Name: Marwan Ahmed Ramadan Ahmed ID: 20177011400

assignment 2

1) For havily doped p-Side $\rho = 2\,\Omega\,cm$

For havily doped n-Side $\rho = 1\,\Omega\,cm$

$n_i = 2.5 \times 10^{13} / cm^3$ $\mu_p = 1800\ cm^2$, $\mu_n = 3800$

p-Side $\sigma = q p \mu_p$ $n = \frac{n_i^2}{p}$ ✓ $N_A = p = $ ✓

$\frac{1}{2} = (1.6 \times 10^{-19}) \times p \times (1800)$

$\sigma = q n \mu_n$ $1 = (1.6 \times 10^{-19}) \times n \times (3800)$

$N_D = n = $ ✓ $p = \frac{n_i^2}{n} = $ ✓

$V_0 = 26 \times 10^{-3} \times \ln\left(\frac{N_A N_D}{n_i^2}\right) = 0.219\,V$ ✓

For p side $p = 1.736 \times 10^{15}\ cm^{-3}$

$\frac{n_i^2}{p} = \frac{(2.5 \times 10^{13})^2}{1.736 \times 10^{16}} = 3.60 \times 10^{11}\ cm^{-3}$

For n-Side:

$n = 1.665 \times 10^{15}\ cm^{-3}$

$p = \frac{n_i^2}{n} = \frac{(2.5 \times 10^{13})^2}{1.665 \times 10^{15}} = 3.799 \times 10^{11}\ cm^{-3}$

2b) $V_0 = \frac{KT}{q} \ln\left(\frac{N_A N_D}{n_i^2}\right)$

heavily doped

$N_A = p = 1.736 \times 10^{15}\ cm^{-3}$, $N_D = n = 1.665 \times 10^{15}\ cm^{-3}$

$V_0 = \frac{(1.38 \times 10^{-23})(300)}{1.6 \times 10^{-19}} \ln\left(\frac{(1.736 \times 10^{15})(1.665 \times 10^{15})}{(2.5 \times 10^{13})^2}\right)$

$V_0 = 0.218V$

2) a) Forward direction

$$V_T = \frac{1125+273}{11600} = 0.0343V$$

$$I = I_o\left(e^{\frac{V}{\eta V_T}} - 1\right) = (30\times10^{-6})\left(e^{\frac{0.2}{0.0343}} - 1\right)$$

$$= 0.01\ A$$

$$r = \frac{\eta V_T}{I} = \frac{0.0343}{0.01} = 3.43\ \Omega$$

b) Reverse direction

$V_T = 0.0343V$, $V = -0.2V$

$$I = I_o\left(e^{\frac{V}{\eta V_T}} - 1\right)$$

$$= (30\times10^{-6})\left(e^{\frac{-0.2}{0.0343}} - 1\right) = -2.991\times10^{-5}A$$

$$r = \frac{\eta V_T}{I + I_o} = \frac{0.0343}{(-2991\times10^{-6}) + (30\times10^{-6})}$$

$$= 381111.11\ \Omega$$

3) Two diodes are Connected to Forward bias, So They are oN.

For diode D1:

$$I = I_0\left(e^{\frac{eV}{\eta K T}} - 1\right)$$

$$= (5\times10^{-9})\left(e^{\frac{(1.6\times10^{-6})(1)}{2(1.38\times10^{-23})(300)}} - 1\right)$$

$$= 1.233\,A$$

$$r = \frac{\eta V_T}{I} = \frac{2(0.025862)}{1.233} = 0.0419\,\Omega$$

For diode D2:

$$I = I_0\left(e^{\frac{eV}{\eta K T}} - 1\right)$$

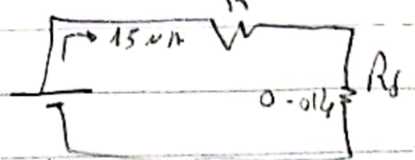
$$= (10\times10^{-9})\left(e^{\frac{(1.6\times10^{-19})(1)}{2(1.38\times10^{-23})(300)}} - 1\right)$$

$$= 2.467\,A$$

$$r = \frac{\eta V_T}{I} = \frac{2(0.0258621)}{2.467} = 0.021\,\Omega$$

The two are parallel their equivalent resistanse is:

$$R_d = \frac{(0.0419)(0.021)}{0.0419 + 0.021} = 0.014\,\Omega$$



$R + R_d = \frac{V}{I}$ $\quad R + 0.014 = \frac{1}{15\times10^{-3}}$ $\quad R = 66.65\,\Omega$

4) Voltage across each diode is:

$$\frac{V}{3} = \frac{2}{3} V$$

$$I = I_0 (e^{\frac{V}{nV_T}} - 1)$$

$= V_T = 0.025V$ at room temperature

$$I = 10^{-14} (e^{\frac{2/3}{0.025}} - 1) = 3.812 \times 10^{-3} A$$

b) $I = (3.812 \times 10^{-3}) - (1 \times 10^{-3})$
$= 2.812 \times 10^{-3} A$

$$I = I_0 (e^{\frac{V}{nV_T}} - 1)$$

$$e^{\frac{V}{0.025}} = \frac{2.812 \times 10^{-3}}{10^{-14}} + 1)$$

$V = 0.659 V$ per each diode

$3V = 3(0.659) = 1.977 V$

Change in out put voltage:

$2 - 1.977 = 0.023 V$

c) $R = \frac{V}{I} = \frac{2}{1 \times 10^{-3}} = 2 K\Omega$

~~5~~5) Builtinvoltage - Barrier potential

$$V_0 = V_T \ln\left(\frac{N_A N_0}{n_i^3}\right)$$

$$= \frac{300}{11600} \ln\left(\frac{(10^{13})(10^{14})}{(1.5\times10^{16})^3}\right) = 0.7532V$$

$$\omega = \sqrt{\frac{2\varepsilon_s}{q}\left(\frac{1}{N_A}+\frac{1}{N_D}\right)V_0}$$

$$= \sqrt{\frac{2(11.04\times10^{-12})}{1.6\times10^{-19}}\left(\frac{1}{10^{13}}+\frac{1}{10^{14}}\right)(0.7532)}$$

$$= 3.28\times10^{-5}\,m$$

$$\frac{X_n}{X_p} = \frac{N_A}{N_D} = \frac{10^{14}}{10^{4}} = 10$$

$X_n = 10 X_p$

$\omega = X_n + X_p = 10X_p + X_p = 11X_p$

$3.28\times10^{-5} = 11 X_p$

$X_p = 2.98\times10^{-6}\,m$ $\quad X_n = 10(2.98\times10^{-6}) =$

$= 2.98\times10^{-6}\,m$