ECE 305 – Spring 2018

Homework 7 Solution

1. a.

$D_n = \frac{kT}{q}\mu_n = 36.4\frac{cm^2}{s}$; $L_n = \sqrt{D_n\tau_n} = 104\ \mu m$ >W_P :Short P-region

$D_p = \frac{kT}{q}\mu_p = 11.7\frac{cm^2}{s}$; $L_p = \sqrt{D_p\tau_p} = 34\ \mu m$ > W_N :Short N-region

$$J_0 = q\left(\frac{D_n}{W_p}\frac{n_i^2}{N_A} + \frac{D_p}{W_n}\frac{n_i^2}{N_D}\right) = q\left(\frac{36.4}{15\times 10^{-4}}\times\frac{10^{20}}{3\times 10^{18}} + \frac{11.7}{10\times 10^{-4}}\times\frac{10^{20}}{10^{17}}\right)\ \text{A cm}^{-2}$$

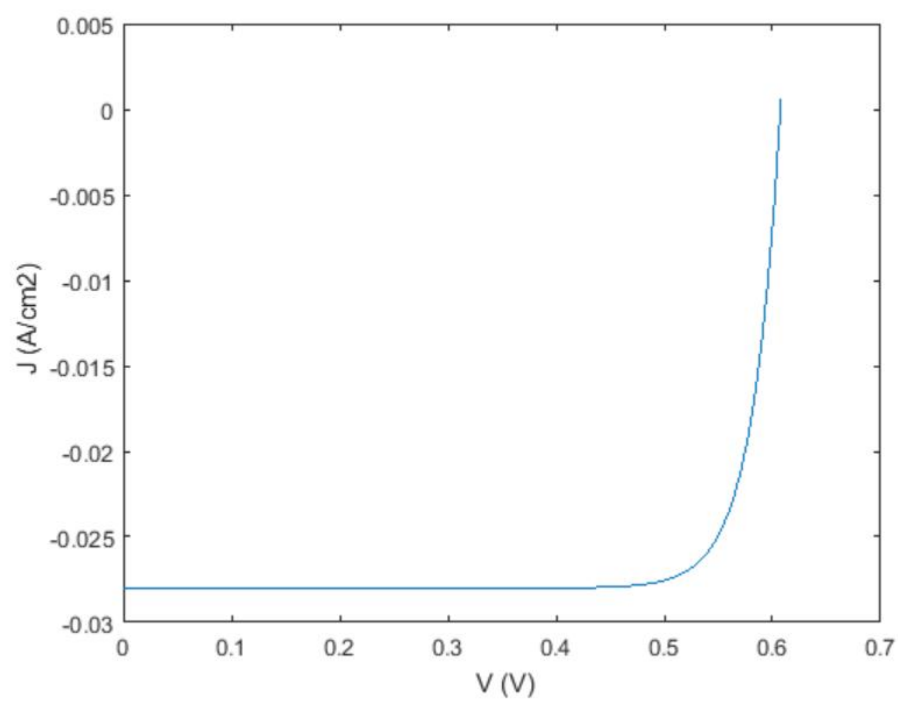
$= q\ (1.25\times 10^{7})\ \text{A cm}^{-2} = 2\times 10^{-12}\ \text{A cm}^{-2}$

b.

$I_{Tot} = I_0(e^{qV/nk_BT} - 1) - I_{SC}$ $\qquad V_{0C} = \frac{nkT}{q}\ln(\frac{I_{SC}}{I_0})$

Thus V_{0C} =0.0259$\times \ln(\frac{28\times10^{-3}}{2\times10^{-12}})$=0.605 V

c.



d.

z_{oc}=qVoc$/nkT = 23.36$

FF=$\frac{z_{oc}-\ln(z_{oc}+0.72)}{z_{oc}+1} = 0.828$

e.

$\eta = \frac{P_{out}}{P_{in}} = \frac{I_{SC}V_{OC}FF}{P_{in}} = \frac{14.0 \text{ mW}}{100 \text{ mW}} = 0.140$

2.

a. $\Phi_M = \Phi_B + X = 0.5 + 4.07 = 4.57$ eV

b. q $V_{bi} = \Phi_B - (E_C - E_F)$

$E_C - E_F = 0.2$ eV

$N_C = 4.7 \times 10^{17}\ \text{cm}^{-3}$

$n = N_C e^{\frac{(E_F - E_C)}{kT}} = 2.14 \times 10^{14}\ \text{cm}^{-3} \gg n_i$

Assuming full ionization $n = N_D = 2.14 \times 10^{14}\ \text{cm}^{-3}$

c.

$K_s = 12.9$

$\epsilon_0 = 8.854 \times 10^{-14}$ F/cm

W=$\sqrt{\frac{2K_s\varepsilon_0(V_{bi}-V_A)}{qN_D}} = 8.17 \times 10^{-5}$ cm

d.

Since it's effectively a one-sided junction, $\mathcal{E}_{max} = \frac{qN_DW}{K_s\varepsilon_0} = 2.45 \times 10^3\ \text{V cm}^{-1}$

e.

$$E_{cr} = \sqrt{\frac{2q(V_A - V_{bi}) \times N_A N_D}{K_s\epsilon_0(N_A + N_D)}} = \sqrt{\frac{2q(V_A - V_{bi}) \times N_D}{K_s\epsilon_0}} \text{ as } N_A \gg N_D \text{ (one sided junction)}$$

For forward bias, when $\mathcal{E}_{max} = |E_{cr}|, V_A$ =2.4383 kV

$$E_{cr} = \sqrt{\frac{2q(V_{bi} + V_R) \times N_A N_D}{K_s\epsilon_0(N_A + N_D)}} = \sqrt{\frac{2q(V_{bi} + V_R) \times N_D}{K_s\epsilon_0}} \text{ as } N_A \gg N_D$$

For reverse bias, when $\mathcal{E}_{max} = |E_{cr}|, V_R = 2.4377$ kV