ECE 305 – Spring 2018

Homework 6 Solution

1.

a. where $J_0 = q(\frac{D_n}{L_n}\frac{n_i^2}{N_A} + \frac{D_p}{L_p}\frac{n_i^2}{N_D})$

$L_n = \sqrt{D_n \tau_n}$=8.53×10^{-3} cm=85.3 μm <<W_p . P-region can be modelled as long.
$L_p = \sqrt{D_p \tau_p}$=3.42×10^{-3} cm=34.2 μm >>W_n. N-region can be modelled as short.
W_n=1×10^{-3} cm

$$J_0 = q\left(\frac{D_n}{L_n}\frac{n_i^2}{N_A} + \frac{D_p}{W_n}\frac{n_i^2}{N_D}\right) = q(4.27 \times 10^6 + 11.7 \times 10^8)\ A\ cm^{-2} = 1.88 \times 10^{-10} A\ cm^{-2}$$

b.

$$J_D = J_0(e^{qV_A/k_BT} - 1)$$

Where $J_0 = 1.88 \times 10^{-10} A\ cm^{-2}$

c.

V_A= -0.4
J ≈ $-J_0 = -1.88 \times 10^{-10} A\ cm^{-2}$
P/A= VJ=7.52× $10^{-11} W\ cm^{-2}$
V_A= 0.4
J ≈ $J_0(e^{qV_A/k_BT} - 1) \approx 9.03 \times 10^{-4} A\ cm^{-2}$
P/A= VJ=$3.61 \times 10^{-4} W\ cm^{-2}$

The power consumption when the diode is reverse biased is comparatively very low as the current is comparatively very low at reverse bias. The power consumed is converted to heat.

2 a. $J \quad = J_0(e^{qV_A/nk_BT} - 1) \approx J_0 e^{\frac{qV_A}{nk_BT}}$ $as\ J = 10mA$ cm^{-2} is quite large

$V_A = \frac{nkT}{q}\ln(\frac{J}{J_0})$

For 1<n<2

$$\frac{kT}{q}\ln\left(\frac{J}{J_0}\right) < V_A < \frac{2kT}{q}\ln\left(\frac{J}{J_0}\right)$$

J=10 mA cm^{-2}

J_0 is not given, so any numerical answer depends on the value of J_0 chosen, for instance J_0 from problem 1.

Alternatively,

Finding ideality factor n first for the red dots, (as shown in 2 b.)

n=1.84

At 10 mA cm^{-2} current density, $V_A \approx 0.5\ V$

Therefore for 1<n<2, as $V_A = \frac{nkT}{q}\ln(\frac{J}{J_0}) \propto n$

$$0.27\ V < V_A < 0.54\ V$$

b. $V_A = \frac{nkT}{q}\ln(J) - \frac{nkT}{q}\ln(J_0) = \frac{n}{40} \times \ln(10) \times log_{10}(J) - constant$

$$\frac{40}{n} \times \frac{1}{\ln(10)} \times V_A + constant = log_{10}(J)$$

Graph of log J (the powers on the numbers on y axis) vs V_A is given.

Slope of the graph=$\frac{40}{n} \times \frac{1}{\ln(10)}$

Taking the furthest red points,

Slope of red points: slope between (0.08,-2.71),(0.4,0.41) ≈9.75

Therefore n=40/9.4× $1/\ln(10)$ ≈1.84 assuming room temperature. This is reasonable as 1<n<2.

(Reasonable solution is acceptable)