DRIFT & DIFFUSION TRANSPORT

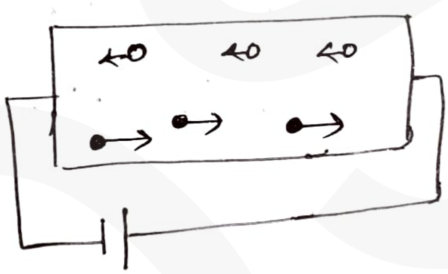
Net current flow through a semiconductor has two components –.

1) drift current.

2) diffusion current

DRIFT CURRENT :

The electric current produced due to the motion of charge carriers under the influence of an external electric field is known as drift current.



Drift current density in a semiconductor due to electrons, $J_n(\text{drift}) = n e \mu_n E$ —(1).

Drift current density due to holes

$$J_p(\text{drift}) = p e \mu_p E \quad \text{—(2)}$$

where, n & p are election & hole density resp'y.

μ_n & μ_p are mobilities of $\bar{e}$s & holes resp'y.

e is charge of an $\bar{e}$

E is the e.field.

resp'y ⇒ respectively

$J_{tot} = ① + ②$

$J_{tot} = ne\mu_n E + pe\mu_p E$

$J_{tot} = eE(n\mu_n + p\mu_p)$ —— ③

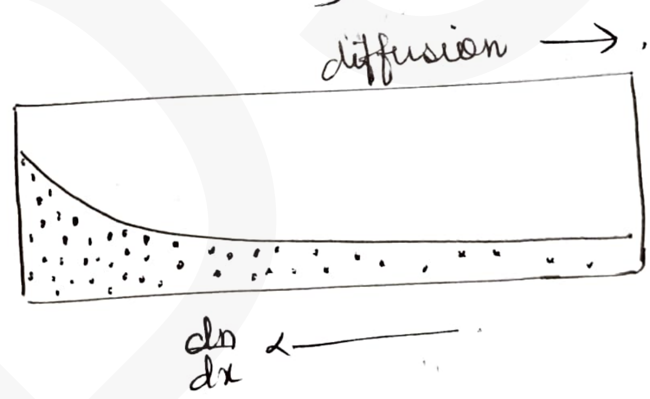
For intrinsic semi conductor

$J_{tot} = n_i eE(\mu_n + \mu_p)$ —— ④

DIFFUSION CURRENT

The current produced due to the ~~process~~ of diffusion of charge carriers from a region of higher concentration to a region of lower concentration is known as diffusion current.

[* Non-uniform distribution of charge carriers causes uneven concentration]



* Diffusion mechanism takes place in addition to the drift caused by an applied electric field.

Let n be the electron conc. & p be the hole concentration which varies with distance x in semi conductor.

The concentration gradient is $\frac{\partial n}{\partial x}$ (for electrons)

According to Ficks law, the rate at which carrier diffuse is proportional to the density gradient and the movement is in the direction of negative gradient.

$\therefore$ The rate of flow of electrons per unit area $\left.\right\} \propto -\frac{\partial n}{\partial x}$

$$= -D_n \frac{\partial n}{\partial x} \quad \text{--- (1)}$$

where, D_n is the diffusion ~~constant~~ coefficient for electrons.

Current density J_n(diffusion) = $(-e)$ (rate of flow across unit area)

$$= (-e)\left(-D_n \frac{\partial n}{\partial x}\right)$$

$$J_n(\text{diffusion}) = +eD_n \frac{\partial n}{\partial x} \quad \text{--- (2)}$$

Similarly if excess of hole conc. is created hole diffusion takes place &

$$J_p(\text{diffusion}) = (e)\left(-D_p \frac{\partial p}{\partial x}\right)$$

here D_p is diffusion coefficient for holes

and $\frac{\partial p}{\partial x}$ is concentration gradient (for holes)

* If there is an electric field E and conc. gradient in x direction, the total hole current is sum of the drift current and diffusion current.

* $J_p = J_p(\text{drift}) + J_p(\text{diffusion})$

$$\boxed{J_p = pe\mu_p E - eD_p \frac{\partial p}{\partial x}}$$

* $$\boxed{J_n = ne\mu_n E + eD_n \frac{\partial n}{\partial x}}$$

$\Rightarrow J_{tot} = J_n + J_p$

* $\frac{D_n}{D_p} = \frac{\mu_n}{\mu_p}$ } Einstein's relation, the relation between diffusion coefficient and mobility of charge carriers.