

$$n_p = \frac{n_i^2}{p_p} = \frac{(1.8 \times 10^6)^2}{1.3 \times 10^{17}} \quad \text{or} \quad \underline{n_p = 2.49 \times 10^5 \text{ cm}^{-3}}$$

(b) Silicon:

$$\sigma = \frac{1}{\rho} = e\mu_n n_p$$

or

$$n_p = \frac{1}{\rho e \mu_n} = \frac{1}{(8)(1.6 \times 10^{-19})(1350)}$$

or

$$\underline{n_p = 5.79 \times 10^{11} \text{ cm}^{-3}}$$

and

$$p_p = \frac{n_i^2}{n_p} = \frac{(1.5 \times 10^{10})^2}{5.79 \times 10^{11}} \Rightarrow \underline{p_p = 3.89 \times 10^7 \text{ cm}^{-3}}$$

Note: For the doping concentrations obtained in part (b), the assumed mobility values are valid.

5.9

$$\sigma_s = e n_i (\mu_n + \mu_p)$$

Then

$$10^{-4} = (1.6 \times 10^{-19})(1000 + 600)n_i$$

or

$$\underline{n_i(300\text{K}) = 3.91 \times 10^7 \text{ cm}^{-3}}$$

Now

$$n_i^2 = N_A N_D \exp\left(\frac{-E_g}{kT}\right)$$

or

$$E_g = kT \ln\left(\frac{N_A N_D}{n_i^2}\right) = (0.0259) \ln\left[\frac{(10^{17})^2}{(3.91 \times 10^7)^2}\right]$$

or

$$\underline{E_g = 1.122 \text{ eV}}$$

Now

$$\begin{aligned} n_i^2(500\text{K}) &= (10^{17})^2 \exp\left[\frac{-1.122}{(0.0259)(500/300)}\right] \\ &= 5.15 \times 10^{16} \end{aligned}$$

or

$$\underline{n_i(500\text{K}) = 2.27 \times 10^{16} \text{ cm}^{-3}}$$

Then

$$\sigma_s = (1.6 \times 10^{-19})(2.27 \times 10^{16})(1000 + 600)$$

so

$$\underline{\sigma_s(500\text{K}) = 5.81 \times 10^{-4} (\Omega \cdot \text{cm})^{-1}}$$

5.10

(a) (i) Silicon: $\sigma_s = e n_i (\mu_n + \mu_p)$

$$\sigma_s = (1.6 \times 10^{-19})(1.5 \times 10^{10})(1350 + 480)$$

or

$$\underline{\sigma_s = 4.39 \times 10^{-8} (\Omega \cdot \text{cm})^{-1}}$$

(ii) Ge:

$$\sigma_s = (1.6 \times 10^{-19})(2.4 \times 10^{11})(3900 + 1900)$$

or

$$\underline{\sigma_s = 2.23 \times 10^{-7} (\Omega \cdot \text{cm})^{-1}}$$

(iii) GaAs:

$$\sigma_s = (1.6 \times 10^{-19})(1.8 \times 10^6)(8500 + 400)$$

or

$$\underline{\sigma_s = 2.56 \times 10^{-6} (\Omega \cdot \text{cm})^{-1}}$$

(b) $R = \frac{L}{\sigma A}$

(i) $R = \frac{200 \times 10^{-4}}{(4.39 \times 10^{-8})(85 \times 10^{-4})} \Rightarrow$
 $\underline{R = 5.36 \times 10^7 \Omega}$

(ii) $R = \frac{200 \times 10^{-4}}{(2.23 \times 10^{-7})(85 \times 10^{-4})} \Rightarrow$
 $\underline{R = 1.06 \times 10^7 \Omega}$

(iii) $R = \frac{200 \times 10^{-4}}{(2.56 \times 10^{-6})(85 \times 10^{-4})} \Rightarrow$
 $\underline{R = 9.19 \times 10^{11} \Omega}$

5.11

(a) $\rho = 5 = \frac{1}{e \mu_n N_A}$

Assume $\mu_n = 1350 \text{ cm}^2/\text{V} \cdot \text{s}$

Then

$$\begin{aligned} N_A &= \frac{1}{(1.6 \times 10^{-19})(1350)(5)} \Rightarrow \\ \underline{N_A = 9.26 \times 10^{16} \text{ cm}^{-3}} \end{aligned}$$

(b)

$$T = 200\text{K} \rightarrow T = -75^\circ\text{C}$$

$$T = 400\text{K} \rightarrow T = 125^\circ\text{C}$$

From Figure 5.2,

$$T = -75^\circ\text{C}, N_A = 10^{16} \text{ cm}^{-3} \Rightarrow$$

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