

A silicon MOS capacitor has an n-type substrate at 300 K with $N_d = 10^{17} \text{ cm}^{-3}$. Find: a) V_t and ϕ_{fn} , b) the maximum depletion layer thickness x_{dT} , and c) the maximum space charge density $|Q'_{SD}(\text{max})|$.

a) Per (7.10), $V_t = \frac{8.617333 \cdot 10^{-7} \text{ eV/K} (300 \text{ K})}{e} \Rightarrow \underline{V_t = 0.025852 \text{ V.}}$

Per Table B.4, $n_i = 1.5 \times 10^{10} \text{ cm}^{-3}$ and $\epsilon_s = 11.7 \epsilon_0$ for silicon at 300 K.

Per (10.7), $\phi_{fn} = V_t \ln \left(\frac{N_d}{n_i} \right) = 0.025852 \ln \left(\frac{10^{17}}{1.5 \times 10^{10}} \right) \Rightarrow \underline{\phi_{fn} = 0.406203 \text{ V.}}$

b) Per (10.9) w/ MKS units,

$$x_{dT} = \sqrt{\frac{4 \epsilon_s \phi_{fn}}{e N_d}} = \sqrt{\frac{4(11.7)8.8541878 \times 10^{-12} (0.406203)}{1.602176634 \times 10^{-19} (10^{23})}} \Rightarrow \underline{x_{dT} = 102.4976 \text{ nm.}}$$

c) Per (10.33b), $|Q'_{SD}(\text{max})| = e N_d x_{dT} = 1.602176634 \times 10^{-19} (10^{23}) 102.4976 \times 10^{-9}$
 $\Rightarrow \underline{|Q'_{SD}(\text{max})| = 1.6422 \times 10^{-3} \text{ C/m}^2 = 1.6422 \times 10^{-7} \text{ C/cm}^2.}$