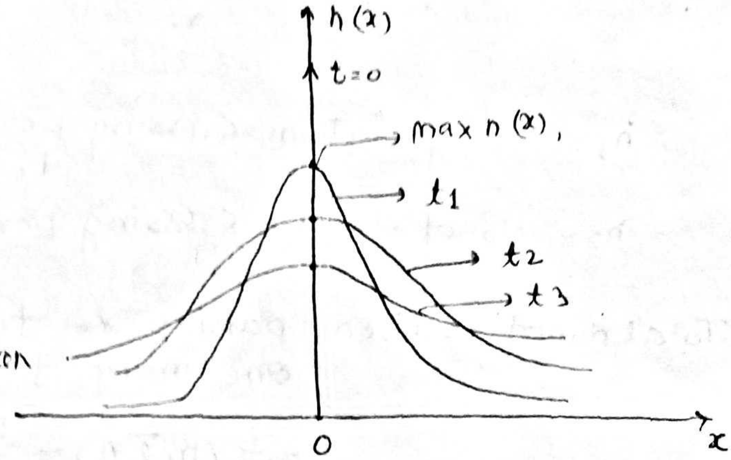
* **Diffusion of charge Carriers** :- When excess carrier generated concentration gradient is formed. The variation of concentration of carriers with distance is called concentration gradient. The concentration gradient flows towards Higher-concentration to Lower concentration. All the carriers in the semiconductor undergo random thermal motion and scattering from Lattice and Impurity. Diffusion occure due to concentration gradient and in the absence of field.

Let Suppose.

$n(x)$ = Max. concentration at x, due to excess carrier generation



As time increasing concentration decreasing.

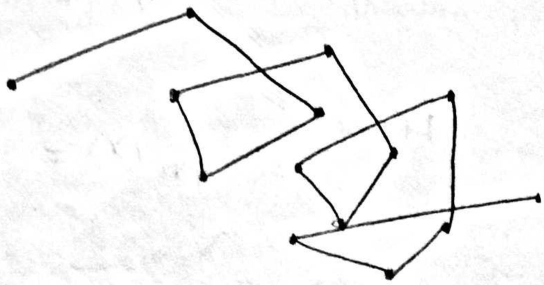
Movement of charge carriers carriers from Higher — concentration to Lower - concentration is called diffusion.

* → Spreading of a pulse of electrons by diffusion ← *

$t_3 > t_2 > t_1$

Note * Diffusion is occure due to Both type of charge carrier's.

The electrons and Holes are moved in the crystal with random thermal motion due to scattering. as shown in the figure-

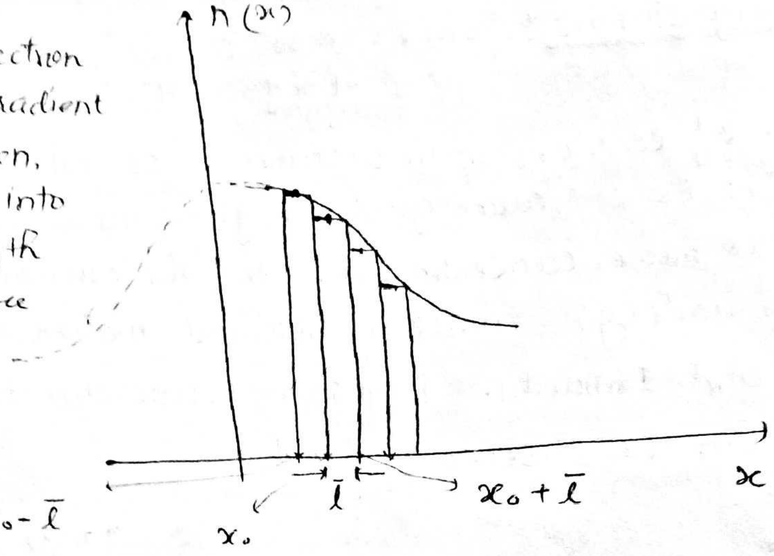


$\bar{t}$ = Mean free time.
= Time between two collisions. (may be Impurity or atom)

$\bar{l}$ = Distance travelled between two Collisions.

$n(x)$ calculated by centre of each strip as shown in the figure-

An arbitary electron concentration gradient in one dimension, division of n (x) into segment of length equal to mean free path of electron,



n_1 = No. of electrons crossing per unit area from Left to Right.

n_2 = No. of electrons crossing per unit area oppisite to n_1.

Total no. of electrons passing x_0 from Left to Right in one mean free time -

$$= \frac{1}{2}(n_1 \bar{l} A) - \frac{1}{2}(n_2 \bar{l} A)$$

Rate of electron flow per unit area = electron flux - density at x_0

$$\phi n(x_0) = \frac{\bar{l}}{2\bar{t}}(n_1 - n_2)$$

where $\bar{l}$ is small diffusion length.

If $\bar{l}$ is very small, then - $\bar{l} = \Delta x$,

$$n_1 - n_2 = \frac{n(x) - n(x+\Delta x)}{\Delta x} \bar{l}$$

Hence,

$$\phi_n(x) = \frac{\bar{l}^2}{2\bar{t}} \lim_{\Delta x \to 0} \frac{n(x) - n(x+\Delta x)}{\Delta x}$$

$$= -\frac{\bar{l}^2}{2\bar{t}} \frac{dn(x)}{dx}$$

$$\boxed{\phi_n(x) = -D_n \frac{dn(x)}{dx}}$$

Where $D_n = \frac{\bar{l}^2}{2\bar{t}}$, called diffusion constant of electrons, and also called distance between two Scattering, two times.

$\frac{dn(x)}{dx}$ called dif concentration Gradient.

Similarly for Holes -

$$\phi_p(x) = -D_p \frac{dp(x)}{dx}$$

During diffusion current density -

$$J_{n(diff.)} = -(-q) D_n \frac{dn(x)}{dx}$$

$$= q D_n \frac{dn(x)}{dx}$$

and for Holes -

$$J_{p(diff.)} = -(+q) D_p \frac{dP(x)}{dx}$$

$$= -q D_p \frac{dP(x)}{dx}$$

Now if field $\mathcal{E}_{(x)}$ also present, It means drift current occure, Now total current density -

$$\boxed{\begin{aligned} J_n &= q\mu_n n(x) \mathcal{E}(x) + q D_n \frac{dn(x)}{dx} \\ J_p &= \underbrace{q\mu_p P(x) \mathcal{E}(x)}_{\text{drift}} - \underbrace{q D_p \frac{dp(x)}{dx}}_{\text{Diffusion.}} \end{aligned}}$$

The total current density is the sum of of the contribution of electrons & Holes.