ECE609 Spring06

HOMEWORK 6 - PRACTICE FINAL EXAM

MOS capacitors and MOSFET

1 MOS capacitors

1. Calculate the flatband voltage of a silicon nMOS capacitor with a substrate doping $Na = 10^{17}cm^{-3}$ and an aluminum gate (with a "work function" $V_M = 4.1V$). Assume (i) there is no fixed charge in the oxide or at the oxide-silicon interface, (ii) we are at room temperature, (iii) $n_i = 10^{10}cm^{-3}$
   $V_{FB} = -0.93V$

2. Using the result previously obtained, calculate the threshold voltage of a silicon nMOS capacitor with a substrate doping $Na = 10^{17}cm^{-3}$, a $20nm$ thick oxide ($\epsilon_{ox} = 3.9\epsilon_0$) and an aluminum gate ($V_M = 4.1V$). Assume there is no fixed charge in the oxide or at the oxide-silicon interface.
   since $V_F = 0.42V$, $V_T = -0.09V$

2 MOSFET

1. Calculate the drain current of a silicon nMOSFET with $V_T = 1V$, $W = 10\mu m$, $L = 1\mu m$ and $tox = 20nm$. The device is biased with $V_{GS} = 3V$ and $V_{DS} = 5V$. Use the quadratic model, a surface mobility of $300cm^2/Vs$ and set $\epsilon_{Si} = 3.9$. Also calculate the transconductance at $V_{GS} = 3V$ and VDS = 5 V and the output conductance at $V_{GS} = 3V$ and $V_{DS} = 0V$.
   The MOSFET is biased in saturation since $V_{DS} > V_{GS} - V_T$
   so $I_D = 1.04mA$
   and $gm = 1.04mS$, $gd = 1.04mS$, S for Siemens

2. Repeat the question above using the variable depletion layer model. Use $V_{FB} = -0.807V$ and $Na = 10^{17}cm^{-3}$. For the transconductance, you will derive the value of the modified mobility μ_n^* and you will comment on the result of the conductance.
   To find out whether the MOSFET is biased in saturation, we need first to calculate $V_{Dsat} = 1.39V$
   We the get $I_D = 0.7mA$
   $g_m = 0.52mS$ with $\mu_n^* = 149cm^2/V - s$
   $g_d = 1.04mS$. which is the same as that of example above since the depletion layer width is constant for V_{DS} = 0.