# ASSIGNMENT 5 — EECE 480

5 marks

1. $V_T = V_{fb} + 2\phi_B + \gamma\sqrt{2\phi_B + V_{SB}}$

$2\phi_B = 2V_{th} \ln \frac{N_A}{n_i}$ ; $\gamma = \sqrt{2q\varepsilon_s N_A} / C_{ox}$.

$C_{ox} = \varepsilon_{ox}/t_{ox}$ ; $V_{SB} = 0$

$2\phi_B = 1.018 \quad V$

$\gamma = 0.53 \quad V^{1/2}$

$C_{ox} = 1.97 \times 10^{-6} \quad F/cm^2$

3 $V_{fb} = 0.47 - 1.018 - 0.53\sqrt{1.018} = \underline{\underline{-1.08\ V}}$

$V_{fb} = (\Phi_m - \Phi_s)/q$

$\Phi_s = \chi_s + E_g/2 + \phi_B$

$= 4.01 + 0.56 + 0.51 = 5.08\ eV$

2 $\therefore \Phi_m = 5.08 - 1.08 = \underline{\underline{4.0\ eV}}$

6 marks

2. $\mu \propto \frac{1}{m^*_{CON}}$

$\frac{1}{m^*_{CON}} = \frac{2}{6m_\ell^*} + \frac{4}{6m_t^*}$ (Eqn 5.36) for unstrained

After straining, 80% of electrons in $\Delta_2$, i.e. with $m^* = m_t^*$
20% " " in $\Delta_4$, i.e. 10% with $m_t^*$ & 10% with $m_\ell^*$

4 $\therefore \frac{1}{m^*_{CON}} = \left[\frac{0.1}{m_\ell^*} + \frac{0.9}{m_t^*}\right] = \frac{0.1}{0.92} + \frac{0.9}{0.19} \rightarrow \underline{m^*_{CON} = 0.206 m_0}$

For unstrained case; $m^*_{CoN} = 0.26\, m_o$

2 $\therefore$ New $\mu_e = 391.4 \times \frac{0.26}{0.206} = \underline{494 \ cm^2 V^{-1} s^{-1}}$

(5 marks) 3. $I_D(\text{sub-threshold}) = \frac{Z}{L} \mu V_{th}^2 C_{ox} (m-1) \exp\left(\frac{V_{GS}-V_T}{m V_{th}}\right) \ldots\ldots \left(1 - e^{-V_{DS}/V_{th}}\right)$

$$m = 1 + \frac{\gamma}{2\sqrt{2\phi_f + V_{SB}}} = \underline{1.26}$$

For $\frac{I_D}{Z} = 14 nA/\mu m$ @ $V_{GS} = 0$, $V_{DS} = 1V$

$V_T = \underline{0.18V}$

5 $\therefore$ $\underline{\Delta V_T \text{ due to short-channel effects} = 0.18 - 0.47 = -0.29V}$

(4 marks) 4. ON current $= I_{Dsat}$ @ $V_{DS} = V_{GS} = 1V$

$I_{Dsat} = Z C_{ox} (V_{GS} - V_T) v_{sat} (\theta - 1)/(\theta + 1)$

$\theta = \left(1 + 2\mu (V_{GS} - V_T)/(m v_{sat} L)\right)^{1/2}$

3 $\underline{I_{Dsat} = 1.15 \ mA/\mu m}$

1 $\frac{ON}{OFF} = \frac{1.15 \times 10^{-3}}{14 \times 10^{-9}} = \underline{8.24 \times 10^4}$