University of New Mexico

Department of Electrical and Computer Engineering

ECE 321L-Electronics I (Fall 2012) **Homework Solutions #5**

2.11 – $N_D(\text{eff}) = 10^{18} - 10^{16} = 9.9 \times 10^{17}\ cm^{-3} \Rightarrow n_0 p_0 = n_i^2$

$\Rightarrow 9.9 \times 10^{17} \times p_0 = (1.062 \times 10^{10})^2 \Rightarrow \underline{p_0 = 114\ cm^{-3}}$

2.15 – a) $\mathcal{E} = V/d = \frac{1^V}{20 \times 10^{-4} cm} = \underline{500\ V/cm}$

b) $n_0 p_0 = n_i^2$; $n_i = BT^{3/2} \exp\left(\frac{-E_g}{2kT/q}\right)$

$n_i = 5.23 \times 10^{15} * (280)^{3/2} * \exp\left(\frac{-1.12}{2 \times 86.17^{\mu V/K} \times 280}\right) = 2.04 \times 10^9\ cm^{-3}$

$n_0 \times 10^{18} = (2.04 \times 10^9)^2 \Rightarrow \underline{n_0 = 2.04 \times 10^9\ cm^{-3}}$

C) $J = \mu_n q \mathcal{E} n_0 + \mu_p q \mathcal{E} p_0$

$= 1500 \times 1.6 \times 10^{-19} \times 500 \times 2.04 \times 10^9 + 500 \times 1.6 \times 10^{-19} \times 500 \times 10^{18}$

$\Rightarrow \underline{J = 40050\ A/cm^2}$

D) $J = 40050\ A/cm^2 * (10^{-4}\ cm/\mu)^2 \Rightarrow \underline{J = 400.5\ \mu A/\mu m^2}$

2.16 – $J \approx \mu_n q \mathcal{E} n_0 = 1200 \times 1.602 \times 10^{-19} * \mathcal{E} * 10^{18} = 10\ kA/cm^2$

$\Rightarrow \underline{\mathcal{E} = 52\ V/cm}$

b) $\mathcal{E} = V/d \Rightarrow 52^{V/cm} = \frac{2^V}{d} \Rightarrow \underline{d = 384\ \mu m}$

2.17 – $J = \sigma \mathcal{E} \Rightarrow 10^{kA/cm^2} = \sigma * 52^{V/cm} \Rightarrow \sigma = 192\ 1/\Omega cm$

$\rho = \frac{1}{\sigma} = 5.2 \times 10^{-3}\ \Omega.cm$

2.22- $J = D_n q \frac{dn}{dx} + D_p q \frac{dp}{dx}$; $\frac{D_n}{\mu_n} = \frac{D_p}{\mu_p} = \frac{KT}{q} = 25.9\ ^{mV}$

$\Rightarrow D_n = 1300 \times 25.9^{mV} = 33.67\ cm^2/s$

$\Rightarrow D_p = 400 \times 25.9^{mV} = 10.36\ cm^2/s$

$\Rightarrow J = 33.67 \times 1.602 \times 10^{-19} \times 10^{20} + 10.36 \times 1.62 \times 10^{-19} \times 10^{17} \Rightarrow \underline{J = 539.56\ A/cm^2}$

2.25- $n_i = 5.23 \times 10^{15} * (345)^{3/2} * exp\left(\frac{-1.12}{2 \times 86.17^{\mu V/K} \times 345}\right) = 2.21 \times 10^{11}\ cm^{-3}$

$V_{bi} = \frac{KT}{q} Ln\left(\frac{N_A N_D}{n_i^2}\right) = 86.17^{\mu V/K} * 345\ Ln\left(\frac{10^{18} \times 10^{15}}{(2.21 \times 10^{11})^2}\right) \Rightarrow \underline{V_{bi} = 0.706\ ^V}$

2.30- $I_D = I_S\left(e^{\frac{V_D}{V_{th}}} - 1\right) \approx I_S e^{V_D/V_{th}} \Rightarrow \frac{I_{D1}}{I_{D2}} = e^{\frac{V_{D1} - V_{D2}}{V_{th}}} = e^{\Delta V/V_{th}}$

$\Rightarrow \Delta V = V_{th} \cdot Ln\left(\frac{I_{D1}}{I_{D2}}\right) \Rightarrow \Delta V = 25.9^{mV} Ln(100) \Rightarrow \underline{\Delta V = 0.119\ ^V}$

2.31- $C_j = \frac{C_{j0}}{\sqrt{1 + \frac{V_R}{V_{bi}}}} \Rightarrow C_j = \frac{2^{PF}}{\sqrt{1 + \frac{V_R}{0.65}}}$

$V_R = 1^V \Rightarrow C_j = 1.255\ ^{PF}$

$V_R = 2^V \Rightarrow C_j = 0.99\ ^{PF}$

$\underline{V_R = 3^V \Rightarrow C_j = 0.844\ ^{PF}}$