EE 362 Electronic, Magnetic, & Optical Properties of Materials
Quiz 7 (Spring 2024)

Name Key A

Instructions: Open book & notes. Place answers in indicated spaces. Show **all** work. Use 4-5 significant figures.

At 300 K, a pn junction in germanium has been uniformly doped with acceptor atoms (5×10^{16} #/cm^3) in the p region and donor atoms (9×10^{16} #/cm^3) in the n region. The junction has a cross-sectional area of 0.05 mm × 50 μm. Find the built-in potential. Next, determine the depletion layer width (m), maximum electric field magnitude (V/m), and junction capacitance (F) when a reverse bias of 0.75 V is applied.

Table B.4, $n_i = 2.4 \times 10^{13}\,cm^{-3} = 2.4 \times 10^{19}\,m^{-3}$ & $\epsilon_r = 16.0$

(7.10) $V_{bi} = \frac{k_B T}{e} \ln\left(\frac{N_a N_d}{n_i^2}\right) = \frac{8.617333 \times 10^{-5}(300)}{1} \ln\left(\frac{5\times10^{16}(9\times10^{16})}{(2.4\times10^{13})^2}\right)$

$V_{bi} = 0.410303\,V$

(7.34) $W = \left\{\frac{2(16)8.8541878\times10^{-12}(0.4103+0.75)}{1.602176634\times10^{-19}}\left[\frac{5\times10^{22}+9\times10^{22}}{5\times10^{22}(9\times10^{22})}\right]\right\}^{1/2}$ ↙ MKS!!

$= 2.5266066 \times 10^{-7}\,m = 252.661\,nm$

(7.37) $E_{max} = -\frac{2(V_{bi}+V_R)}{W} = -\frac{2(0.410303+0.75)}{2.5266066\times10^{-7}}$

$= -9.184675 \times 10^6\,V/m \Rightarrow |E_{max}| = 9.1847\,\frac{MV}{m}$

(7.43) $C' = \epsilon_s / W = \frac{16(8.8541878\times10^{-12})}{2.5266066\times10^{-7}} = 5.607007\times10^{-4}\,\frac{F}{m^2}$

$C = C'A = 5.607007\times10^{-4}\left[(0.05\times10^{-3})(50\times10^{-6})\right]$

$= 1.40175\times10^{-12}\,F$

built-in potential = 0.410303 V

depletion layer width = 252.661 nm

$|E_{max}|$ = 9.1847 MV/m

junction capacitance = 1.40175 pF

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Name Key B

Instructions: Open book & notes. Place answers in indicated spaces. Show **all** work. Use 4-5 significant figures.

At 300 K, a pn junction in germanium has been uniformly doped with acceptor atoms (6×10^{16} #/cm^3) in the p region and donor atoms (5×10^{15} #/cm^3) in the n region. The junction has a cross-sectional area of 0.08 mm × 60 μm. Find the built-in potential. Next, determine the depletion layer width (m), maximum electric field magnitude (V/m), and junction capacitance (F) when a reverse bias of 0.8 V is applied.

Table B.4, $n_i = 2.4 \times 10^{13}\ cm^{-3} = 2.4 \times 10^{19}\ m^{-3}$, $\epsilon_r = 16.0$

(7.10) $V_{bi} = \frac{k_B T}{e} \ln\left(\frac{N_a N_d}{n_i^2}\right) = \frac{8.617333 \times 10^{-5}\ eV/K\,(300K)}{e} \ln\left(\frac{6\times10^{16}(5\times10^{15})}{(2.4\times10^{13})^2}\right)$

$V_{bi} = 0.340295\ V$

MKS!!

(7.34) $W = \left\{\frac{2\epsilon_s(V_R + V_{bi})}{e}\frac{(N_a+N_d)}{N_a N_d}\right\}^{1/2}$

$= \left\{\frac{2(16)8.8541878\times10^{-12}(0.8+0.3403)}{1.602176634\times10^{-19}}\left[\frac{6\times10^{22}+5\times10^{21}}{6\times10^{22}(5\times10^{21})}\right]\right\}^{1/2}$

$= 6.609959 \times 10^{-7}\ m = 660.996\ nm$

(7.37) $E_{max} = \frac{-2(V_{bi}+V_R)}{W} = \frac{-2(0.3403+0.8)}{6.609959\times10^{-7}}$

$|E_{max}| = 3.45023 \times 10^6\ V/m$

(7.43) $C' = \epsilon_s/W = \frac{16(8.8541878\times10^{-12})}{6.60996\times10^{-7}} = 2.14324\times10^{-4}\ F/m^2$

$C = C'A = 2.14324\times10^{-4}\left[0.08\times10^{-3}/60\times10^{-6}\right] = 1.02875\times10^{-12}\ F$

built-in potential = 0.3403 V

depletion layer width = 660.996 nm

$|E_{max}|$ = 3.4502 MV/m

junction capacitance = 1.02875 pF