ECE 5205 HW#3 2-20-2014 Total 20 points turn in 2-27-2014

1. **MOS Capacitor**. In the lecture, equation (1) (see 2nd page) has been derived for the semiconductor charge. Show that in accumulation and strong inversion the charge Qs increases as exp(ψ/2kT).(3 points)

2. **MOS Capacitor**. Assume a p-type substrate with uniform boron doping of $1x10^{16}$ cm^{-3}. Using the formula (2) (see 2nd page) derived in the lecture, calculate the Si capacitance for surface potentials $\psi = -0.21V$ and 0.85V. (4 points)

3. **MOS Capacitor**. The work function for aluminum is 4.10V; the electron affinity for Si is 4.05V. Assume a p-type doping level of $1x10^{14}$ cm^{-3}. Calculate the flat band voltage assuming that there are no oxide charges of any kind. (2 points)

4. **Flat Band Voltage**: Calculate flat band voltage for MOS capacitor with a p-type semiconductor substrate of $1x10^{16}$ cm^{-3}, SiO2 thickness of 200A and n+polysilicon gate. Assume that you have trapped charge $Qss=5x10^{10}$ cm^{-2} located directly adjacent to the oxide-Si interface. (2 points)

5. **Threshold Voltage**: Design the oxide thickness of an MOS system to yield a specified threshold voltage of $V_T=0.65V$. Consider an N+ polysilicon gate and a p-type substrate of $3x10^{16}$ cm^{-3} and assume $Qss=10^{11}$ cm^{-2} . (4 points)

6. **CV characteristics of a MOS capacitor**. Consider a p-type substrate of $1x10^{16}$ cm^{-3}, an oxide thickness of 550A and an aluminum gate. Calculate C_{ox}, C_{min} (for maximum depletion) and C_{FB} (flat band capacitance of the entire MOS capacitance system. (5 points)

$$Q_s = -\varepsilon_s E_s = \pm \frac{\varepsilon_s \sqrt{2}}{\beta L_D} F(\beta\psi_s, \frac{n_{po}}{p_{po}})$$

Eq. (1) Si charge as a function of the surface potential, see lecture notes

$$C_D \equiv \frac{\partial Q_s}{\partial \psi_s} = \frac{\varepsilon_s}{\sqrt{2} L_D} \frac{[1 - (\exp(-\beta\psi_s) + \frac{n_{po}}{p_{po}} (\exp(\beta\psi_s) - 1)]}{F(\beta\psi_s, \frac{n_{po}}{p_{po}})}$$

Eq. (2) Differential capacitance of the depletion layer, see lecture notes