ELECTRONICS DEVICES AND CIRCUITS

Section A

Conducting Materials

OBJECTIVE

THERMAL CONDUCTIVITY AND WIEDMANN FRANZ LAW

❖ Carrier Diffusion

➢Diffusion current is due to the movement of the carriers from high concentration region towards to low concentration region. As the carriers diffuse, a diffusion current flows. The force behind the diffusion current is the ***random thermal motion of carriers***.

$$\frac{dn}{dx} = \frac{1}{kT} \cdot \frac{dP}{dx}$$

➢ A concentration gradient produces a pressure gradient which produces the force on the charge carriers causing to move them.

How can we produce a concentration gradient in a semiconductor?

1) By making a semiconductor or metal contact.
2) By illuminating a portion of the semiconductor with light.

Illuminating a portion of the semiconductor with light

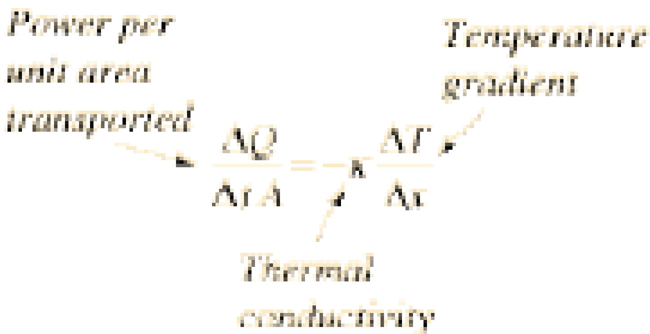
- By means of illumination, electron-hole pairs can be produced when the photon energy>E_g.

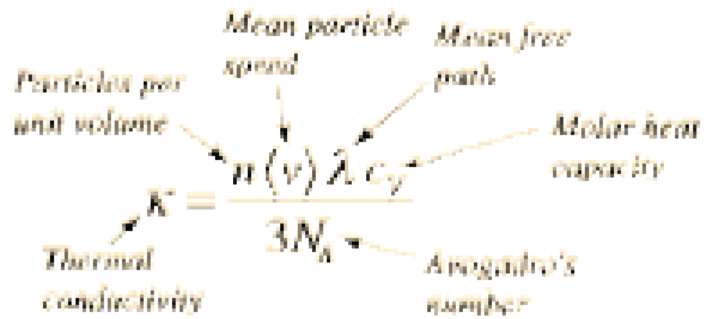
- So the increased number of electron-hole pairs move towards to the lower concentration region until they reach to their equilibrium values. So there is a number of charge carriers crossing per unit area per unit time, which is called as flux. Flux is proportional to the concentration gradient, dn/dx.

$$Flux = -D_n \frac{dn}{dx}$$

Thermal conductivity of metals

- The thermal conductivity is given by:





$$\kappa = \frac{1}{3} c v \ell$$

- For the case of the Fermi gas: $C_{el} = \frac{1}{2}\pi^2 N_e k_B \cdot \frac{T}{T_F}$; $v = v_F$

$$\Rightarrow \quad \kappa = \frac{\pi^2}{3} \cdot \frac{n_e k_B^2 T}{m v_F^2} \cdot v_F \cdot \ell \quad = \frac{\pi^2 n_e k_B^2 T \tau}{3m}$$

- Wiedemann-Franz's law

$$\frac{\kappa}{\sigma} = \frac{\pi^2 n_e k_B^2 T \tau / 3m}{n_e e^2 \tau / m} = \frac{\pi^2}{3} \left(\frac{k_B^2}{e} \right)^2 T$$