Semiconductor Electronics

NCERT Examples

Ex 1. For semiconductors, bandgap energy $E_g < 3 eV$. For carbon, $E_g \sim 5.5$ eV, for Si, $E_g \sim 1.1$ eV and for Ge, $E_g \sim 0.66$ eV.

Here E_g for carbon (5.5 eV) > 3 eV. So carbon is and insulator but the values of E_g for Si and Ge are less than 3 eV so these are semiconductors.

OR

Due to the higher value of E_g for carbon (5.5 eV), Energy required to take out an electron from carbon atom is much higher, hence no. of free electrons are negligibly small in carbon which makes it insulator.

Ex. 2 Given,

$N_{Si} = 5 \times 10^{28}$ atoms / m^3

doping concentration of As,

$1 \text{ ppm} = \frac{1}{10^6}$

So no. of donor atoms $N_D = \frac{N_{Si}}{10^6}$

$= \frac{5 \times 10^{28}}{10^6}$

$N_D = 5 \times 10^{22}$ atoms/m3

$n_i = 1.5 \times 10^{16} \, m^{-3}$ (intrinsic carrier concentration)

$n_e = ?$ $\quad n_h = ?$

For no. of electrons, n_e

here $N_D \simeq n_e$

so $n_e = 5 \times 10^{22}\ m^{-3}$ Ans

For no. of holes, n_h

by $n_i^2 = n_e n_h$

$$n_h = \frac{n_i^2}{n_e} = \frac{(1.5 \times 10^{16})^2}{5 \times 10^{22}}$$

$$= \frac{\overset{0.3}{\cancel{1.5}} \times 1.5}{\cancel{5}} \times 10^{32-22}$$

$$= 0.45 \times 10^{10}$$

$$n_h = 4.5 \times 10^{9}\ m^{-3}$$ Ans

Ex.3 No, we cannot create p-n junction by joining slabs of p-type and n-type semiconductors, physically because the surfaces of slabs have roughness much larger than atomic spacing (2Å to 3Å). This prevents atomic level continuity, so the interface acts like a barrier to charge carriers and the depletion region will not form.

Ex.4 Consider the graph as a straight line b/w I = 10 mA to I = 20 mA. [1 mA = 10^{-3} A]

(a) Now the dynamic resistance, for, V = 0.7 V to 0.8 V

$$(r_d)_{F.B} = \frac{\Delta V}{\Delta I} = \frac{0.8 - 0.7}{(20-10) \times 10^{-3}}$$

$$= \frac{0.1}{10 \times 10^{-3}}$$

$= 0.1 \times 10^{2}$

$(r_d)_{FB} = 10\,\Omega$ Ans

(b) From the curve at $V = -10\,V$, $I = -1\,\mu A$

$I = -1 \times 10^{-6}\,A$

$(r_d)_{RB} = \frac{V}{I}$ [I Constant]

$= \frac{-10}{-1 \times 10^{-6}}$

$= 10 \times 10^{6}$

$(r_d)_{RB} = 10^{7}\,\Omega$

Ans