Introduction

Semiconductors are 4th group of elements in periodic table.
valence electrons are 4.
ex: Carbon, Silicon, germanium,Tin,lead.
Mostly used semiconductor material is Silicon and germanium.
semiconductors are negative temperature coefficient as the temperature increases Energy gap of the semiconductor decreases.

Intrinsic Semiconductors

An intrinsic semiconductor is a semiconductor in which no other material is intentionally doped (similar to mixing). Example: Si, Ge.
Notes:
1. It behaves as an insulator at absolute zero.
2. Electrons are excited by thermal energy.
3. They are different from pure semiconductors and may consist of some level of impurities. The conductivity of intrinsic semiconductor is more than that of a pure semiconductor as the impurities provide a few energy levels in the bandgap.
Note:
Pure semiconductors are semiconductors that have no impurities. Ideally, no semiconductor is pure in nature.

Mass Action Law

Law of mass action
The law of mass action states that the product of number of electrons in the conduction band and the number of holes in the valence band is constant at a fixed temperature and is independent of amount of donor and acceptor impurity added.
Mathematically it is represented as
$np = ni^2$ = constant
Where ni is the intrinsic carrier concentration
n is number of electrons in conduction band
p is number of holes in valence band

Mobility

The charge carriers move by the influence of an external electric field. So, due to the application of an electric field charge carriers will get some drift velocity to move in the conductors or the Semiconductors. Electrical mobility of charge carriers is defined as the drift velocity of the carriers per unit applied electric field.
Now, what is the electron mobility formula? Let, after applying an external electric field E, the charge carriers get the drift velocity V. Then the formula for the mobility of the charge carriers is,
$\mu = V/E$
This is the formula of mobility of charge carriers. This is also the the electron mobility formula.

Classification of Semiconductors

There are mainly 2 types of semiconductors
1) Intrinsic Semiconductors.
2) Extrinsic Semiconductors are of 2 types.
1) P-Type Semiconductor.
2) N-Type Semiconductor.

Classification of Semiconductors (cont)

Semiconductor contains electrons and holes.

Extrinsic Semiconductors

Process of doping

Doping a semiconductor can be done in many ways including adding impurity to molten semiconductor, heating semiconductor in an atmosphere containing dopant atoms and bombarding semiconductor with the dopant atoms.

Types of dopants

There are two types of dopants that can be added to a semiconductor. This gives rise to the following types of extrinsic semiconductors:

1. n-type semiconductor: Pentavalent impurities (Ex: As, P) are added which introduces an extra valence electron which requires lesser energy for conduction. Addition of pentavalent impurity adds a new energy level (called donor levels) near the conduction band in the energy band diagram.
2. p-type semiconductor: Trivalent impurities (Ex: B, In) are added which introduces an extra hole which requires lesser energy for conduction. Addition of trivalent impurity adds a new energy level (called acceptor levels) near the valence band in the energy band diagram.

Charge Neutrality

A semiconductor is said to be "Electrical neutral" when the total positive charge concentration is equal to total negative charge concentration

Types of Materials

CONDUCTORS

Contains plenty of free electrons.

Energy gap = 0.

Semi-Conductors

Contains Valency Electrons = 4.

Energy gap = 1eV.

Insulators

Tightly bound electrons.

Energy gap >6eV.

Einstein Relationship (semiconductor)

$$\frac{D_p}{\mu_p} = \frac{D_n}{\mu_n} = V_T$$

The equation which relates the mobility μ (of electrons or holes) and the diffusion coefficient (of electrons Dn or holes Dp) is known as Einstein Relationship.

Hall Effect

Principle of Hall Effect

The principle of Hall Effect states that when a current-carrying conductor or a semiconductor is introduced to a perpendicular magnetic field, a voltage can be measured at the right angle to the current path. This effect of obtaining a measurable voltage is known as the Hall Effect.

The Hall voltage represented as VH is given by the formula:

V(hall effect) = IB / qnd

Here,

I is the current flowing through the sensor

B is the magnetic Field Strength

q is the charge

n is the number of charge carriers per unit volume

d is the thickness of the sensor.