HW #6 Solutions

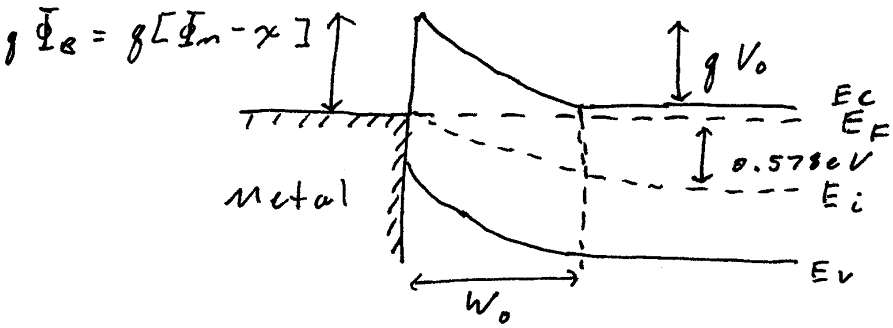
1. <u>Schottky Barrier</u>: n-type GaAs

$N_D - N_A = 10^{16}\ cm^{-3}$ $\qquad$ $n_i = 2\times10^{6}\ cm^{-3}$ @ 300K

$q\Phi_m = 6\ eV$ $\qquad$ $E_g = 1.43\ eV$

$q\chi = 4\ eV$ $\qquad$ $\epsilon_r = 13.2$

a) Equilibrium Energy Band Diagram



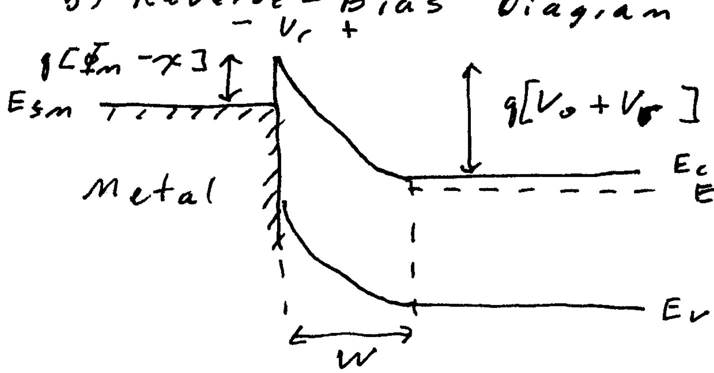
$\Phi_S = \frac{E_g}{2} - [E_F - E_i]$
$= 0.137\ eV$

$W_0 = \left[\frac{2\epsilon V_0}{q}\frac{1}{N_D}\right]^{1/2}$
$= 5.22\times10^{-5}\ cm$

$E_F - E_i = kT\ln\left(\frac{N_D}{n_i}\right) = 0.0259\ eV\ln\left(\frac{10^{16}\ cm^{-3}}{2\times10^{6}\ cm^{-3}}\right)$
$= 0.578\ eV$

$q[\Phi_m - \chi] = qV_0 + \Phi_S \rightarrow V_0 = 2V - 0.137V = 1.863V$

b) Reverse-Bias Diagram for $V_r = -2V$



$= 3.863\ eV$

$W = \left[\frac{2\epsilon[V_0 + V_r]}{q}\left(\frac{1}{N_D}\right)\right]^{1/2} = 7.52\times10^{-5}\ cm$

$= \left[\frac{2(13.2)(\epsilon_0)(3.863\ V)}{q}\left(\frac{1}{10^{16}\ cm^{-3}}\right)\right]^{1/2}$

2. MESFET: n-GaAs

$\Phi_{Bn} = 0.84 V$
$N_D = 8 \times 10^{17} cm^{-3}$
$N_A = 2 \times 10^{17} cm^{-3}$
$E_g = 1.43 eV$

$\delta = \frac{E_g}{2} - [E_F - E_i]$
$= \frac{1.43 eV}{2} - 0.685 eV$
$= 0.0305 eV$

$E_F - E_i = kT \ln\left(\frac{n_n}{n_i}\right) = 0.0259 eV \ln\left(\frac{8 \times 10^{17} - 2 \times 10^{17}}{2 \times 10^6}\right)$
$= 0.685 eV$

$qV_o = \Phi_{Bn} - \delta = 0.84V - 0.0305 eV = 0.8095 eV$
$\hookrightarrow V_o = 0.8095 V$

$W = \left[\frac{2\epsilon V_o}{q}\left(\frac{N_A + N_D}{N_A N_D}\right)\right]^{1/2} = \boxed{4.439 \times 10^{-6} cm}$

3. MOSFET: p-MOS (p-channel)

$N_D = 3 \times 10^{16} cm^{-3}$
$t_{SiO_2} = 750 Å$
$Q_i = 2 \times 10^{11} q \left[\frac{C}{cm^2}\right]$
$= (2 \times 10^{11})(1.6 \times 10^{-19}) \left[\frac{C}{cm^2}\right] = 3.2 \times 10^{-8} \frac{C}{cm^2}$

Use Figure 6-17 (Streetman) to find $\Phi_{ms} \approx -0.21 V$

$C_i = \frac{\epsilon_s}{d} = \frac{(3.9)\epsilon_0}{750 Å} = 4.602 \times 10^{-8} F/cm^2$

Φ_F [redacted] $= +\frac{kT}{q} \ln\left(\frac{N_D}{n_i}\right) = 0.376 V$

$V_{FB} = \Phi_{ms} - \frac{Q_i}{C_i} = -0.21V - \frac{3.2 \times 10^{-8}}{4.602 \times 10^{-8}} \left[\frac{C}{F}\right] = \boxed{-0.905 V}$

$W_m = \left[\frac{2\epsilon_s}{qN_D} \phi_s(inv)\right]^{1/2} = \left[\frac{2\epsilon_s}{qN_D}[2\Phi_F]\right]^{1/2} = 0.181 \mu m$

$Q_d = qN_D W_m = 8.68 \times 10^{-8} \left[\frac{C}{cm^2}\right]$

$\boxed{-3.545V} = V_T = V_{FB} - \frac{Q_d}{C_i} - 2\Phi_F = -0.905V - \left[\frac{8.68 \times 10^{-8}}{4.602 \times 10^{-8}}\right] V - 2(0.376)$