Fall 2008

EE 612: Nanoscale Transistors

HW3: DUE TUESDAY, SEPTEMBER 16

MOS Electrostatics (quantum)

The purpose of this exercise is to review MOS electrostatics using the numerical simulation program, Shred, which is part of the ABACUS suite of educational tools on nanoHUB.org. Before you begin this assignment, familiarize yourself with using Shred on nanoHUB.org. After logging on, find the tool ABACUS. After starting it up, select the tool, Shred, from the drop down menu.

For these exercises, assume:

N_A = 2.7 x 10^{18} cm^{-3} for the bulk doping
EOT = 1.1 nm
Q_F = 0.0
T = 300K
V_{DD} = 1.0V
Assume an n^+ polysilicon gate with $(E_F - E_C)$ = 0.0 and ignore poly depletion.

Modify the Schred input to perform a ***quantum mechanical*** MOS C-V simulation for this device for $-2 \leq V_G \leq 2$ V. You should consider three different gate electrodes: polysilicon doped at 1 x 10^{20} cm^{-3}, polysilicon doped at 1.5 x 10^{20} cm^{-3}, and a metal gate with a workfunction corresponding to a polysilicon gate with $E_F - E_C$.

1) Determine the equivalent electrical oxide thickness (EOT_{elec}) at $V_G = 1.0$ V for each of the three cases, and compare them to the value obtained in HW2.

Perform a second simulation that does a ***classical analysis*** for N_P = 1e20 cm^{-3}.

2) Compare the quantum mechanical and classical C-V curves and <u>discuss</u> the differences.

3) Determine the threshold voltage shift due to quantum mechanical confinement and compare it to the value that you would get from Fig. 4.17 and eqn. (4.57) on p. 198 of Taur and Ning.

4) For the on-state (V_G = V_{DD}) compare the quantum mechanical and classical electron density profiles.

5) How much does poly depletion increase EOT_{elec} when $N_P = 1.0 \times 10^{20}$ cm^{-3}?

6) How much does the inversion layer thickness increase EOT_{elec} when $N_P = 1.0 \times 10^{20}$ cm^{-3}?