Electronic Circuits-1(CNET-112)
Level 4th
Department of CNET

College of CS & IS
Jazan University
KSA

CHAPTER 2
Semiconductor Physics
Objectives

In this Chapter, we will learn the following topics:-

1) Materials:- Conductor, Insulator, semiconductor
2) Energy Band Diagram of Materials
3) The Silicon/Germanium Atomic Structure
4) Intrinsic/Extrinsic Semiconductor Material, Doping.
5) P-Type & N -Type Semiconductor
6) Majority and minority charge carriers

Materials:- Conductor, Insulator, semiconductor

1. Conductor:- A conductor is an object or type of material that allows the flow of electrical current in one or more directions. A metal wire is a common electrical conductor.

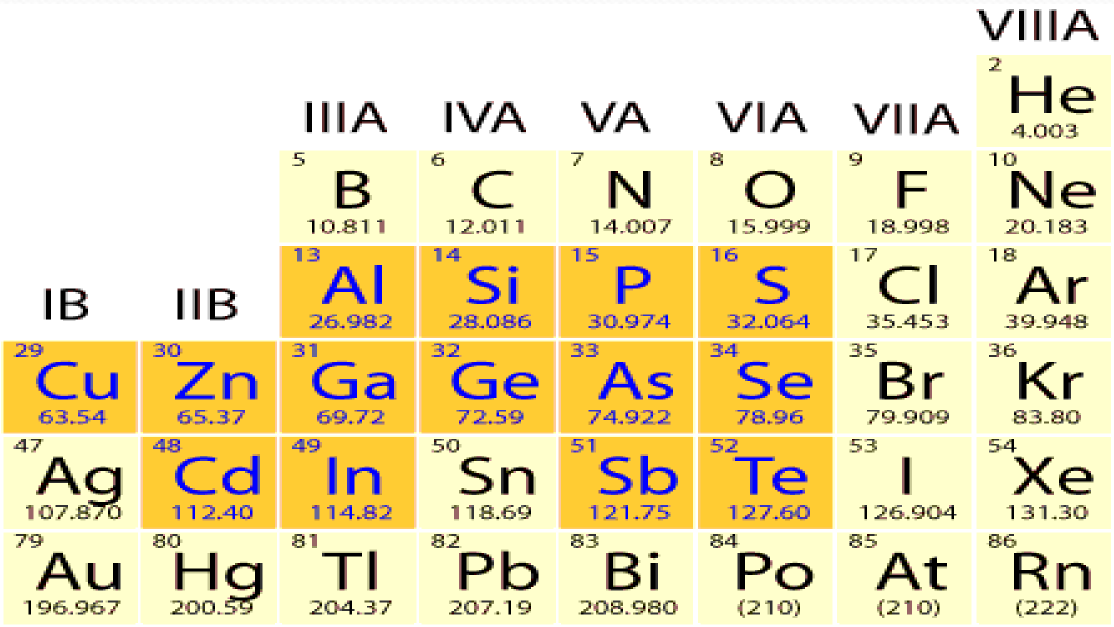
Examples:- Iron, Copper, Silver etc.

2. Insulator:- An electrical insulator is a material whose internal electric charges do not flow freely, and therefore make it nearly impossible to conduct an electric current under the influence of an electric field.

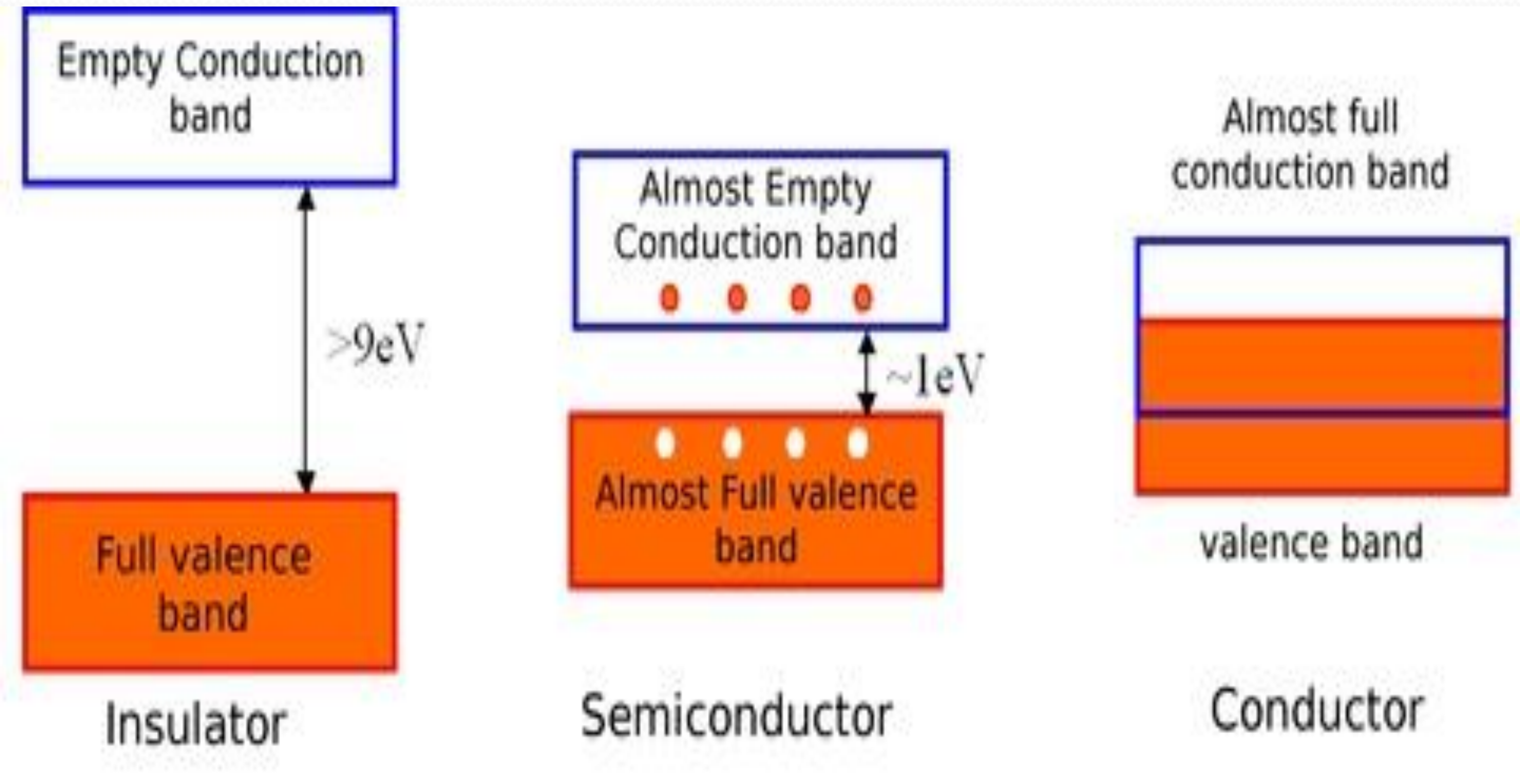
Examples:- Rubber, Wood, Plastic.

3. Semiconductor:- A electrical semiconductor is a material whose electrical properties lies between conductor and insulator.

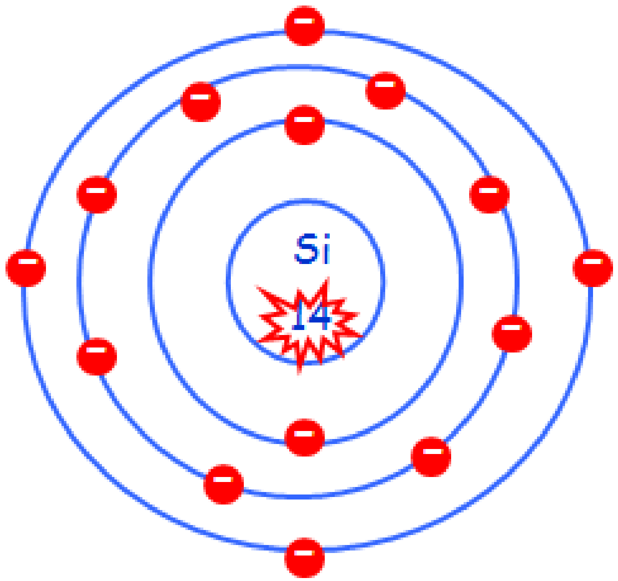
Example:- Silicon(Si), Germanium(Ge), etc.



Energy Band Diagram of Materials



The Silicon Atomic Structure

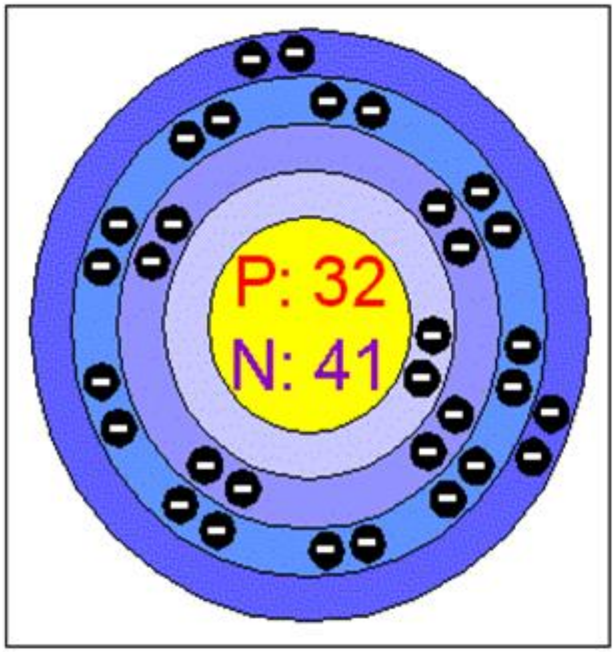


Silicon : It's a Group 4 element which means it has 4 electrons in outer shell

However, like all other elements it would prefer to have 8 electrons in its outer shell

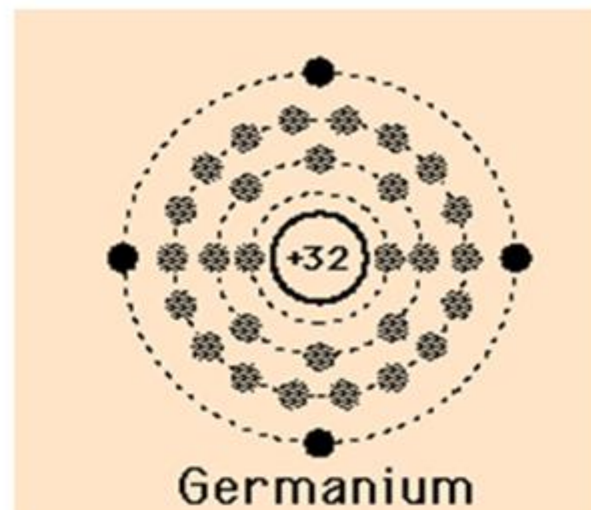
The Germanium Atomic Structure

Atomic Structure



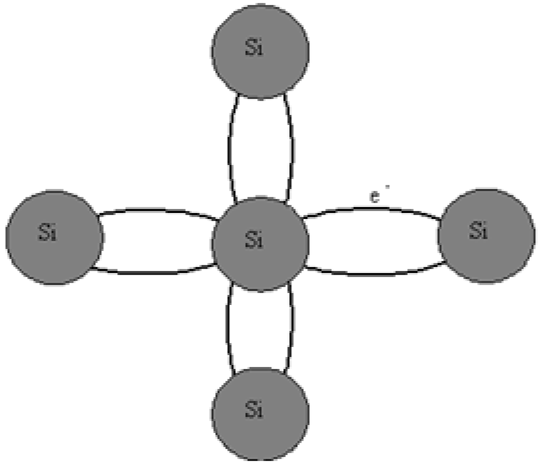
Number of Energy Levels: 4

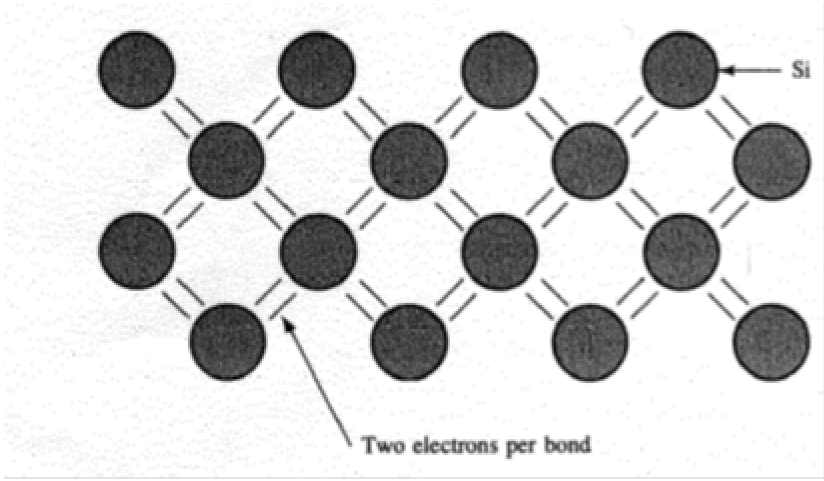
First Energy Level: 2
Second Energy Level: 8
Third Energy Level: 18
Fourth Energy Level: 4



Bonding of Si atoms

This results in the covalent bonding of Si atoms in the crystal matrix





A Covalent Bond Formed by the Sharing of Electrons in an Outer Energy Level

Covalent Bonding

Figure. Covalent bonding of GaAs atom

- The figure show the covalent bonding between two different atom
- Gallium is having 3 valence electrons and Arsenide is having 5 valence electrons
- Which will result in stronger bonding between two atoms.

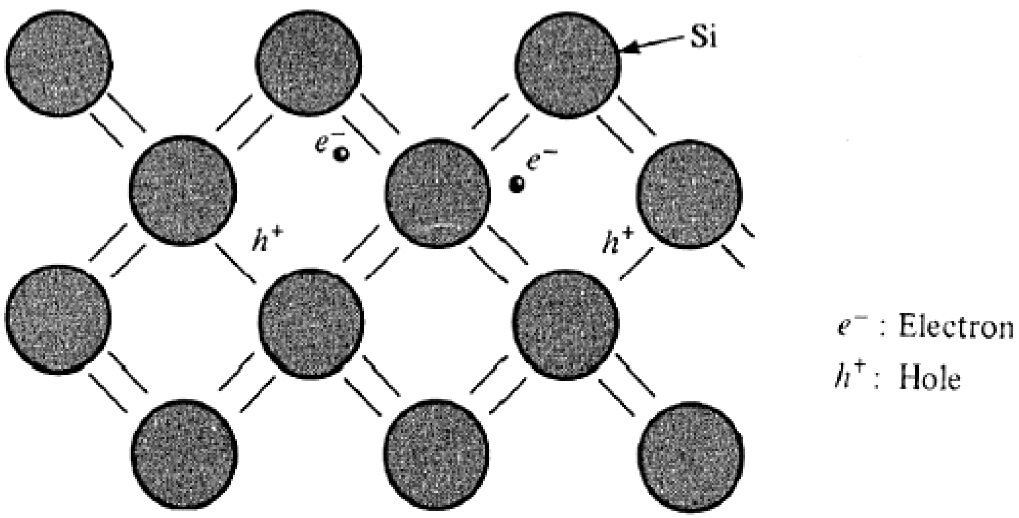
Intrinsic Semiconductor

A perfect semiconductor crystal with no impurities or lattice defects is called an ***intrinsic*** semiconductor.

At T=0 K –
No charge carriers
Valence band is filled with electrons
Conduction band is empty

At T>0
Electron-hole pairs are generated

EHPs are the only charge carriers in *intrinsic material*



Since electron and holes are created in pairs – the electron concentration in conduction band, n (electron/cm^3) is equal to the concentration of holes in the valence band, p (holes/cm^3).

Each of these intrinsic carrier concentrations is denoted n_i.

Thus for intrinsic materials $n=p=n_i$

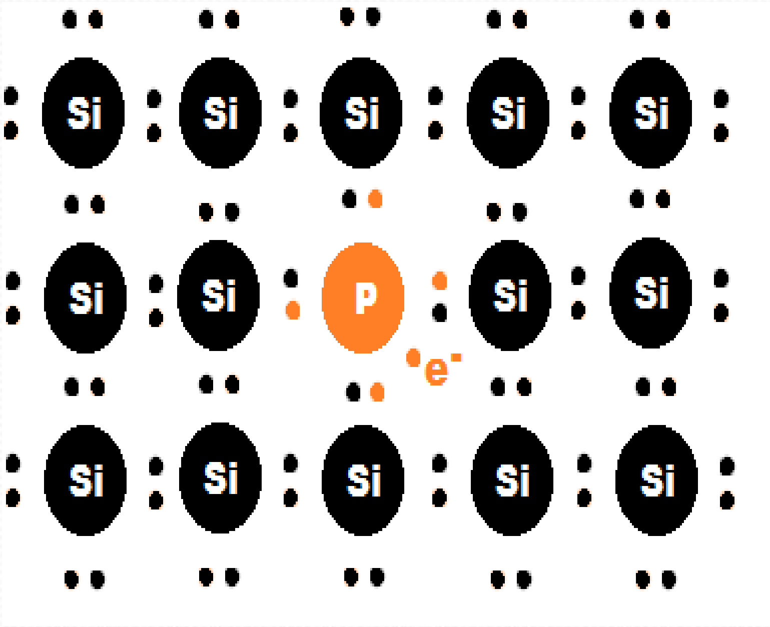
Extrinsic Semiconductor

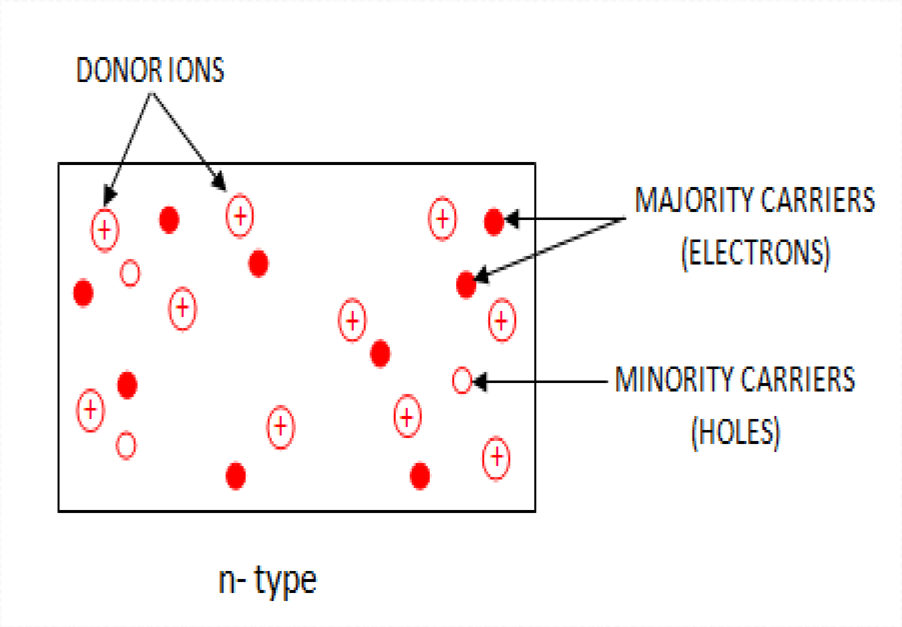
An extrinsic semiconductor is a material with impurities introduced into its crystal lattice. The goal of these impurities is to change the electrical properties of the material, specifically (increasing) its conductivity.

The Process of adding impurities is called **Doping**.

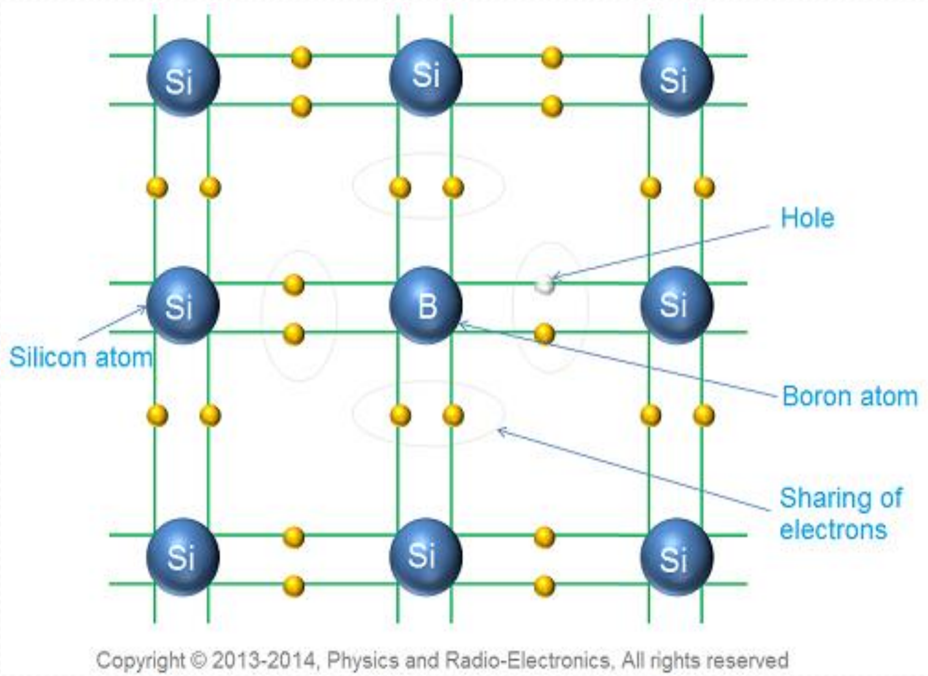
Classification of Extrinsic Semiconductor

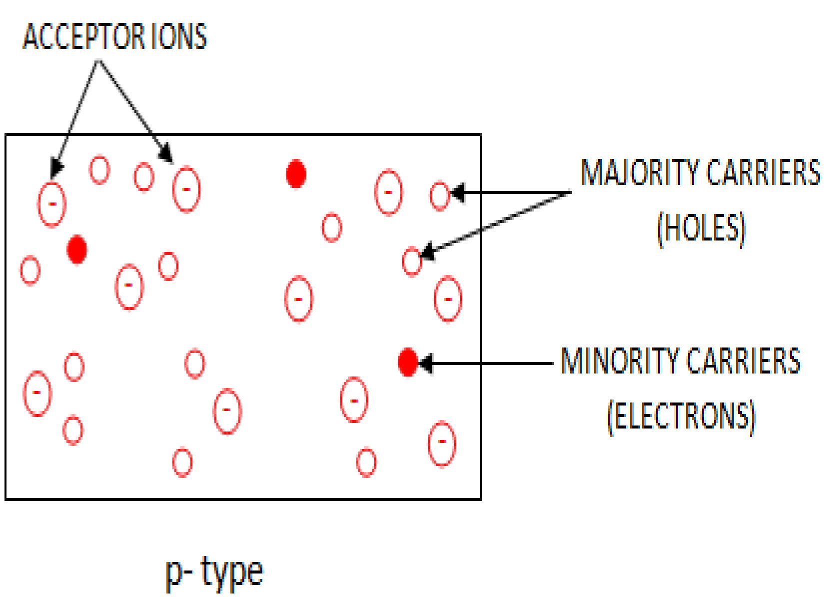
1. N-Type Semiconductor:- In N-type semiconductors, electrons are the majority carriers and holes are the minority carriers. N-type semiconductors are created by doping an intrinsic semiconductor with donar impurities or pentavalent impurities[like Phosphorus(P), Arsenic(As), Antimony(Sb)].





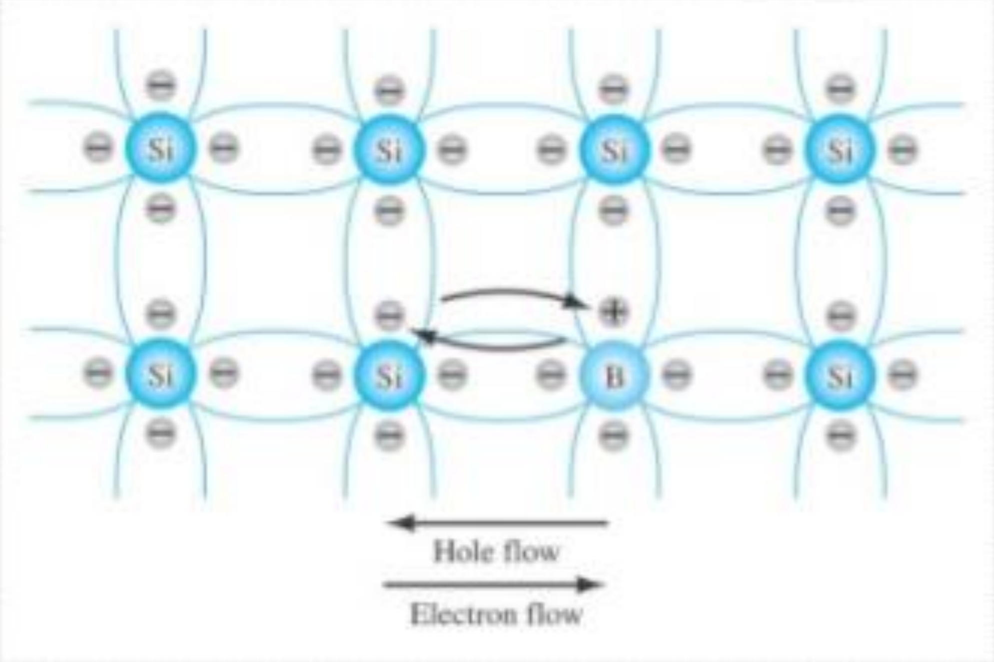
2. P-Type Semiconductor:- In p-type semiconductors, holes are the majority carriers and electrons are the minority carriers. P-type semiconductors are created by doping an intrinsic semiconductor with acceptor impurities or trivalent impurities[like Boron(B), Aluminum(Al), Gallium(Ga)].





Electron versus Hole Flow

•The valence electron acquires sufficient kinetic energy to break its covalent bond and fills the void created by hole
•When the electron move to fill the hole therefore a transfer of holes to the left and electrons to the right
•This flow is known as conventional flow.



Majority and minority charge carriers

The charge carriers that are present in large quantity are called *majority charge carriers*. The majority charge carriers carry most of the electric charge or electric current in the semiconductor. Hence, majority charge carriers are mainly responsible for electric current flow in the semiconductor.

The charge carriers that are present in small quantity are called *minority charge carriers*. The minority charge carriers carry very small amount of electric charge or electric current in the semiconductor.

Intrinsic and Extrinsic Semiconductor

References

1. Conductor, Insulator and Semiconductor

- https://www.youtube.com/watch?v=0NBTvJF6ghQ

2. Energy Bank Diagram of Conductor, Insulator and Semiconductor

- https://www.youtube.com/watch?v=pw_tzpgytcE

3. Extrinsic Semiconductor

- https://www.youtube.com/watch?v=s6rQI7t9XM4

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