Electronics
Lecture 1
(Sixth Semester General Course)

Manoj Kr. Das
Associate Professor
Physics Department
J N College, Boko

History of Electronics:

In the present century we are dealing with electronic circuits and devices in some of the other form like computer, television, mobile etc. At present without electronics it is really impossible to work.

History of electronics began with the invention of *vacuum diode* by *J A Fleming* in 1897 and after that a *vacuum triode* was developed by *Lee De Forest* to amplify an electrical signal. This lead to the *tetrode* and *pentode* tubes that dominated the era of world war II. After that transistor era began with junction *Transistor* in 1948 Even though this particular invention got Nobel prize by *Wlliam Bradford, Skockley, John Bardeen and Walter* in 1956 .

The use of Germanium and Silicon semiconductor materials made these transistors gains popularity and wide-accepted usages in different electronic circuit. The subsequent years witnessed of invention of $Integrated\ Circuit\ (IC)$ that drastically changed the nature of electronic circuit, which cause low cost, small size and weight. After that introduction of $JFET, MOSFET$ improves the process of designed making more powerful and reliable transistor.

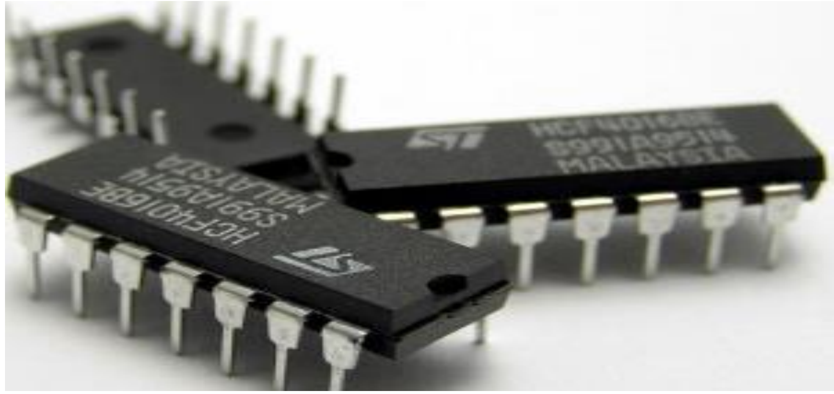


Fig 1

From the year 1958 to 1975 marked the introduction of IC with enlarged capabilities with several thousand components in a single chip such as small scale integration, medium scale integration and very large scale integration IC. Digital integrated circuit yet anther robust the development of IC that overall structure of computer. These IC are developed with Transistor-Transistor Logic(TTL), Integrated Injection Logic($I2L$), Emitter Coupled Logic(ECL) etc. All these radical changes in all these components lead to the introduction of Microprocessor in 1969. Soon after Analog Integrated Circuits were developed that introduced the Operational Amplifier($OAPM$) for analog signal processing.

This is all about the fundamental understanding of electronics history.

Semiconductor:

Semiconductor are the materials whose conductivity property lie between conductor and insulator.

Germanium, Silicon, Gallium, Arsenide etc. are best example of semiconductor.

The atomic Number of Silicon is 14 and of Germanium is 32,

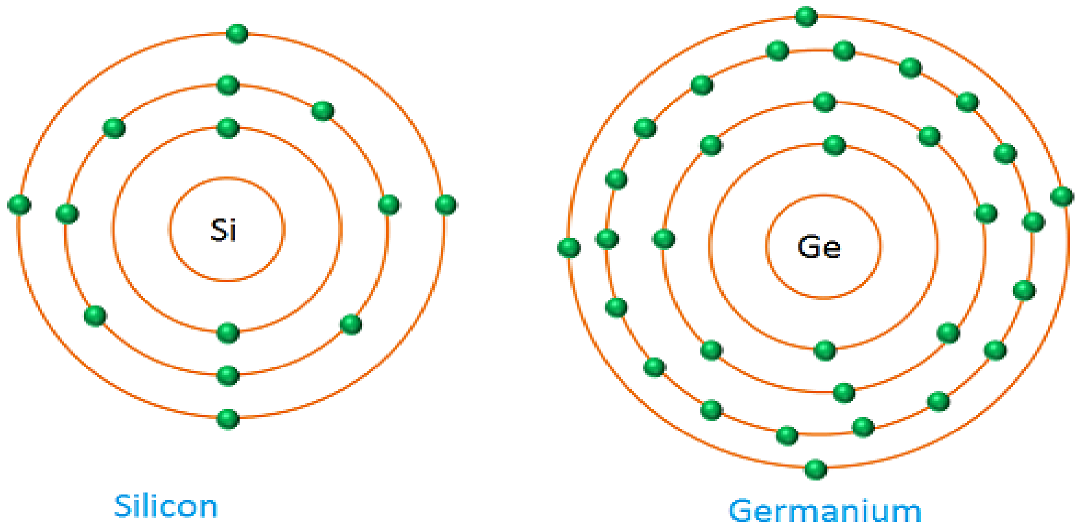


Fig 2

Let us take the case of Germanium.

In case of Germanium (Ge) the atomic number is 32. There are four valance electron in the outer orbit.

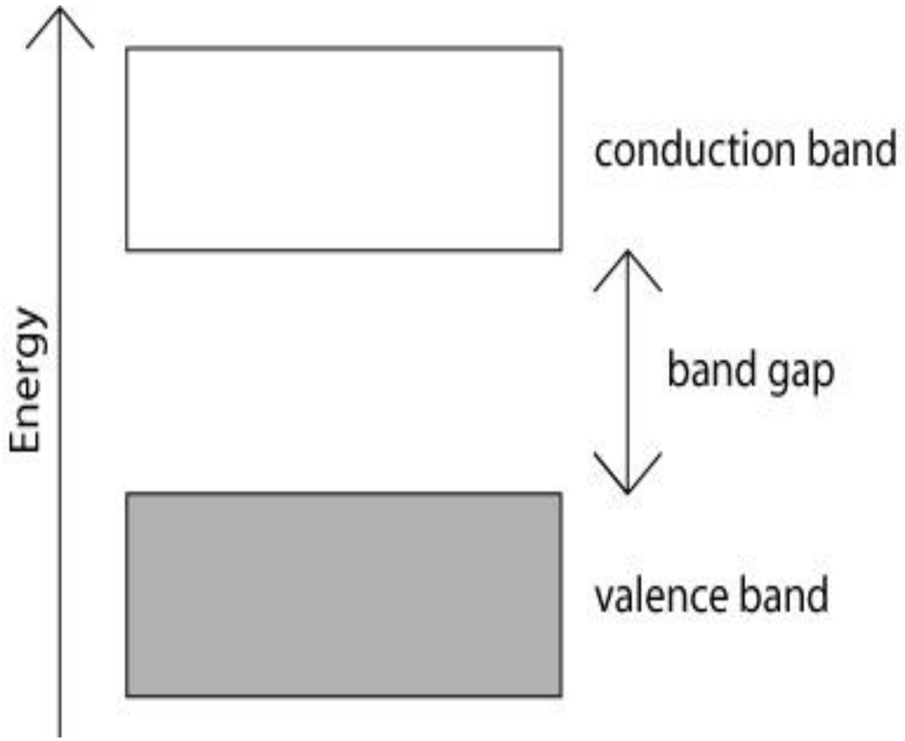


Fig 3

When it is excited the electrons goes to the conduction band and the electrons are known as Free Electron.

The vacant spaces are created in the valance band and these are known as Hole.

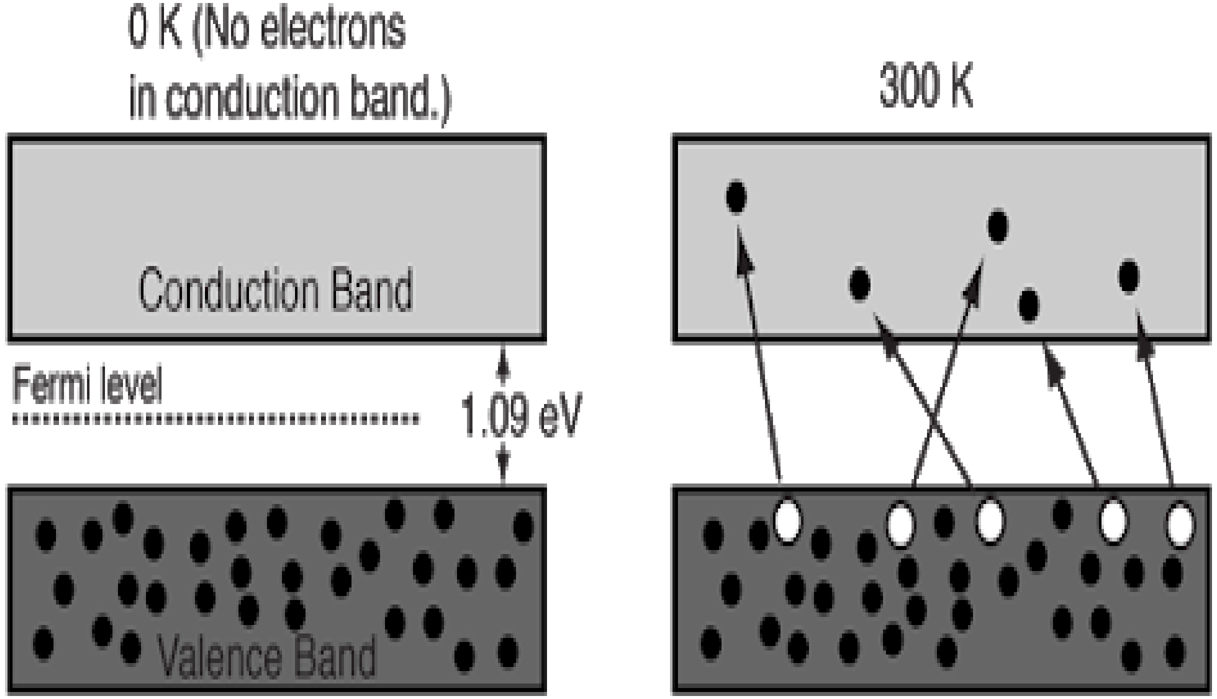
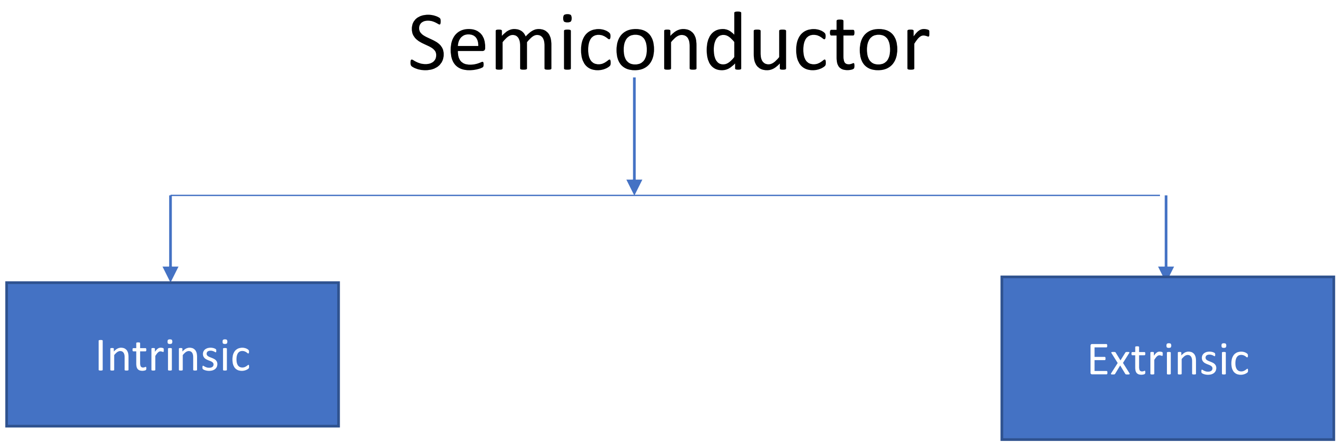
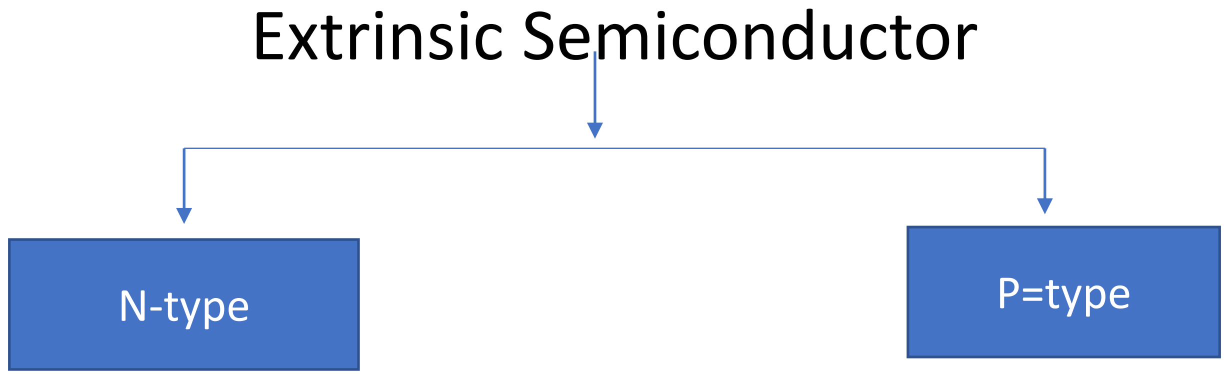


Fig 4



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 $n_e = n_p$.

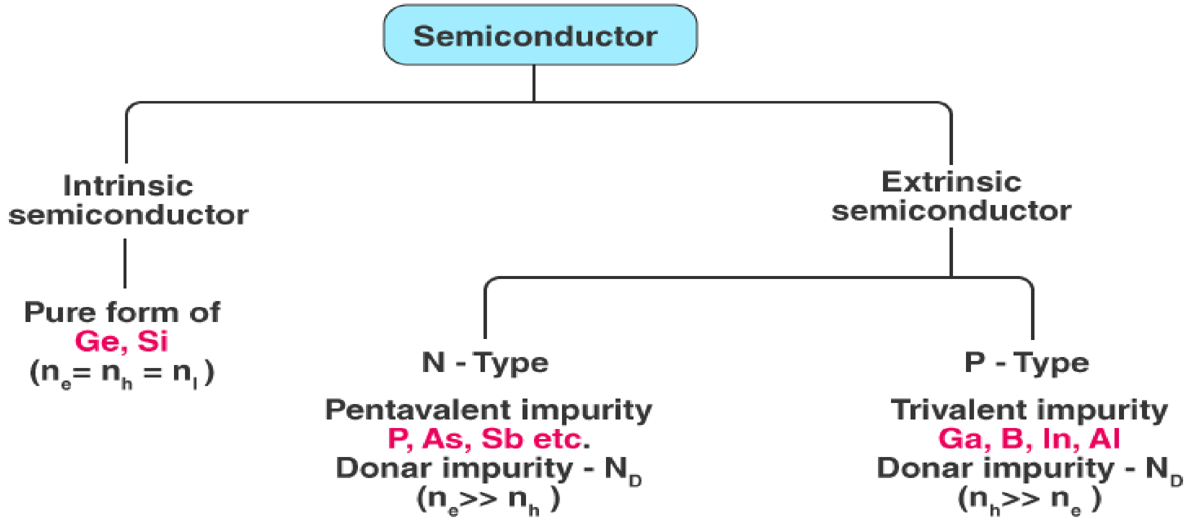


Fig 5

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.

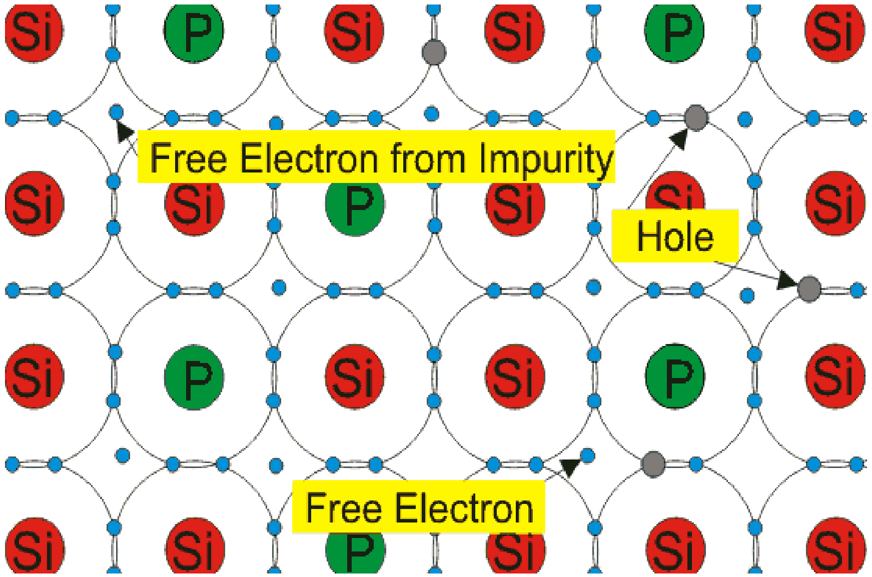


Fig 6

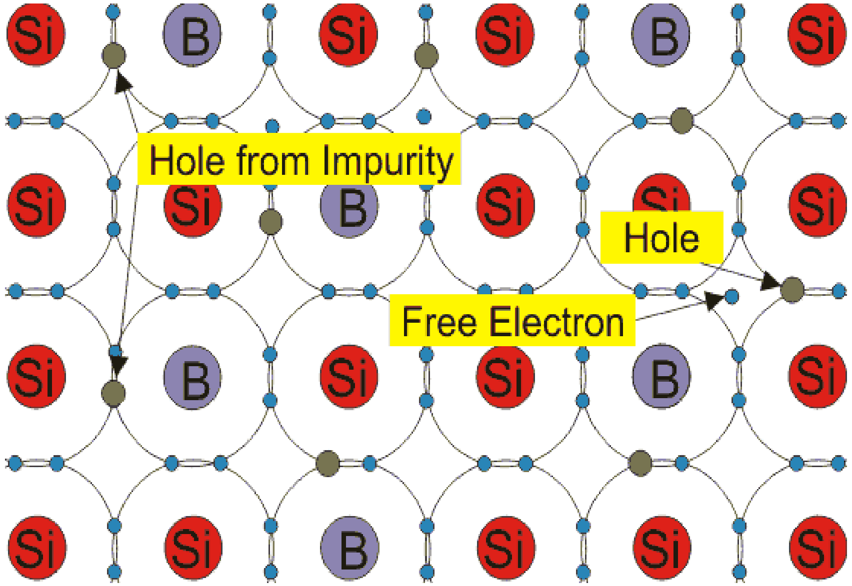


Fig 7

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.