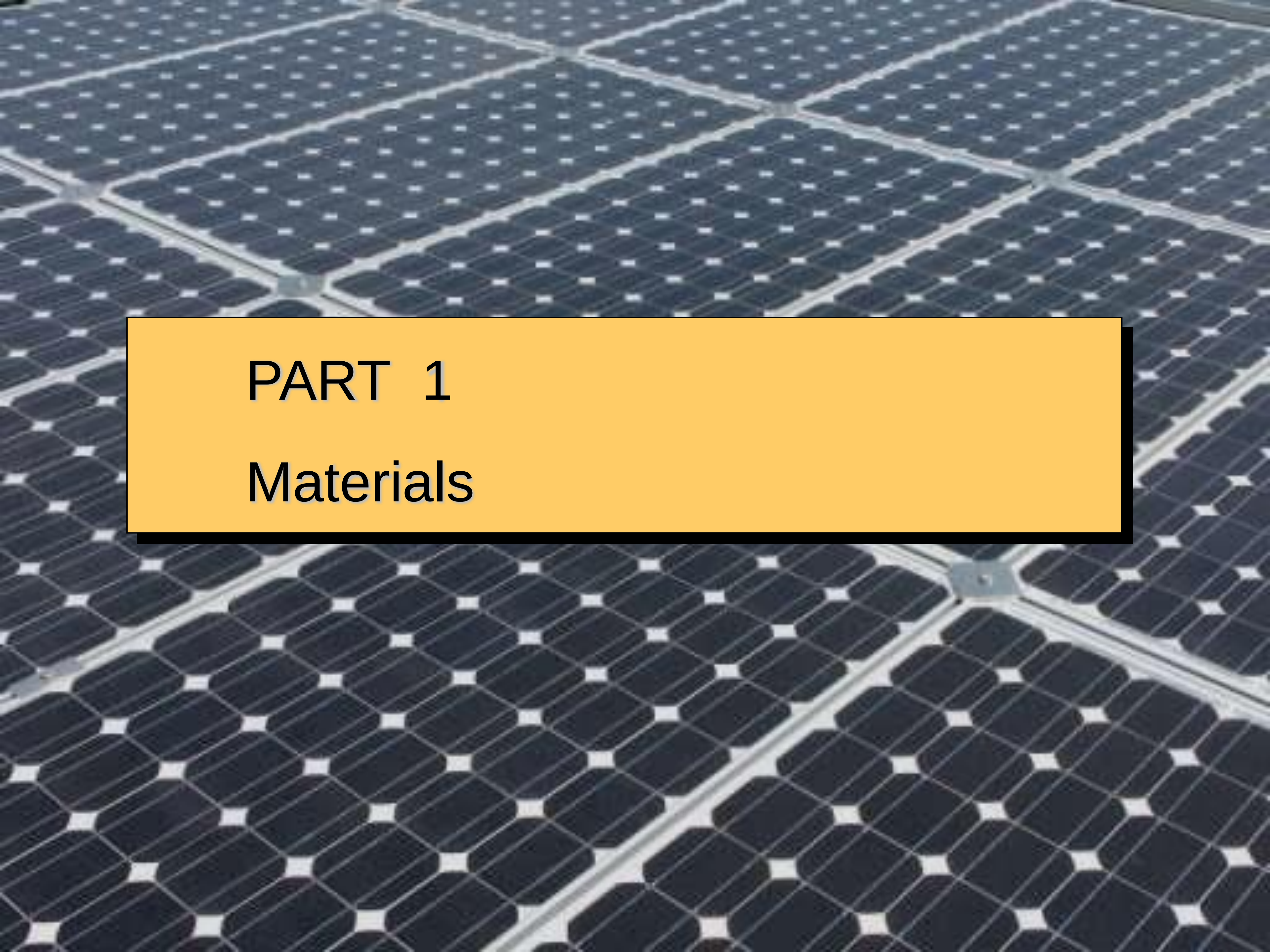
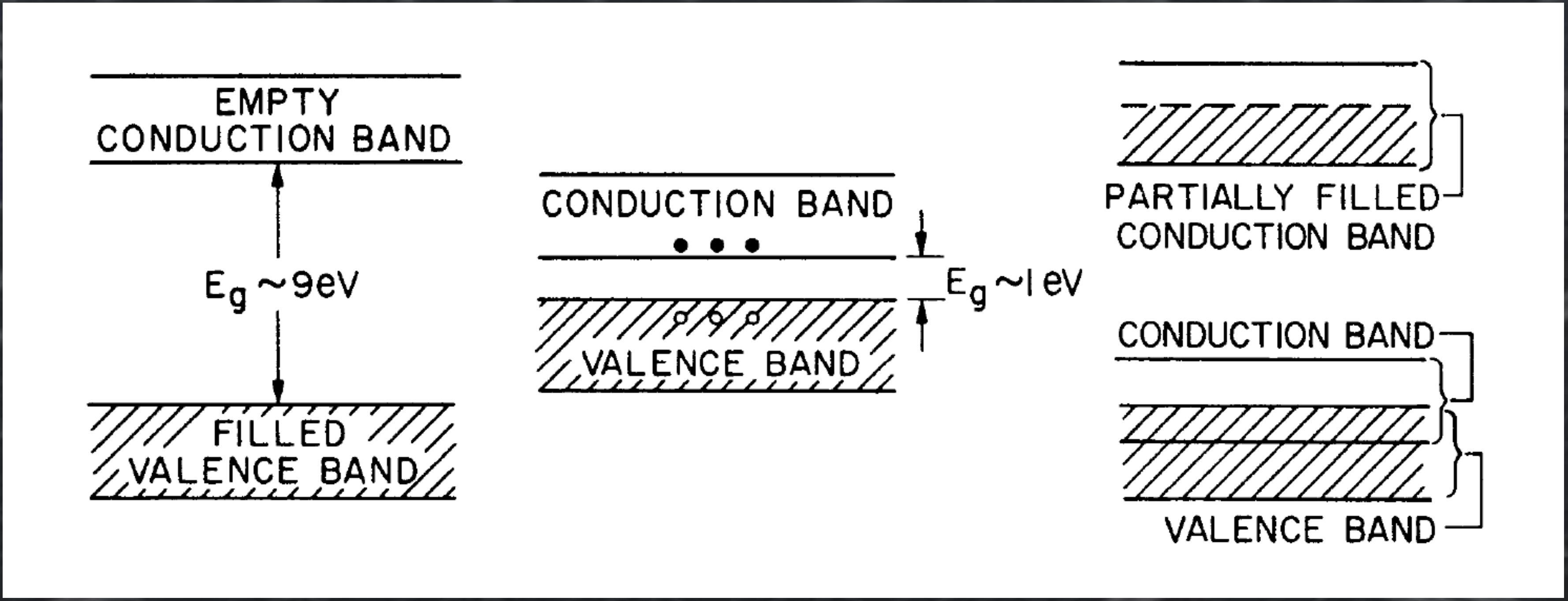


PART 1

Materials

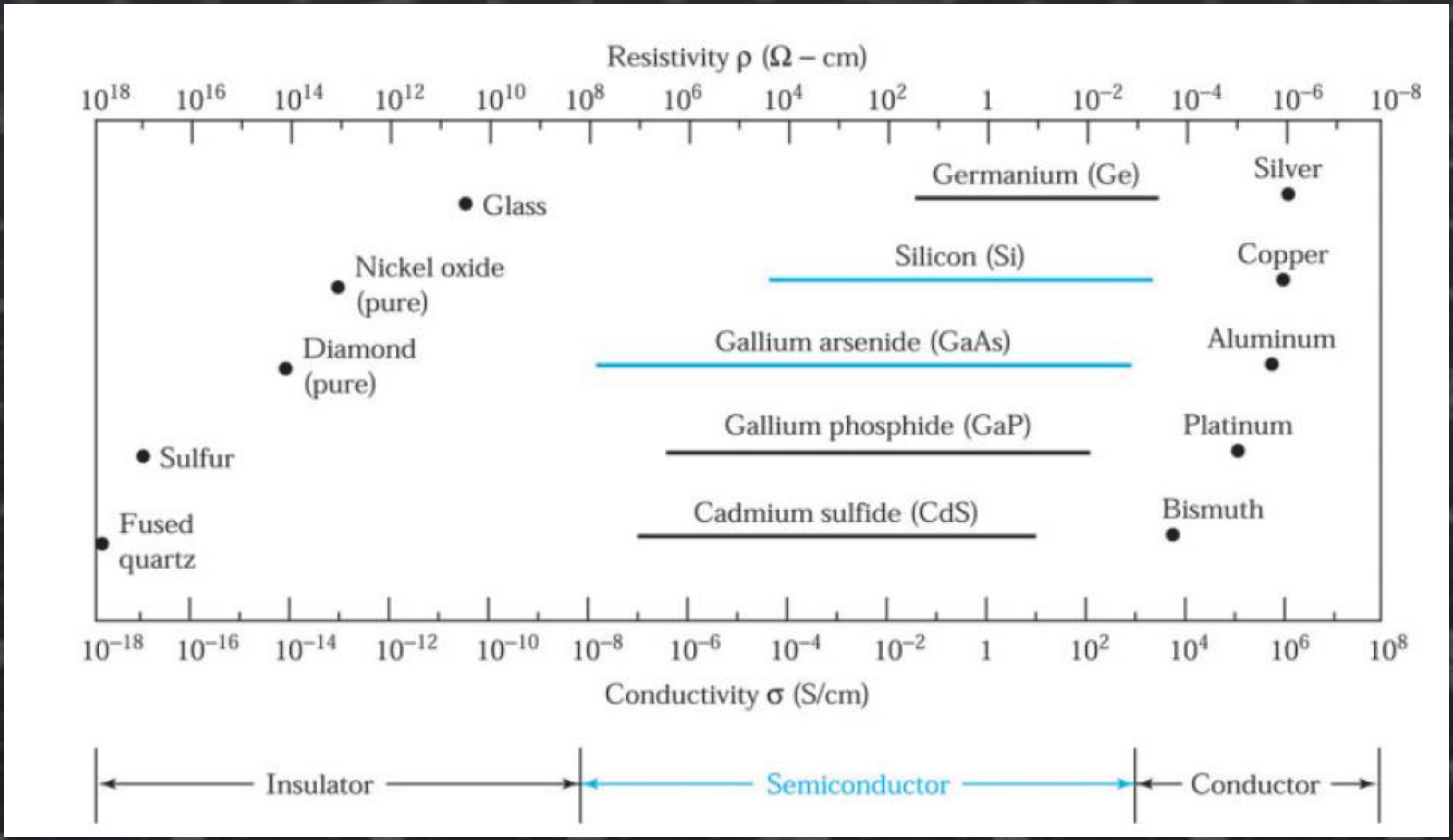
PHYSICS OF SOLAR CELLS

Energy band formation

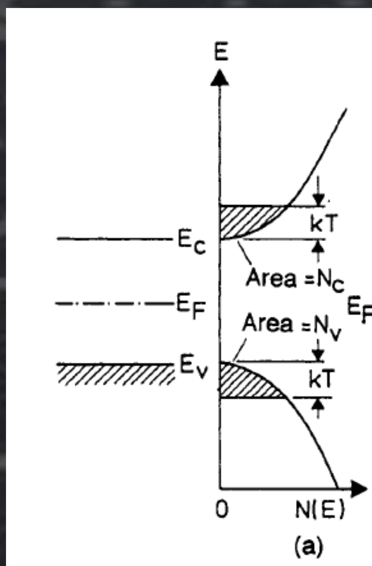


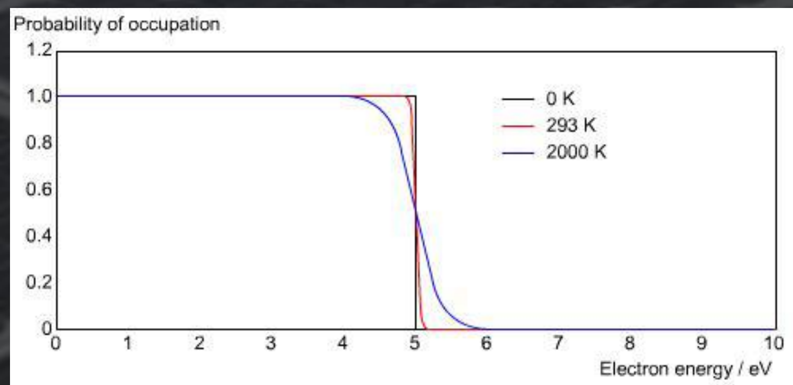
a) Insulator b)Semiconductor c)Conductor

PHYSICS OF SOLAR CELLS



PHYSICS OF SOLAR CELLS

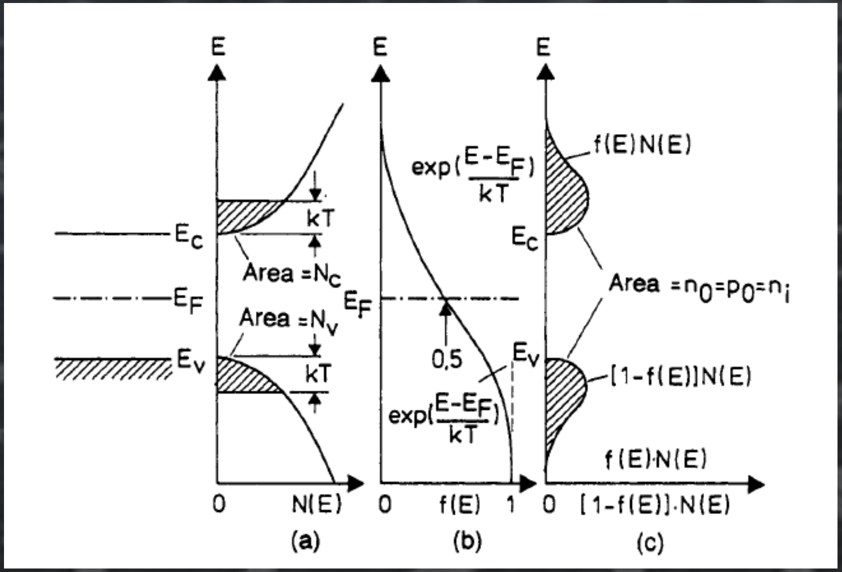




Fermi-Dirac distribution for several temperatures

$$n = \int_{E_c}^{E_{max}} f(E)N(E)\,dE$$

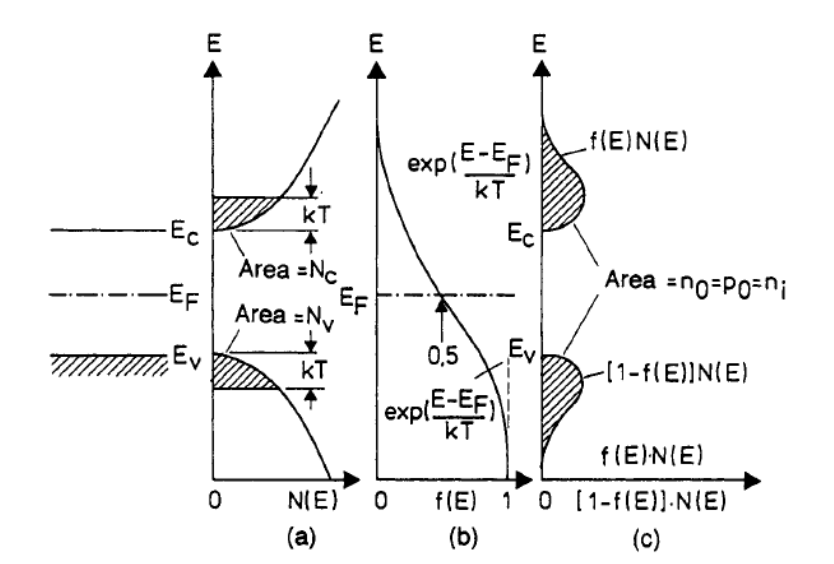
PHYSICS OF SOLAR CELLS



$$n = \int_{E_c}^{E_{max}} f(E)N(E)\,dE$$

$$n = N_C \exp\left(\frac{E_F - E_C}{kT}\right)$$

PHYSICS OF SOLAR CELLS



$$np = N_C N_V \exp\left(\frac{E_V - E_C}{kT}\right) = N_C N_V \exp\left(-\frac{E_g}{kT}\right)$$

$$np = n_i^2$$

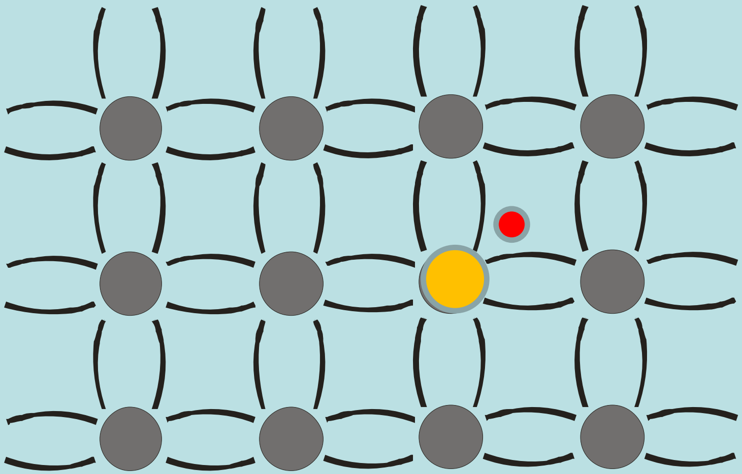
$N_C = 2.86 \times 10^{19}\ \text{cm}^{-3}$ $\quad N_V = 3.10 \times 10^{19}\ \text{cm}^{-3}$ $\quad E_g = 1.124\ \text{eV}$

$n_i = 1.08 \times 10^{10}\ \text{cm}^{-3}$

Para silício a 300K

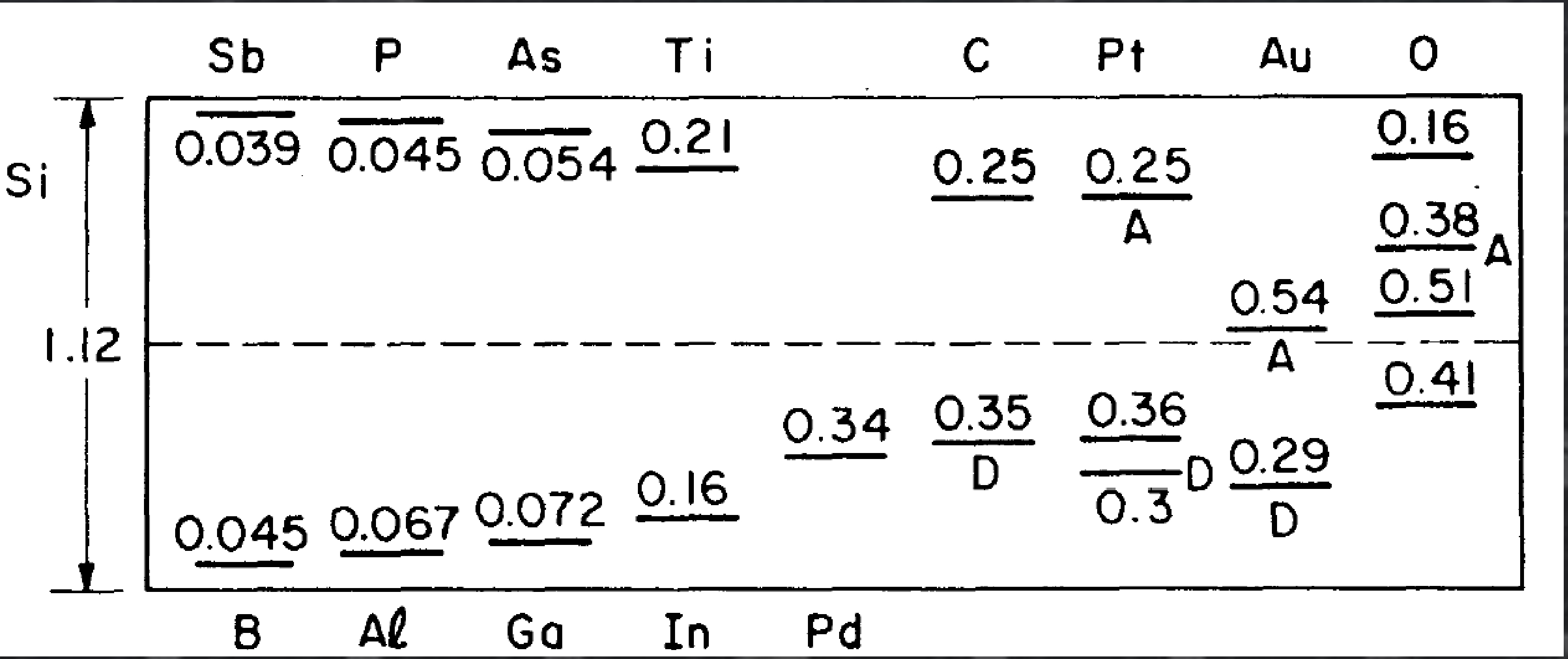
PHYSICS OF SOLAR CELLS

Adding an atom of group V



PHYSICS OF SOLAR CELLS

$E_n = -13.6/n^2$



PHYSICS OF SOLAR CELLS

If we add impurity atoms ND= 10^{16} at/cm^3

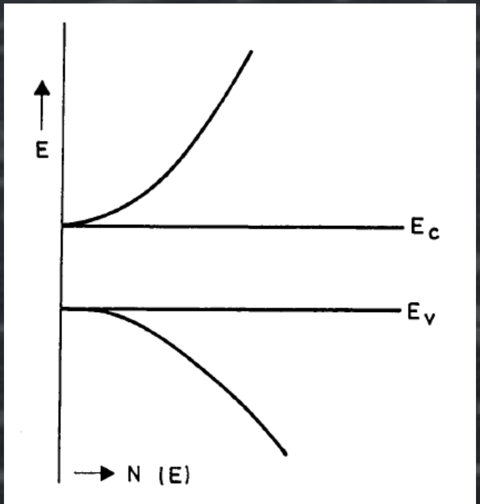
We will have at room temp n= 10^{16} electrons/cm^3

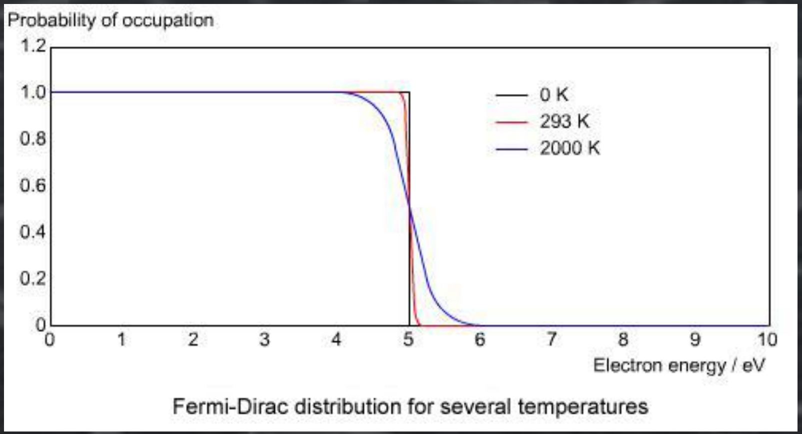
$$p = n_i^2 / N_D^+ = 10^4 \text{ cm}^{-3}$$

In this case n and p are not equal anymore

Since n>>p we call this a n-type semiconductor

PHYSICS OF SOLAR CELLS



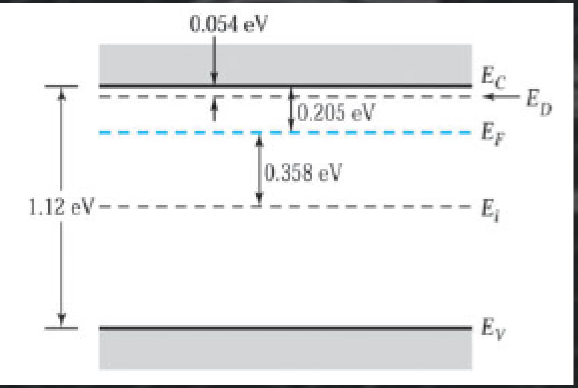


$$n = \int_{E_c}^{E_{max}} f(E)N(E)\,dE$$

$$n = N_C \exp\left(\frac{E_F - E_C}{kT}\right)$$

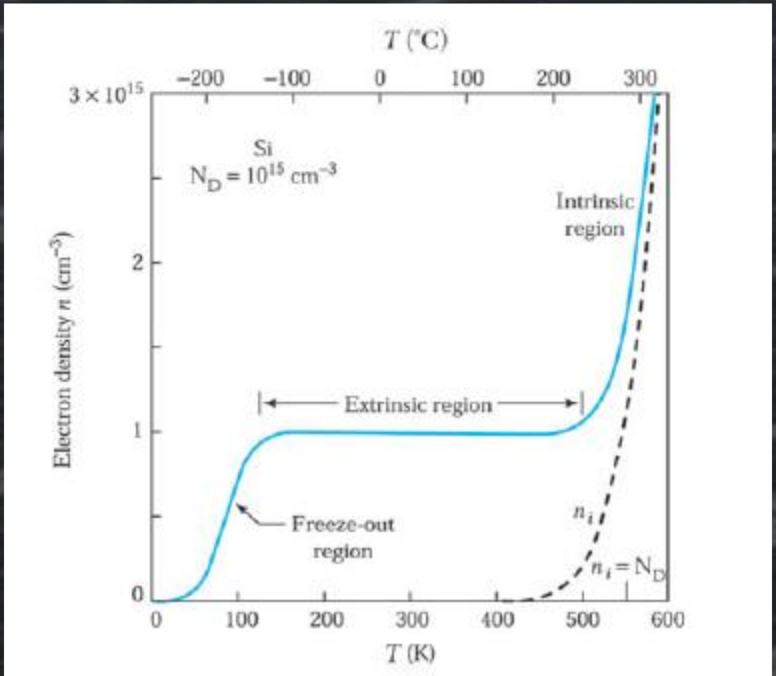
With complete ionization $n = N_D$

$$N_D = N_C \exp\left(\frac{E_F - E_C}{kT}\right)$$



$$E_F - E_C = kT \ln\left(N_D/N_C\right)$$

PHYSICS OF SOLAR CELLS



CHARGE TRANSPORT

There are two mechanismos for charge transport

Electric field

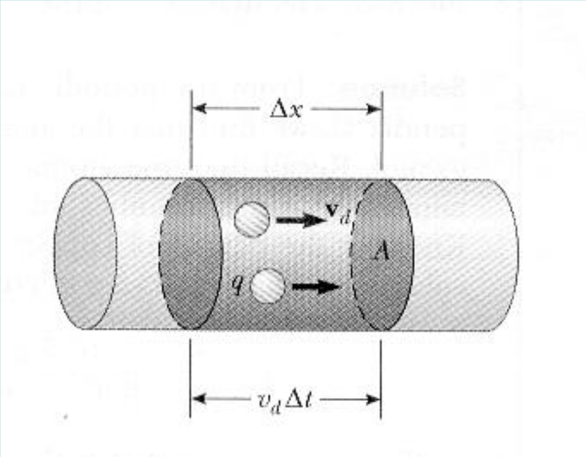
Diffusion

CHARGE TRANSPORT

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = n\, q\, v_{drift}\, A$$

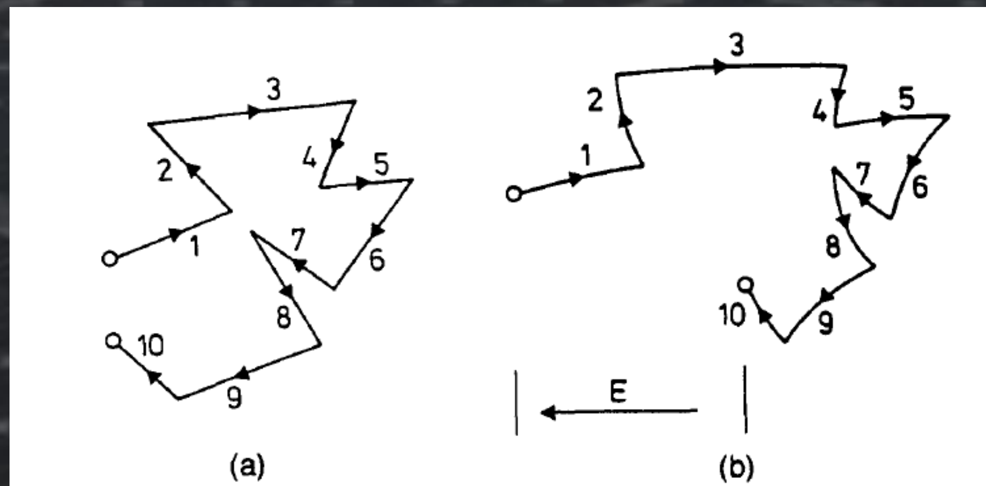
$$j = I_n = n\, q\, v_{drift}$$



$n\, A\Delta x$

$$\Delta Q = (nAv_d\, \Delta t)q$$

CHARGE TRANSPORT



$F = qE$ $F = ma$ $a = qE/m^*$

$V_{drift} = vo + a\, t_{med}$ Tmed= average time between colisions

$$V_{drift} = -\frac{1}{2}\frac{q}{m_n^*}E\bar{t}$$

CHARGE TRANSPORT

$j = I_n = n\, q\, v_{drift}$

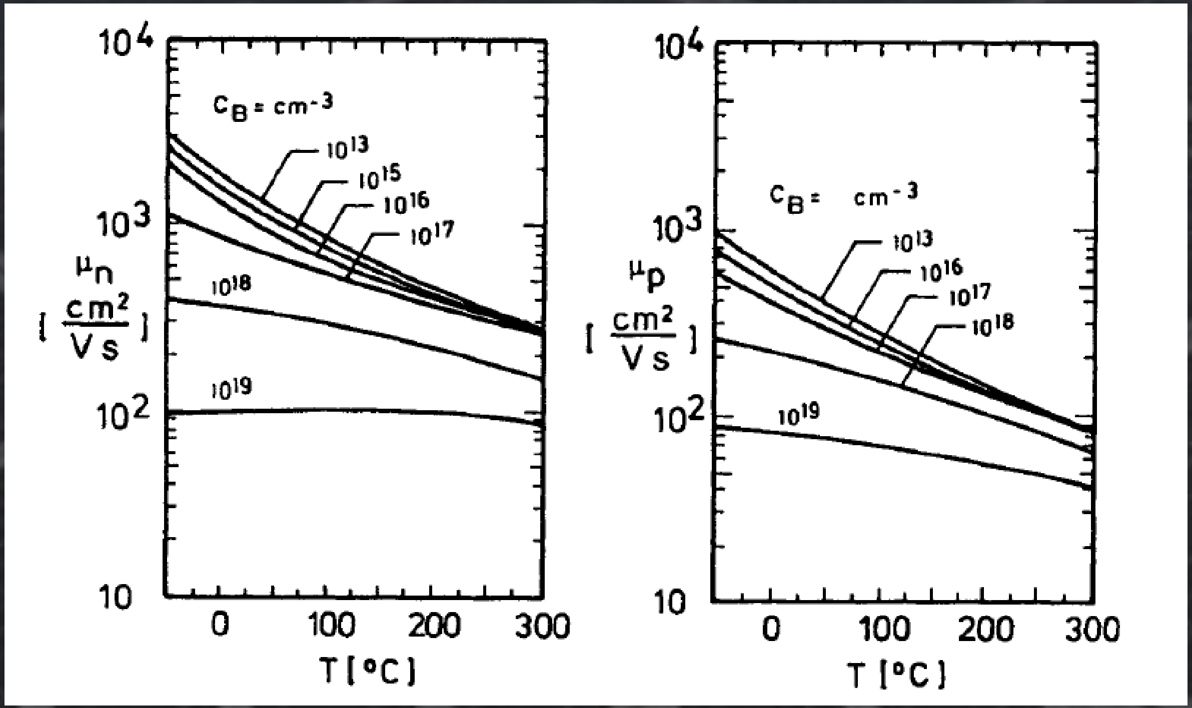
$$\frac{1}{2}\,\frac{q\bar{t}}{m_n^*} = \mu_n$$

$$I_n = n q \mu_n E$$

$$I_n = \sigma E \qquad j = \sigma E$$

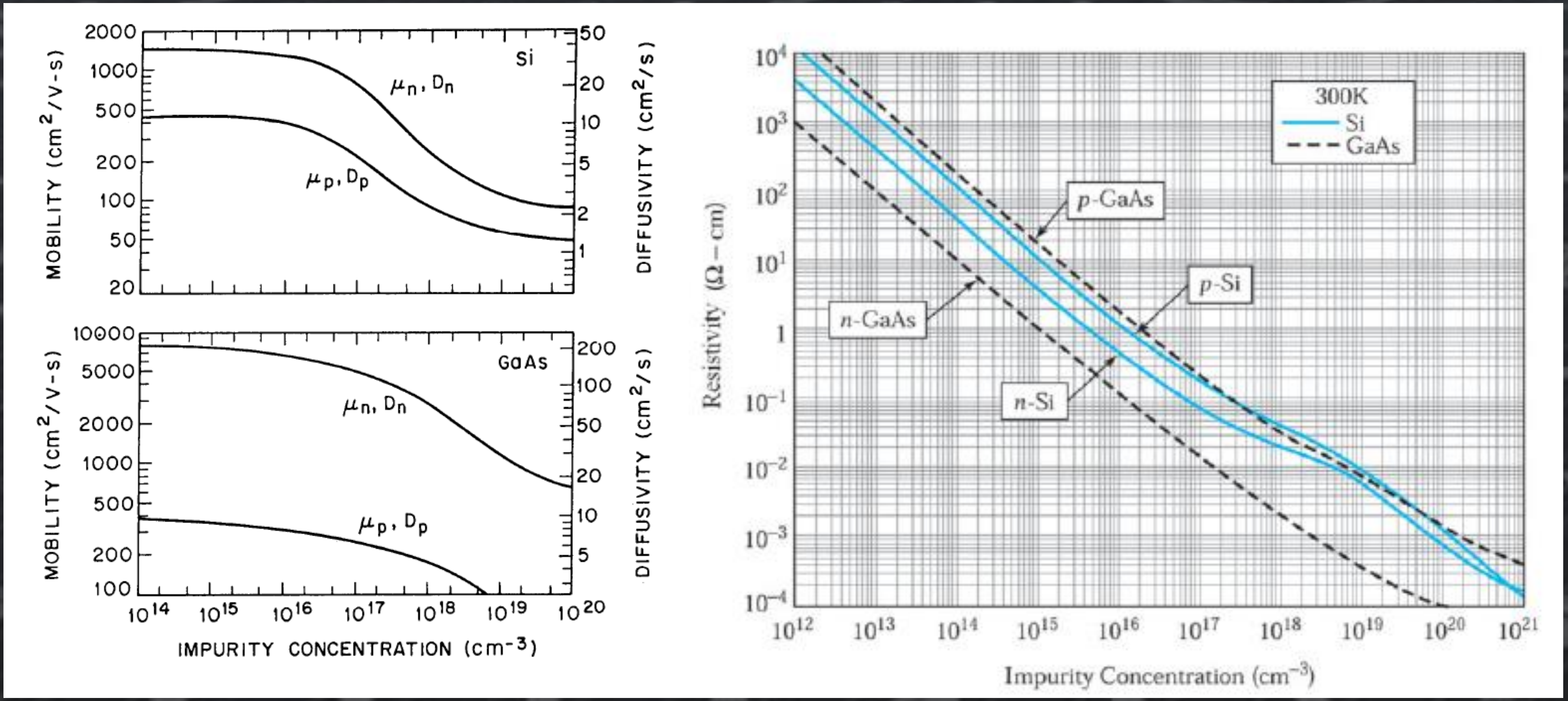
$$\sigma = n q \mu_n$$

$$\sigma = q\,(n\mu_n + p\mu_p)$$

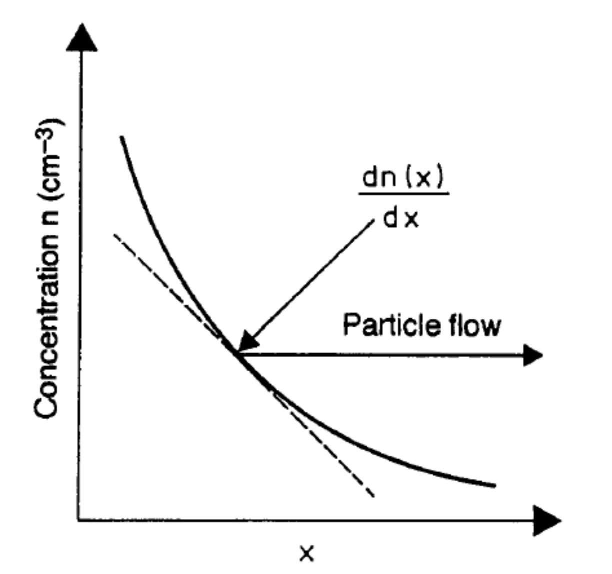


$$\rho = \sigma^{-1} = [q(n\mu_n + p\mu_p)]^{-1}$$

CHARGE TRANSPORT



CHARGE TRANSPORT



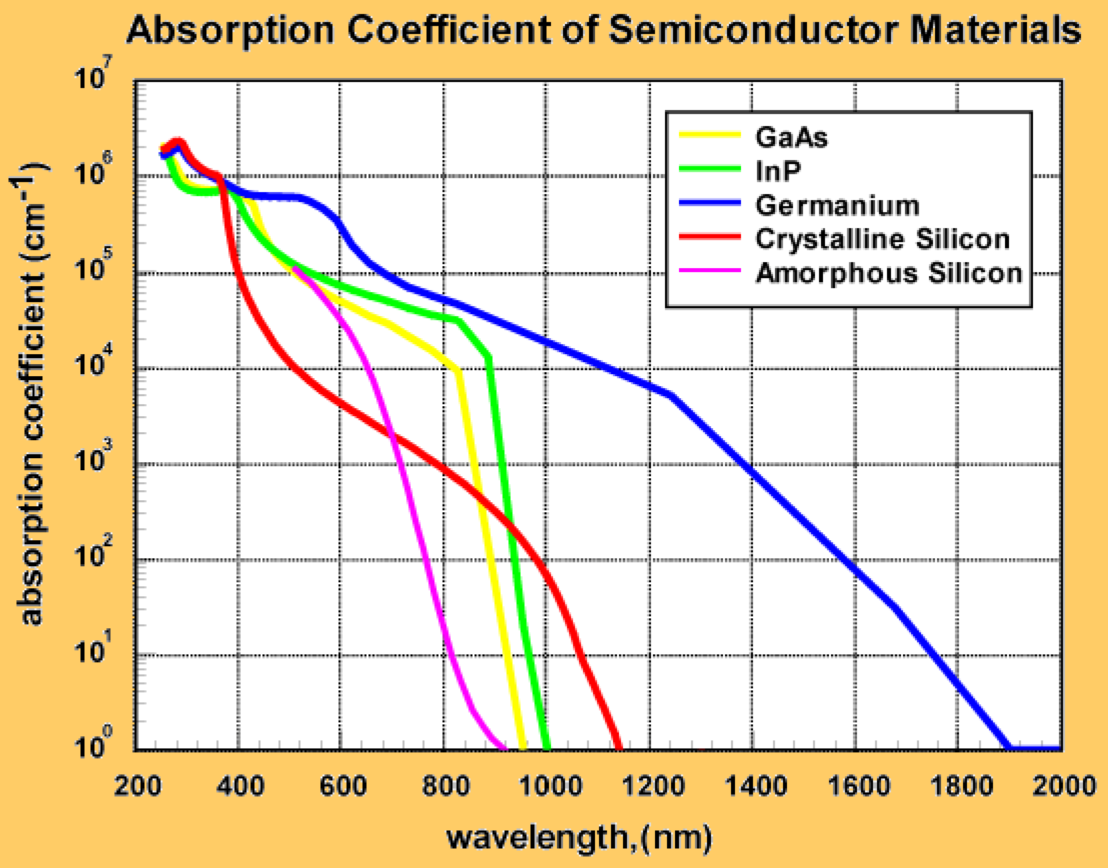
$$\frac{dN}{dt} = -D_n \frac{dn(x)}{dx}$$

$$I_n = -q\frac{dn}{dt} = qD_n\frac{dn(x)}{dx}$$

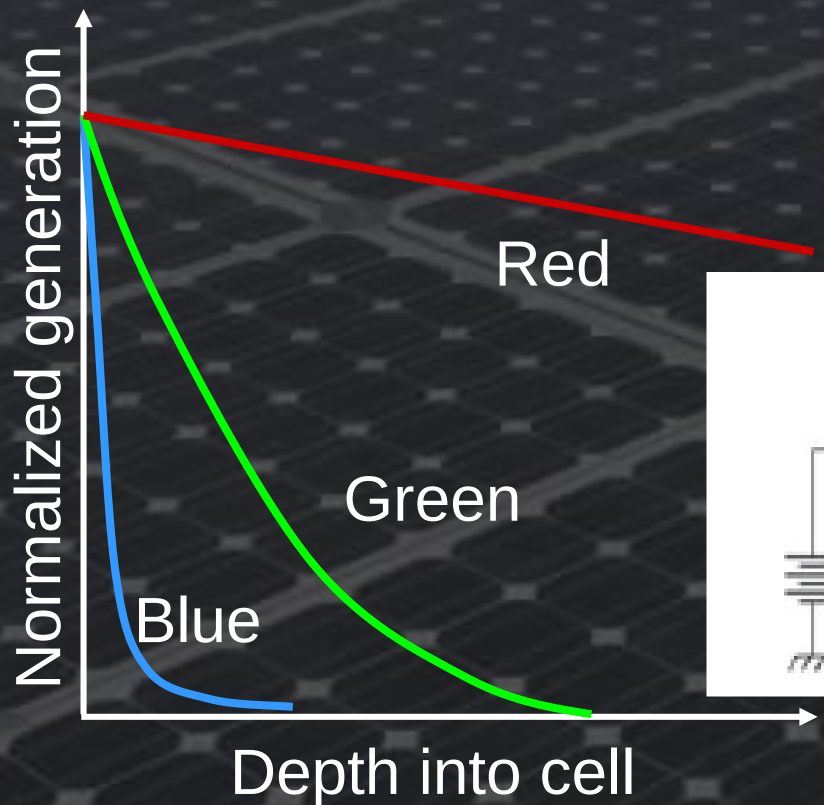
$$I_n = q\left(n\mu_n E + D_n\frac{dn}{dx}\right)$$

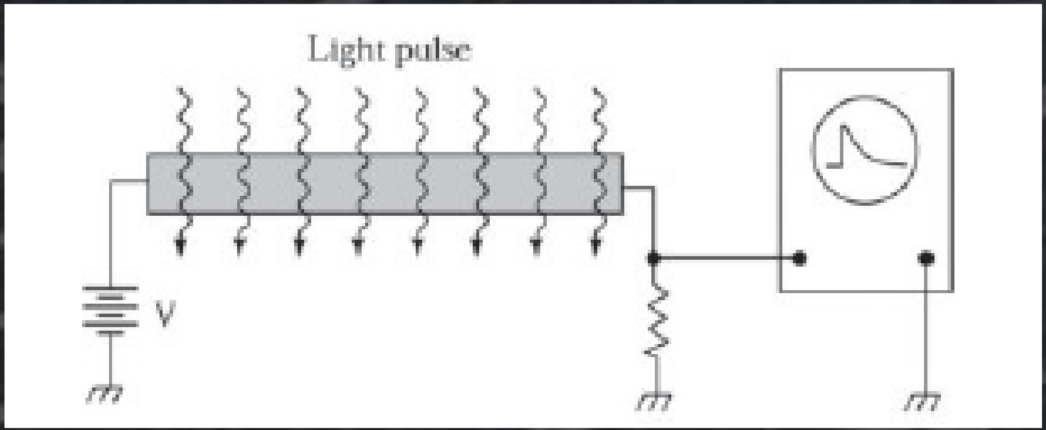
$$D = \frac{kT}{q}\mu$$

GENERATION OF CHARGE



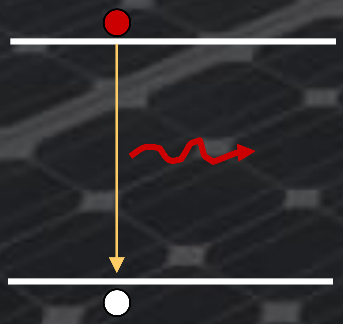
GENERATION OF CHARGE



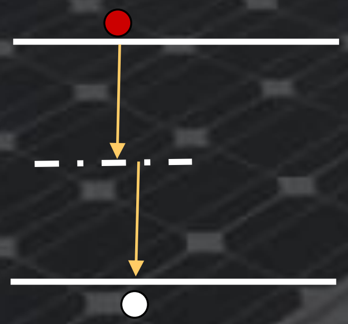


CHARGE RECOMBINATION

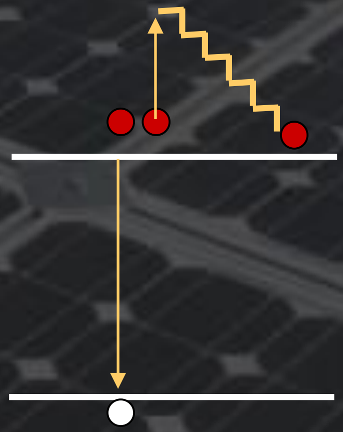
Radiative



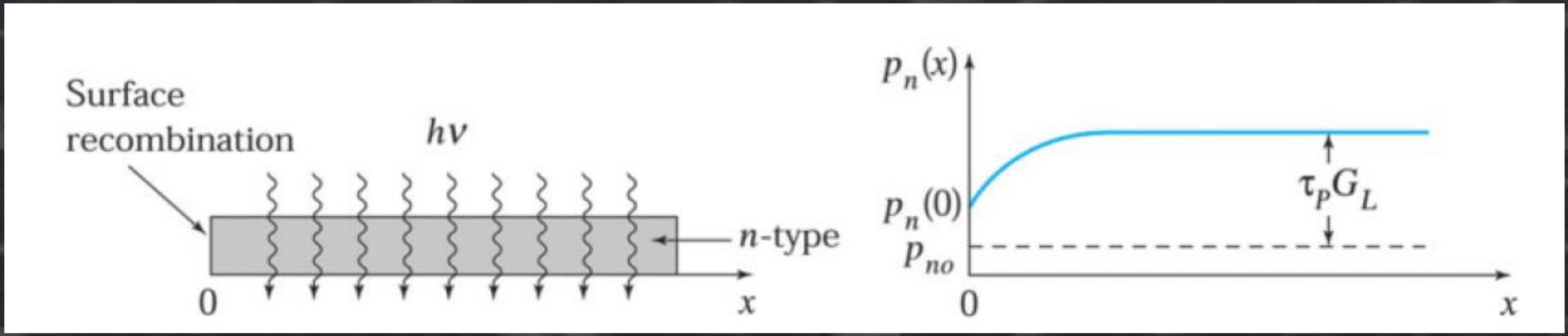
Shockley-Read-Hall

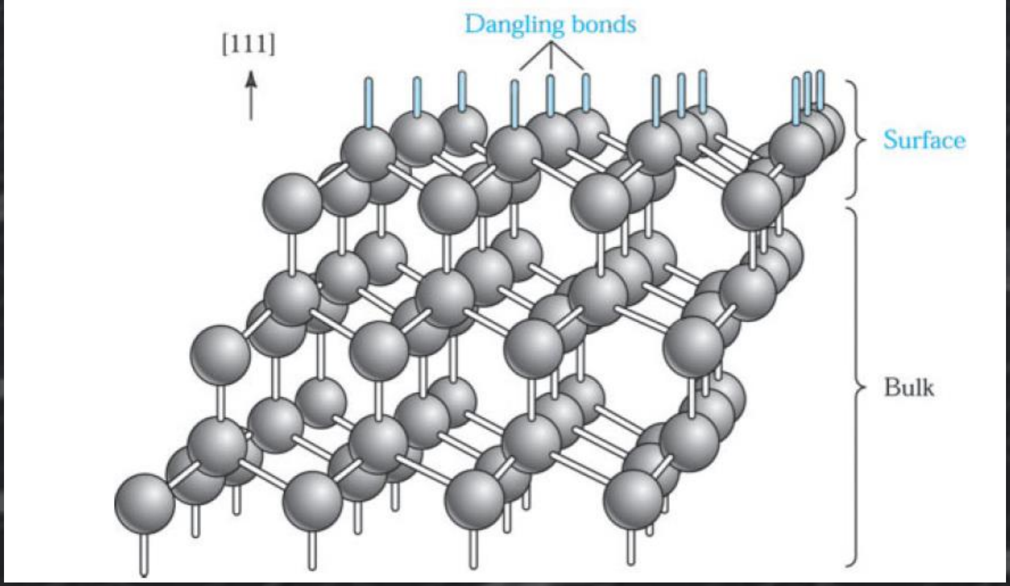


Auger



CHARGE RECOMBINATION

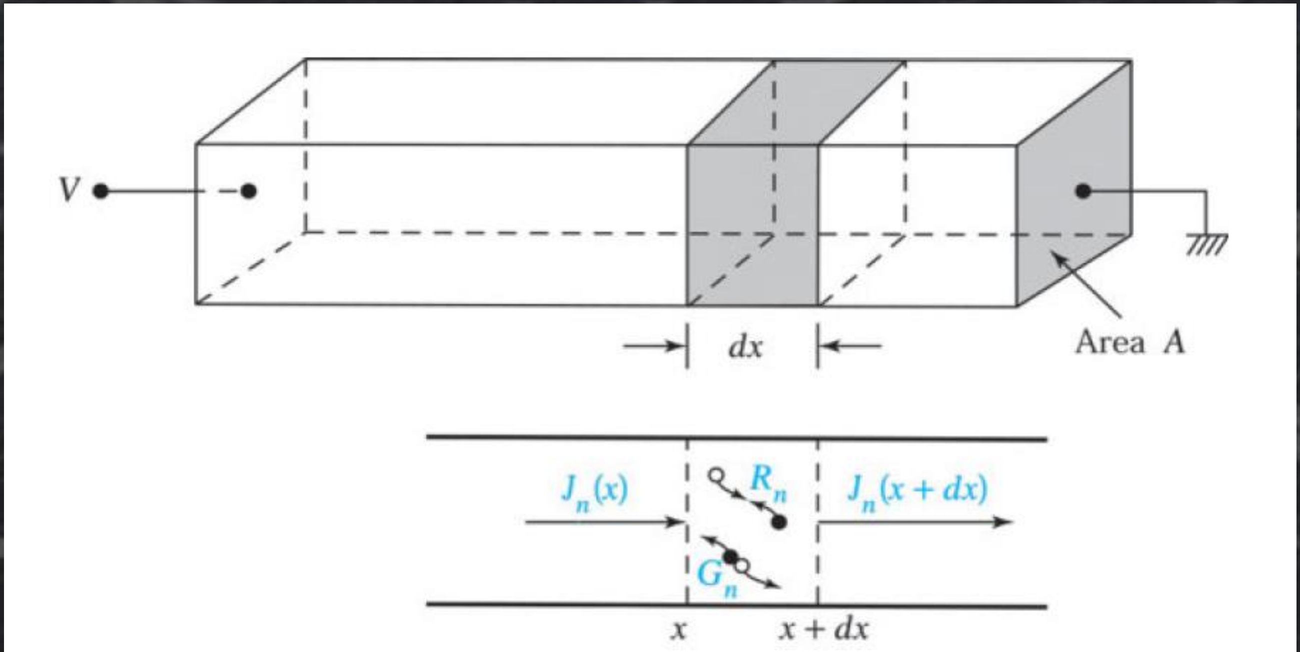




CHARGE RECOMBINATION

$$\tau = \frac{\Delta n}{R}$$

$$\frac{1}{\tau_{total}} = \frac{1}{\tau_{radiation}} + \frac{1}{\tau_{Auger}} + \frac{1}{\tau_{trap}}$$



PHYSICS OF SOLAR CELLS