ECE 5205 Homework assignment # 8 (turn in by 4-17-2014)

1. **Velocity Saturation and saturation current:** Compare ideal MOSFET saturation current (see eq.(1)) with a MOSFET suffering velocity saturation (see eq.(2)) with following parameters μ_n=1000cm^2/V-sec, Cox=10^{-8}F/cm^2, W=10μm, L=1μm, V_T=0.4V and v_{sat}=5x10^6 cm/sec. a) calculate saturation current for both cases for V_{gs}=2V and V_d=3V; for which case is the saturation current larger? b) calculate the transconductance for both cases; for which case is the drain current more sensitive to the gate bias? (6 points)

2. **Mobility:** Consider electrons in a an inversion channel; a) at $V_{g1}=V_T$+2V the mobility due to phonon scattering μ_{ph}=900cm^2/V-sec, due to impurity scattering μ_i=900cm^2/V-sec, and due to surface scattering μ_{surf}=900cm^2/V-sec; what is the overall channel electron mobility? b) at $V_{g2}=V_T$+4V the phonon mobility and the impurity mobility remain the same, but the surface mobility degrades to μ_{surf}=700cm^2/V-sec; what is the overall channel electron mobility? (3 points)

3. **Channel length modulation:** Consider n-channel MOSFET with substrate doping N_A=2x10^{16} cm-3, V_T=0.4V, L=1μm, V_{gs}=1V and V_{ds}=2.5V. Determine the ratio of actual drain current I_D compared to the ideal value due to channel length modulation. Hint: Use the formula for the length of depletion region between the channel pinch-off and the drain – see corresponding slides in the lecture notes. (3 points)

4. **The mobility** of electrons in pure GaAs at 300 K is 8500 cm^2/(Vs). Calculate the mean scattering time. Note that this scattering time is due only to lattice vibrations. If the GaAS sample is doped at at N_D=10^{17}cm^{-3}, the mobility is measured to decrease to 5000 cm^2/(Vs). From this information determine the mean scattering time due only to ionized impurity scattering. Assume effective mass of electron in GaAs m_{eff}=0.067m_e. (4 points)

$$I_{dsat} = \mu_{eff} C_{ox} \frac{W}{2L} (V_g - V_T)^2$$

eq.(1) ideal MOSFET in saturation

$$I_{dsat} = WC_{ox} v_{sat} (V_g - V_T)$$

eq.(2) MOSFET in saturation and subject to velocity saturation

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5. Channel conductivity: Consider a n-MOSFET with $N_A=5x10^{16}cm^{-3}$. a) Calculate the channel conductivity near the Si-SiO_2 interface under the flat band condition and at inversion. Assume electron mobility of μ_n=600 cm^2/Vs and hole mobility μ_h=200 $cm^2/(Vs)$. b) calculate the conductivity of an undoped Si with μ_n=1000 cm^2/Vs and μ_h=350 $cm^2/(Vs)$. (4 points)