ELEG 646; **ELEG 446 - Nanoelectronic Device Principles – Spring 2011**

Homework #12 - due Friday, 13 May 2011, in class

1. Problem 8.5 in chapter 8 of Muller & Kamins, p. 422 in 3rd edition. Hints: start with $Q_s = -C_{ox}(V_G - V_{FB} - \psi_s)$, then $C_G = -dQ_s/dV_G$. Notes: (a) The symbol ϕ_s in this problem is the same as our ψ_s, in the class lectures; (b) V_{FB} is a constant with V_G, but ϕ_s is not. Recall that ψ and ϕ differ by a constant. More hints: careful with book's notation: sometimes they use ϕ_s with the meaning as in our lectures, but sometimes they use ϕ_s to mean our ψ_s, as in Fig. 8.8, and on page 393. See Berglund, IEEE TED, v. ED13, p. 701, 1966.

2. Derive an expression for the depletion width x_d of an MOS capacitor that is valid for the depletion condition: $V_{FB} < V_{GS} < V_T$. Express x_d in terms of V_{GS}, and oxide parameters such as d_{ox}, ε_{ox}, etc. The suggested approach is to set up the MOS charging equation: $V_{ox} + \Psi_s = V_{GS} - V_{FB}$, where $V_{ox} = -Q_{dep}/C_{ox}$, which depends linearly on x_d, and $\Psi_s = qN_A x_d^2/2\varepsilon_s$. Solve the resulting quadratic equation for x_d. Note that this result for x_d can be used to yield the semiconductor contribution ($Cs = \varepsilon_s/x_d$) to the total gate capacitance in this depletion region, by putting C_S in series with C_{ox}.

3. Problem 8.6 in chapter 8 of Muller & Kamins, p. 422 in 3rd edition. Hint: Keep in mind that the semiconductor capacitance $(-Q_G) = Q_s = Q_n - qN_a x_d$, so that x_d can be expressed in terms of charges.

4. Consider a MOS capacitor of area 1 cm^2 made on ***n-silicon*** with $N_D = 1.5 \times 10^{14}\ cm^{-3}$ and an Al gate. The SiO_2 layer is 200 nm thick. The Si is 20 μm thick and is epitaxially grown on n^+-silicon substrate having $N_D = 10^{19}\ cm^{-3}$. Neglecting any interface charge between Si and SiO_2, determine the gate capacitance measured under flat-band conditions. Hint: this is not asking for only the semiconductor depletion capacitance at flat band.

5. Problem 8.14 in chapter 8 of Muller & Kamins, p. 423 in 3rd edition. Hint: consider the motion of ions and the filling of states as the V_G becomes more positive and then more negative. for both n and p-type substrates.

Homework assignments will appear on the web at:
http://www.ece.udel.edu/~kolodzey/courses/eleg646s11.html

Include your name, due date, assignment number, and course number on each submission.