

- 7.16** An abrupt silicon pn junction at $T = 300$ K has impurity doping concentrations of $N_a = 5 \times 10^{16} \text{ cm}^{-3}$ and $N_d = 10^{15} \text{ cm}^{-3}$. Calculate (a) V_{bi} , (b) W at (i) $V_R = 0$ and (ii) $V_R = 5$ V, and (c) $|E_{\max}|$ at (i) $V_R = 0$ and (ii) $V_R = 5$.

Table B.4, $\epsilon_r = 11.7$ + $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ @ 300K

$$a) \quad (7.10) \quad V_{bi} = \frac{k_B T}{e} \ln \left(\frac{N_a N_d}{n_i^2} \right) = V_t \ln \left(\frac{N_a N_d}{n_i^2} \right)$$

$$V_t = \frac{8.617333 \times 10^{-5} \text{ eV/K} (300\text{K})}{e} = 0.025852 \text{ V}$$

$$V_{bi} = 0.025852 \ln \left(\frac{5 \times 10^{16} (10^{15})}{(1.5 \times 10^{10})^2} \right) \Rightarrow \underline{\underline{V_{bi} = 0.67543 \text{ V}}}$$

$$b) \quad (i) \quad \text{Per (7.31), } W_{OV} = \left\{ \frac{2 \epsilon_s V_{bi}}{e} \left(\frac{N_a + N_d}{N_a N_d} \right) \right\}^{1/2}$$

$$W_{OV} = \left\{ \frac{2(11.7)8.8542 \times 10^{-12} (0.67543)}{1.6021766 \times 10^{-19}} \left(\frac{5 \times 10^{22} + 10^{21}}{5 \times 10^{22} (10^{21})} \right) \right\}^{1/2}$$

$$\underline{\underline{W_{OV} = 9.43884 \times 10^{-7} \text{ m} = 0.94388 \mu\text{m}}}$$

$$(ii) \quad \text{Per (7.34)} \quad W_{SV} = \left\{ \frac{2 \epsilon_s (V_{bi} + V_R)}{e} \left(\frac{N_a + N_d}{N_a N_d} \right) \right\}^{1/2}$$

$$W_{SV} = \left\{ \frac{2(11.7)8.8542 \times 10^{-12} (5.67543)}{1.6021766 \times 10^{-19}} \left(\frac{5 \times 10^{22} + 10^{21}}{5 \times 10^{22} (10^{21})} \right) \right\}^{1/2}$$

$$\underline{\underline{W_{SV} = 2.73607 \times 10^{-6} \text{ m} = 2.73607 \mu\text{m}}}$$

$$c) \quad (7.37) \quad E_{\max} = -\frac{2(V_{bi} + V_R)}{W}$$

$$(i) \quad |E_{\max}|_{OV} = \left| \frac{-2(0.67543 + 0)}{9.43884 \times 10^{-7}} \right| \Rightarrow \underline{\underline{|E_{\max}|_{OV} = 1.4312 \frac{\text{MV}}{\text{m}}}}$$

$$(ii) \quad |E_{\max}|_{SV} = \left| \frac{-2(5.67543)}{2.736 \times 10^{-6}} \right| \Rightarrow \underline{\underline{|E_{\max}|_{SV} = 4.1486 \frac{\text{MV}}{\text{m}}}}$$