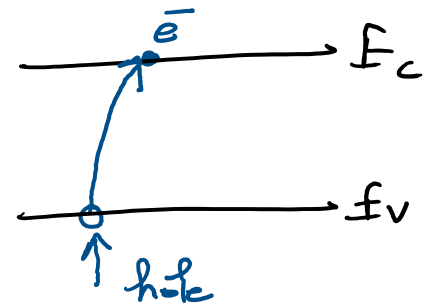
ECE 310 - Lecture 5.

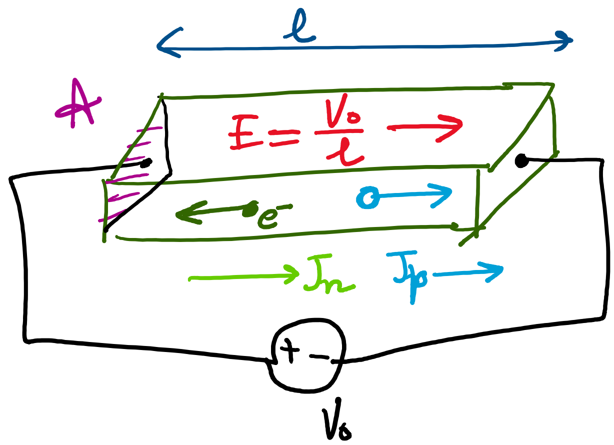
Monday, January 22, 2018   10:34 AM

$$np = n_i^2$$

Transport → Drift

Diffusion



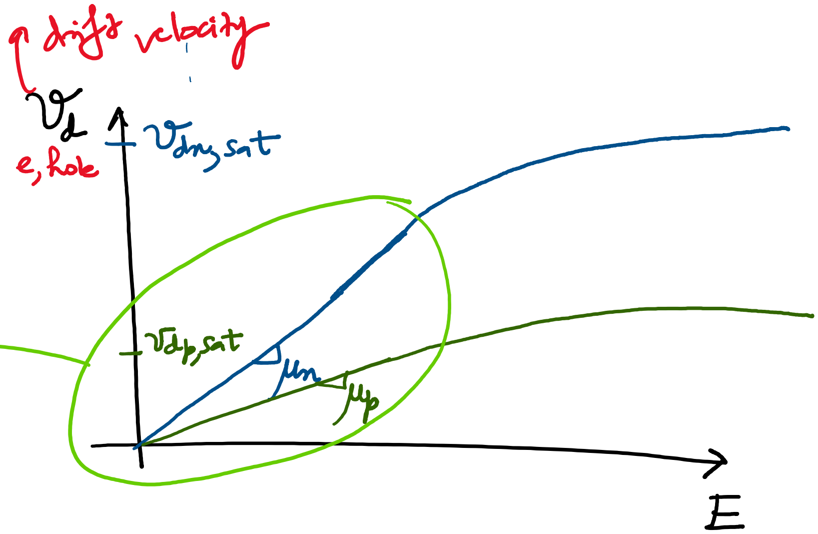


$$J_{tot} = J_n + J_p$$

$$J_n = q\,n\,\mu_n E$$

$$J_p = q\,p\,\mu_p E$$

$$J_{total} = J_n + J_p = q\,(n\mu_n + p\mu_p)\,E$$



for low to moderate Electric fields

$$v_d = \mu E$$

$$v_d = \frac{\mu_0 E}{1 + \frac{\mu_0 E}{v_{dsat}}}$$ ← Better model at high E-fields

$$\mu(T) \propto T^{-3/2}$$

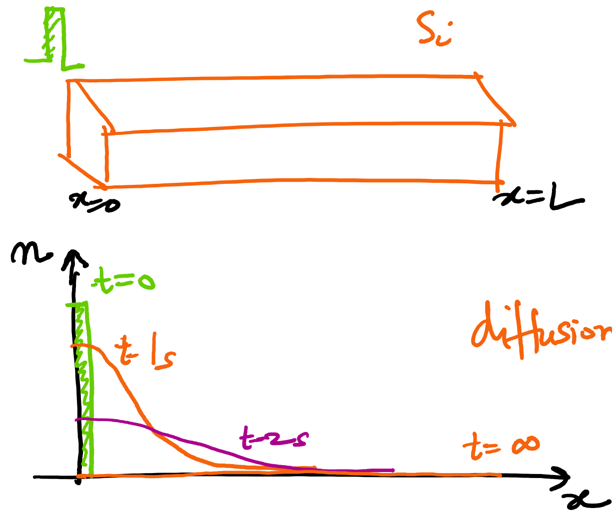
$$E = \frac{V_0}{l}$$

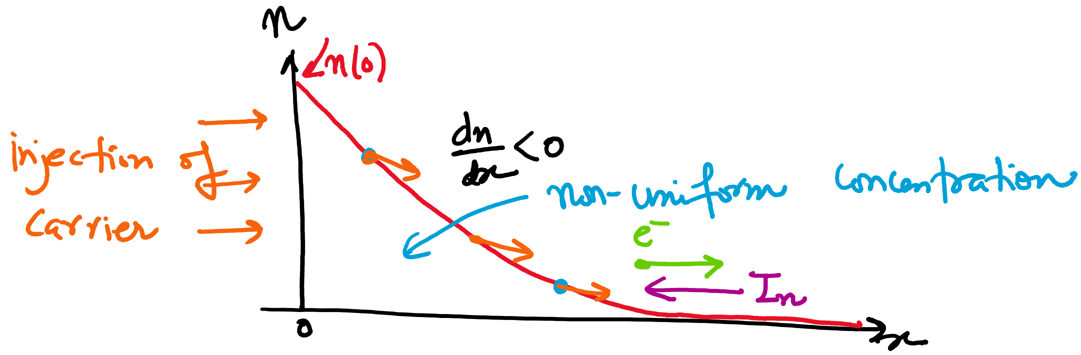
1980 → L = 10 μm

2017 → L = 14 nm

Monday, January 22, 2018 10:55 AM

Diffusion :





Carriers move towards regim of lower concentration

↳ Even in the absence of E-field

↳ current flow as long as the non uniform concentration sustains.

$$\text{rate of electron flow} \propto -\frac{dn}{dx}$$

$$I \propto A(-q)\left(-\frac{dn}{dx}\right) = A\,q\,D_n \cdot \frac{dn}{dx}$$

D_n → Diffusion Coefficient ← cm^2/s

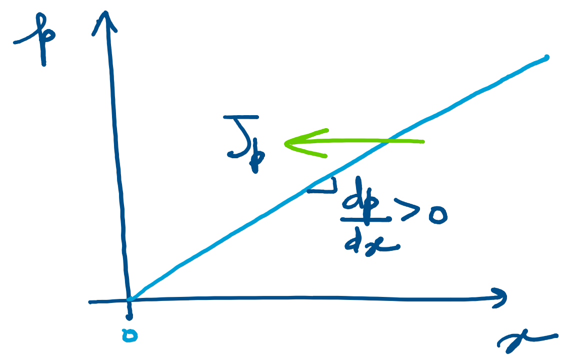
Example : Si → $D_n = 34\ cm^2/s$

$D_p = 12\ cm^2/s$

Example : $Si \Rightarrow D_n = 34\ cm^2/s$

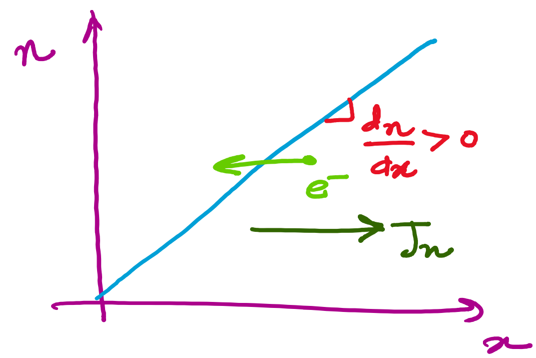
$D_p = 12\ cm^2/s$

$$J_p = -qD_p \cdot \frac{dp}{dx}$$



$$J_{total,\,diff} = J_{n,\,diff} + J_{p,\,diff}$$

$$\boxed{J_{tot,\,diff} = q\left[D_n \frac{dn}{dx} - D_p \frac{dp}{dx}\right]}$$



$\left.\frac{dp}{dx}\right\}$ Concentration "gradients"

$\left.\frac{dn}{dx}\right\}$

$\mu_n \quad \mu_p$

$D_n \quad D_p$

Einstein Relation :

$$\boxed{D = \mu V_T}$$

$V_T \Rightarrow$ Thermal voltage

$= \frac{kT}{q}$

$\simeq 26mV$ at Room Temp ($T = 300K$)

$D_n = \mu_n V_T$

$D_p = \mu_p V_T$

$$\boxed{\frac{\mu_n}{\mu_p} = \frac{D_n}{D_p}}$$