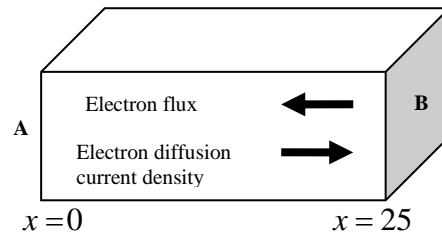


Answer to Tutorial questions – 02

ME4252 Nanomaterial for Energy Engineering

- Figure shows the directions of electron diffusion flux and current densities in a rectangular bar of Silicon and x is measured in μm . The electron concentration varies linearly from 1×10^{17} to $7 \times 10^{16} \text{ cm}^{-3}$ between the two ends at $T = 300 \text{ K}$. Calculate the diffusion current density, if the electron mobility is, $\mu_n = 9.62 \times 10^3 \text{ cm}^2 \text{ V}^{-1} \text{ sec}^{-1}$



Answer:

$$J_n|_{diff} = 480 \text{ A/cm}^2$$

- The intrinsic carrier density at 300 K in silicon is $1.5 \times 10^{16} \text{ m}^{-3}$. If the electron and hole mobilities are 0.13 and $0.05 \text{ m}^2 \text{ V}^{-1} \text{ s}^{-1}$, respectively, calculate the conductivity of (a) intrinsic silicon and (b) silicon containing 1 donor impurity atom per 10^8 silicon atoms. The atomic weight of Si is 28.09 g/mole and its density is $2.33 \times 10^3 \text{ kg/m}^3$.

Answer:

(a) $\sigma_i = 0.432 \times 10^{-3} \Omega^{-1} \text{ m}^{-1}$

(b) $\sigma_{ext} = 10.4 \Omega^{-1} \text{ m}^{-1}$

- The intrinsic carrier concentration in Si is found to be no greater than $1 \times 10^{12} \text{ cm}^{-3}$. Assume $E_g = 1.12 \text{ eV}$. Determine the maximum temperature allowed for Si. Given: $N_C \approx 2.8 \times 10^{19} \text{ cm}^{-3}$ and $N_V = 1.04 \times 10^{19} \text{ cm}^{-3}$.

Answer:

$$T_{max} = 390 \text{ K}$$

- Germanium has the same crystal structure as silicon but its band gap is 0.67 eV . If the total density of states in the conduction band (N_c) and in the valence band (N_v) are the same as they are for silicon, what value of n_i would you expect for Ge at 300 K ? Assume $n_i = 10^{10} / \text{cm}^3$ and $E_g = 1.12 \text{ eV}$.

Answer:

For Ge:

$$n_i = 6.1 \times 10^{13} \text{ cm}^{-3}$$

This is 6000 times larger because the band-gap is smaller.
