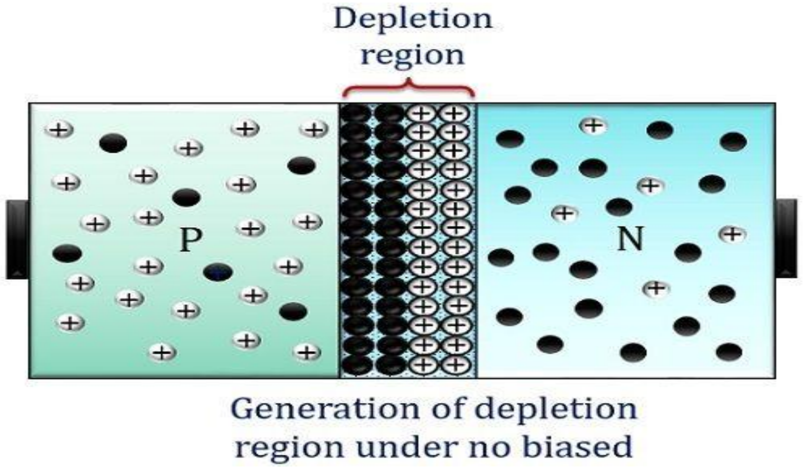


Fig 6 .Unbiased condition of Diode