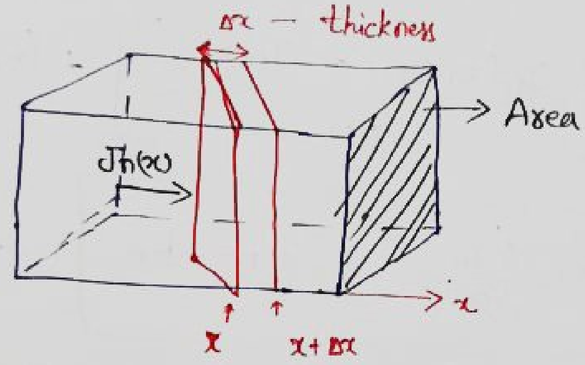
The Continuity Equation

→ All semiconductor devices operates under non equilibrium conditions in which current of holes and electrons flow through the semiconductor

→ The equation that states a condition of dynamic equilibrium for the concentration of mobile carriers in elementary volume of the semiconductor is known as continuity equation.



$J_n(x)$ = Current density at x point

$J_n(x+\Delta x)$ = Current density concentration gradiant

Change in e^- concentration :—

$$\frac{\partial n}{\partial t} A\cdot\Delta x = \frac{J_n(x)\, A}{-q} - \frac{J_n(x+\Delta x)}{-q} + (G_n - R_n)\, A\cdot\Delta x \quad \text{—(1)}$$

Change in e^- consentraction w.r.t time and no. of e^- increasing w.r.to time in Box = no. of e^- flowing in Box − no. of e^- flowing out of Box + no of e^- generated in Box − no of e^- hole recombine in Box

Here, ⇒ $-q$ for e^- charge carrier.

$$\frac{\partial n}{\partial t}\cancel{A}\,\cancel{\Delta x} = \frac{J_n(x)\cdot\cancel{A}}{-q}\times\frac{\cancel{\Delta x}}{\Delta x} - \frac{J_n(x+\Delta x)\cdot\cancel{A}}{-q}\frac{\cancel{\Delta x}}{\Delta x} + (G_n - R_n)\,A\,\Delta x$$

$$\frac{\partial n}{\partial t} = \frac{J_n(x)}{-q\times\Delta x} - \frac{J_n(x+\Delta x)}{-q\cdot\Delta x} + (G_n - R_n)$$

$$\frac{\partial n}{\partial t} = \frac{1}{q}\left[\frac{J_n(x+\Delta x)}{\Delta x} - \frac{J_n(x)}{\Delta x}\right] + G_n - R_n$$

$$= \frac{1}{q}\left[\frac{J_n(x+\Delta x) - J_n(x)}{\Delta x}\right] + G_n - R_n$$

$$\boxed{\frac{\partial n}{\partial t} = \frac{1}{q}\times\frac{\partial J_n}{\partial x} + G_n - R_n} \quad \text{—— (2)}$$

Where $J_n(x+\Delta x) - J_n(x)$ Partial diff. equat

Change in hole consentration w. r. t. time :-

$$\frac{\partial p}{\partial t} = \frac{1}{-q}\frac{\partial J_p}{\partial x} + G_p - R_p$$

Proof:- From eqn (1)

$$\frac{\partial p}{\partial t} A\cdot\Delta x = \frac{J_p(x)\cdot A}{q} - \frac{J_p(x+\Delta x)\cdot A}{q} + (G_p - R_p)\,A\cdot\Delta x$$

Here +q for holes charge carriers.

$$\frac{\partial p}{\partial t}\cancel{A}\cdot\cancel{\Delta x} = \frac{J_p(x)\cdot\cancel{A}}{q}\times\frac{\cancel{\Delta x}}{\Delta x} - J_p(x+\Delta x)\frac{\cancel{A}\cdot\cancel{\Delta x}}{\Delta x} + (G_p - R_p)\,A\,\Delta x$$

$$\frac{\partial p}{\partial t} = -\frac{1}{q}\left[\frac{J_p(x+\ldots}{}\right.$$

$$\frac{\partial p}{\partial t} = -\frac{1}{q}\times\frac{\partial J_p}{\partial x} + \ldots$$

eqn (2) & (3) is k...
semiconductor.

$$\frac{\partial p}{\partial t} = -\frac{1}{q}\left[\frac{J_p(x+\Delta x) - J_p(x)}{\Delta x}\right] + (G_p - R_p)\cancel{A\,\Delta x}$$

$$\boxed{\frac{\partial p}{\partial t} = -\frac{1}{q} \times \frac{\partial J_p}{\partial x} + G_p - R_p} \quad \text{—— (3)}$$

eq^n (2) & (3) is k/as continuity equation of semiconductor.