Semiconductor Materials

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Conductivity of metal

$$\sigma = \frac{ne^2\tau}{m}$$

Where, n = density of conductor electron

τ = Relaxation time

Conductivity of Semiconductor

The current flowing through a pure semiconductor is carried by two kinds of carriers, ie. electrons and holes.

Conductivity of a intrinsic semiconductor

$$\sigma = \frac{n_e e^2 \tau_e}{m_e} + \frac{n_n e^2 \tau_h}{m_h}$$

Where, τ_e, τ_h = Relaxation times for electrons and holes respectively.

m_e, m_h = Effective mass of electrons and holes respectively.

n_e, n_n = Number of conduction electrons and holes respectively.

- Current density

$$J = ne V_d$$

where, V_d = Drift velocity

Mobility

Mobility of electron

$$\mu_e = \frac{e\tau_e}{m_e}$$

Mobility of Hole

$$\mu_h = \frac{e\tau_h}{m_h}$$

Concentration of holes in the n-type semiconductor

$$n_{hn} = \frac{n_i^2}{N_D}$$

Where, n_i = intrinsic concentration

N_D = concentration of donor atom

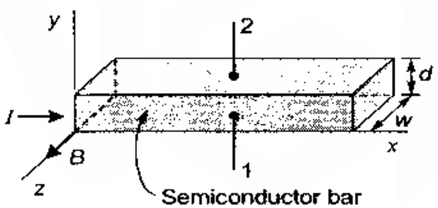
Concentration of holes in the p-type semiconductor

$$n_{ep} = \frac{n_i^2}{N_A}$$

Where, N_A = Concentration of acceptor atom

Hall Effect

If a specimen (metal or semiconductor) carrying a current-I is placed in a transverse magnetic field B, an electric field E is induced in the direction perpendicular to both I and B. This phenomenon, known as Hall effect, is used to determine whether a semiconductor is n-or p-type and to find the carrier concentration. Also, by simultaneously measuring the conductivity s, the mobility μ can be calculated.



Hall Voltage

$$V_H = \frac{BI}{\rho w}$$

where, w = Width of the specimen

ρ = the charge density

Hall Angle

$$\tan\theta_H = \frac{E_y}{E_x}$$

Hall Coefficient

$$R_H = \frac{E}{BJ} = \frac{1}{en_h} = \frac{-1}{en_e}$$

Where, E = Applied electric field

B = Applied magnetic field

J = Current density in the

If the conductivity is measured together with the Hall coefficient, the mobility can be determined from

$$\mu = \sigma R_H$$

Remember: ....

- For n-type semiconductor Hall voltage (V_H) and Hall coefficient (R_H) is negative.
- For p-type semiconductor Hall voltage (V_H) and Hall coefficient (R_H) is positive.
- Hall voltage is large for semiconductor than metal, since $V_H \propto R_H$ i.e.

  $V_H \propto \frac{1}{\sigma}$.

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Einstein Relation (Electrical Mobility Equation)

$$D_h = \left(\frac{kT}{e}\right)\mu_h, \quad D_e = \left(\frac{kT}{e}\right)\mu_e$$

where D_h, D_e = Diffusion constant for holes and electron respectively

$$\frac{D_h}{\mu_h} = \frac{D_e}{\mu_e} = \frac{kT}{e}$$

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