7.17 HALL EFFECT

Measurement of conductivity will not determine whether the conduction is due to electron or holes and therefore will not distinguish between p-type and n-type semiconductor.

Therefore Hall effect is used to distinguish between the two types of carriers and their carrier densities and is used to determine the mobility of charge carriers.

Hall Effect

When a conductor (metal or semiconductor) carrying a current is placed in a transverse magnetic field, an electric field is produced inside the conductor in a direction normal to both the current and the magnetic field. This phenomenon is known as **Hall effect** *and the generated voltage is called* **"Hall voltage"**.

Hall Effect in n-type Semiconductor

Let us consider an n-type material to which the current is allowed to pass along x-direction from left to right and the magnetic field is applied in z-direction, as a result Hall voltage is produced in y direction as shown in fig 7.22.

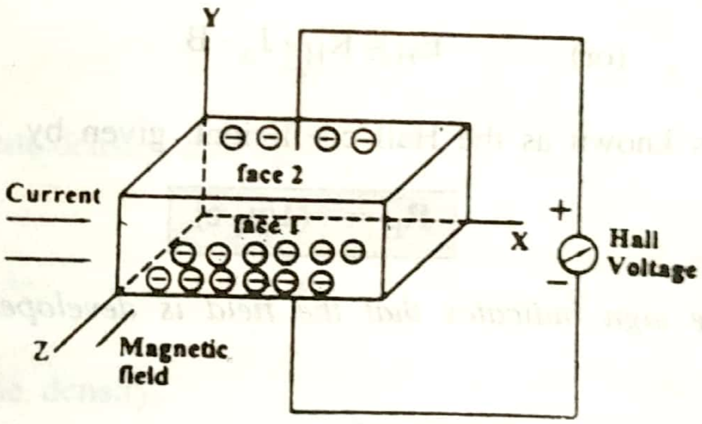

Fig. 7.22

Since the direction of current is from left to right the electrons moves from right to left in x-direction as shown in fig. 7.23.

Now due to the magnetic field applied the electrons move towards downward direction with the velocity 'v' and cause the negative charge to accumulate at face (1) of the material as shown fig. 7.22 & fig. 7.23. Therefore a potential difference is established between face (2) and face (1) of the specimen which gives rise to field E_H in the negative y direction.

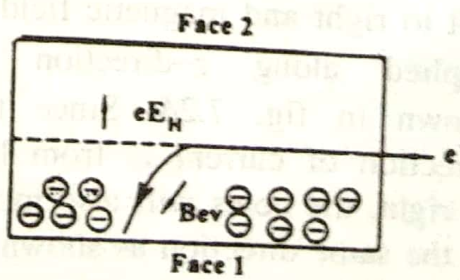

Fig. 7.23

Here, the Force due to potential difference $= -eE_H$ ...(1)

Force due to magnetic field $= -Bev$ ...(2)

∴ At equilibrium equation (1) = equation (2)

$$-eE_H = -Bev$$

$$\text{(or) } E_H = Bv \qquad ...(3)$$

We know the current density J_x in the x direction is

$$J_x = -n_e ev$$

$$\text{(or) } v = -\frac{J_x}{n_e e} \qquad ...(4)$$

Substituting equation (4) in equation (3) we get

$$E_H = -\frac{BJ_x}{n_e e} \qquad ...(5)$$

$$\text{(or)} \qquad E_H = R_H \cdot J_x \cdot B \qquad ...(6)$$

Where R_H is known as the Hall coefficient, given by

$$R_H = -(1/n_e e)$$

The negative sign indicates that the field is developed in the negative y direction.

UNIT 5

Hall Effect in p-type Semiconductor

Let us consider a *p*–type material for which the current is passed along *x*–direction from left to right and magnetic field is applied along *z*–direction as shown in fig. 7.24. Since the direction of current is from left to right, the holes will also move in the same direction as shown in fig. 7.25.

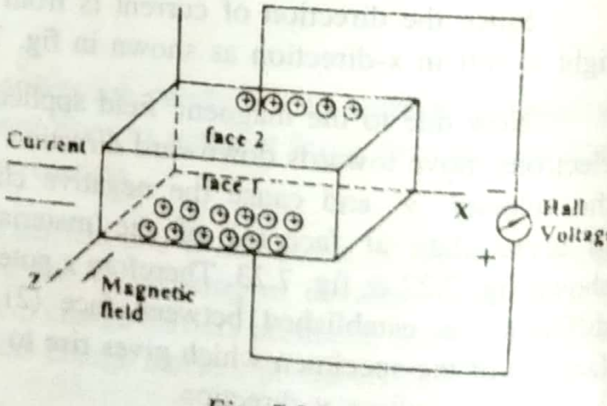

Fig. 7.24

Now due to the magnetic field applied, the holes move towards the downward direction with velocity 'v' and accumulates at the face (1) as shown in fig. 7.24 and fig. 7.25.

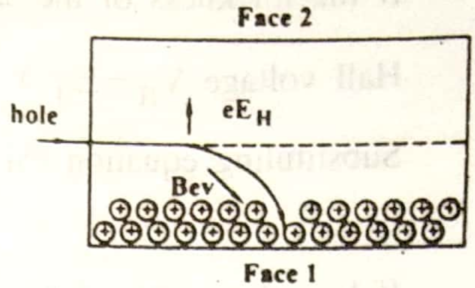

Fig. 7.25

∴ A potential difference is established between face (1) and (2) in the positive *y* direction.

∴ Force due to the potential difference $= eE_H$ ...(7)

Force due to magnetic field $= Bev$ ...(8)

[Since hole is considered to be an electron with same mass but positive charge negative sign is not included.]

At equilibrium equation (7) = equation (8)

$$\therefore eE_H = Bev$$

(or) $$E_H = Bv \quad ...(9)$$

We know current density $J_x = n_h e v$

(or) $$v = \frac{J_x}{n_h} e \quad ...(10)$$

where $n_h \rightarrow$ hole density.

Substituting equation (10) in (9) we get

$$E_H = \frac{BJ_x}{n_h e}$$

$$\text{(or)} \quad E_H = R_H J_x B$$

where $$R_H = \frac{1}{n_h e} \quad ...(11)$$

Equation (11) represents the Hall coefficient and the *positive sign indicates that the Hall field is developed in the positive y direction.*