ELEG 646; ELEG 446 - Nanoelectronic Device Principles – Spring 2005
Homework #10 (revision 3) - due noon Friday, 20 May 2005, in 140 Evans Hall

1. Using the surface field estimation, (a) calculate the intrinsic depth \( x_i \) at a temperature of 4K for n-channel Si MOSFET at the onset of strong inversion, assuming that the bulk Fermi potential \( \phi_{pB} = -0.3 \) V (even at 4K in this hypothetical case). (b) Briefly explain your numerical result for \( x_i \). Discuss the significance of this number, and if it agree with quantum mechanics.

2. Consider the MOS capacitor (same as problem 5 of Homework 9) of area 1 cm² made on n-silicon with \( N_D = 1.5 \times 10^{14} \) cm⁻³ and an Al gate. The SiO₂ layer is 200 nm thick. Assume that now the oxide contains \( 10^{12} \) mobile ions. Determine the flat-band and the threshold voltages when (a) all the ions are uniformly distributed in the oxide, (b) all the ions are at the Si-SiO₂ interface, and (c) all the ions are at the Al-SiO₂ interface.

3. (a) An Al gate enhancement-type n-channel Si MOSFET has a substrate concentration \( N_a = 6 \times 10^{15} \) cm⁻³ and an oxide thickness of 0.1 µm. The SiO₂ has \( 10^{10} \) charges cm⁻². Determine the threshold voltage of the transistor. When the transistor is operated in the linear region with \( V_D = 0.5 \) V, calculate the gate voltage to obtain a drain current of 2 mA. Assume \( L = 10 \) µm, \( \mu_n = 500 \) cm²/V-sec, and \( Z = 100L \). Calculate the \( g_m \) of the device and the cutoff frequency of operation \( f_T \). (b) What changes will occur in the characteristics of the MOSFET when the gate metal is replaced by p-polysilicon doped with \( N_a > 10^{19} \) cm⁻³ operated at the same current in the linear region with \( V_D = 0.5 \) V?

Homework assignments will appear on the web at:
http://www.ece.udel.edu/~kolodzey/courses/eleg646s05.html

Note: On each homework and report submission, you must please give your name, the due date, assignment number and the course number.