

VE311 Homework 3

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Problem 1.

(a)

$$\phi_j = V_T \ln \frac{N_A N_D}{n_i^2} = 0.025 \text{ V} \cdot \ln \frac{10^{19} \text{ cm}^{-3} \cdot 10^{18} \text{ cm}^{-3}}{(10^{10} \text{ cm}^{-3})^2} \approx 0.979 \text{ V}$$

$$\begin{aligned} w_{do} &= \sqrt{\frac{2\varepsilon_s}{q} \left(\frac{1}{N_A} + \frac{1}{N_D} \right) \phi_j} \\ &= \sqrt{\frac{2 \cdot 11.7 \cdot 8.85 \times 10^{-14} \text{ F/cm}}{1.60 \times 10^{-19} \text{ C}} \left(\frac{1}{10^{19} \text{ cm}^{-3}} + \frac{1}{10^{18} \text{ cm}^{-3}} \right) 0.979 \text{ V}} \\ &\approx 3.73 \times 10^{-2} \mu\text{m} \end{aligned}$$

(b)

$$\begin{aligned} x_p &= \frac{w_{do}}{1 + \frac{N_A}{N_D}} = \frac{3.73 \times 10^{-2} \mu\text{m}}{1 + \frac{10^{19} \text{ cm}^{-3}}{10^{18} \text{ cm}^{-3}}} \approx 3.39 \times 10^{-3} \mu\text{m} \\ x_n &= \frac{w_{do}}{1 + \frac{N_D}{N_A}} = \frac{3.73 \times 10^{-2} \mu\text{m}}{1 + \frac{10^{18} \text{ cm}^{-3}}{10^{19} \text{ cm}^{-3}}} \approx 3.39 \times 10^{-2} \mu\text{m} \end{aligned}$$

(c)

$$\phi_j = 0.979 \text{ V}$$

(d)

$$E_{MAX} = \frac{q N_A x_p}{\varepsilon_s} = \frac{1.60 \times 10^{-19} \text{ C} \cdot 10^{19} \text{ cm}^{-3} \cdot 3.39 \times 10^{-3} \mu\text{m}}{11.7 \cdot 8.85 \times 10^{-14} \text{ F/cm}} \approx 523 \text{ kV/cm}$$

Problem 2.

(a)

$$\begin{aligned} w_d &= w_{do} \sqrt{1 + \frac{v_R}{\phi_j}} = 3w_{do} \\ v_R &= 8\phi_j = 8 \cdot 0.85 \text{ V} = 6.8 \text{ V} \end{aligned}$$

(b)

$$w_d = w_{do} \sqrt{1 + \frac{v_R}{\phi_j}} = 0.4 \mu\text{m} \cdot \sqrt{1 + \frac{7 \text{ V}}{0.85 \text{ V}}} \approx 1.22 \mu\text{m}$$

Problem 3.

$$j = \sigma E$$
$$E = \frac{j}{\sigma} = \frac{5000 \text{ A/cm}^2}{1/2.5 \Omega^{-1} \cdot \text{cm}^{-1}} = 12.5 \text{ kV/cm}$$