HOMEWORK-6

1)

a) $V_{bi} = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right)$

$= 0.026 \ln\left(\frac{5.12\times10^{16} \times 1.47\times10^{18}}{(1.062\times10^{10})^2}\right)$

$V_\gamma = V_{bi} = 0.887$

b) Depletion width at zero bias

$W_{do} = \sqrt{\frac{2\epsilon_{si}}{q}\frac{N_A+N_D}{N_A N_D}(V_{bi})}$

$= \sqrt{\frac{2\times12(8.85\times10^{-14})}{1.6\times10^{-19}}\left(\frac{5.12\times10^{16}+1.47\times10^{18}}{5.12\times10^{16}\times1.47\times10^{18}}\right)(0.887)}$

$W_{do} = 0.15\mu m$

c) Junction Capacitance (C_j)

$C_j = \frac{\epsilon_{si}A}{W} = \frac{1.06\times10^{-12}\times10^{-2}}{0.15\times10^{-4}}$

$C_j = 706 pF$

d) Depletion width at $-5v$ bias

$W_d = \sqrt{\frac{2\times12\times8.85\times10^{-14}\times(5.12\times10^{16}+1.47\times10^{18})}{1.6\times10^{-19}\quad(5.12\times10^{16}\times1.47\times10^{18})}(0.887+5)}$

$W_d = 0.39\mu m$

e) Junction capacitance at -5V bias

$$C_j = \frac{\epsilon_{si} A}{w_d} = \frac{12 \times 8.85 \times 10^{-14} \times 10^{-2}}{0.39 \times 10^{-4}}$$

$$C_j = 272\,PF$$

f) Given $\epsilon_c = 3 \times 10^5$ V/cm

$$\epsilon = \frac{\Delta V}{d} = \frac{V_{Bi} - V_D}{W_{BD}}$$

$$V_{Bi} - V_D = \epsilon_c W_{BD}$$

$$= \epsilon_c \sqrt{\frac{2\epsilon_{si}}{q}\left(\frac{N_A + N_D}{N_A N_D}\right)(V_{bi} - V_D)}$$

$$\epsilon_c = \frac{0.887 - V_D}{\sqrt{\frac{2 \times 12 \times 8.85 \times 10^{-14}}{1.6 \times 10^{-19}}\left(\frac{5.12 \times 10^{16} + 1.47 \times 10^{18}}{5.12 \times 10^{16} \times 1.47 \times 10^{18}}\right)(0.887 - V_D)}}$$

Solving we have

$$V_D = -23.27V$$

g) Depletion width at breakdown voltage

$$w_d = \sqrt{\frac{2 \times 12 \times 8.85 \times 10^{-14}}{1.6 \times 10^{-19}}\left(\frac{5.12 \times 10^{16} + 1.47 \times 10^{18}}{5.12 \times 10^{16} \times 1.47 \times 10^{18}}\right)(0.887 + 23.27)}$$

$$w_d = 0.81\,\mu m$$

2)

a)

$$E_c = \frac{V_x}{W_d} = \frac{V_{bi} - V_d}{W_d}$$

$$E_c = \frac{V_T \ln\left(\frac{N_A}{n_i}\right)^2 - V_D}{\sqrt{\frac{2\epsilon_{si}}{q}\left(\frac{2}{N_A}\right)(V_{bi} - V_D)}} \quad \because N_A = N_D$$

$$3\times10^5 = \frac{0.026 \times \ln\left(\frac{N_A}{n_i}\right)^2 - 250}{\sqrt{\frac{2\times12\times8.85\times10^{-14}}{1.6\times10^{-19}}\left(\frac{2}{N_A}\right)(V_{bi} - 250)}}$$

on solving we have

$$N_A = 9.53\times10^{15} = N_D$$

b)

$$V_{bi} = V_T \ln\left(\frac{N_A N_D}{n_i^2}\right) = 0.026 \ln\left(\frac{9.53\times10^{15}}{1.662\times10^{10}}\right)^2$$

$$V_{bi} = 0.712V$$

c) Depletion width at zero bias

$$W_d = \sqrt{\frac{2\times12\times8.85\times10^{-14}}{1.6\times10^{-19}} \frac{\times 2}{9.53\times10^{15}} \times (0.712)}$$

$$W_d = 0.445\ \mu m =$$ [illegible]

d) Depletion width at $V_D = 250V$

$$W_d = \sqrt{\frac{2\times12\times8.85\times10^{-14}\times2}{1.6\times10^{-19}\times9.53\times10^{15}} \times (0.712 + 250)}$$

$$W_d = 8.35\ \mu m$$

3) a) $L_{eff} = L - 2x_d$

$= 0.5 - 2(0.11) = 0.28$

$L_{eff} = 0.28\mu m$

b) $C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = \frac{3.9(8.85\times10^{-12} F/m)}{5.7\times10^{-9}} = 6.06$

$C_{ox} = 6.06\ fF/\mu m^2$

c) $C_{GSOV} = C_{GDOV} = W C_{ox} x_a = 5\times6.06\times110$

$= 3.333 fF$

d) channel capacitances

	C_{GBCH}	C_{GSCH}	C_{GDCH}
cut off	$C_{ox} W L_{eff}$ $6.06(5)(0.28)$ 8.484	0	0
Linear	0	$\frac{1}{2} C_{ox} L_{eff} W$ $= 4.242$	4.242
saturation	0	$\frac{2}{3}\times8.484$ $5.656 pF$	0

e) C_{jDB} & C_{JSB}

$C_{JDB} = 5.781 fF$

$C_{JSB} = 15.758$

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