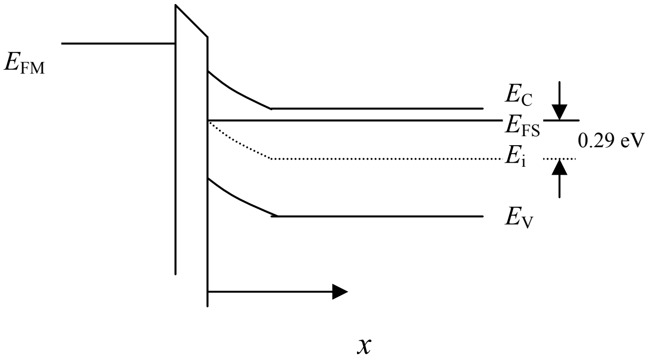
ECSE-2210 Microelectronics Technology
Class Activity 27

1. The energy band diagram for an ideal MOS-C is shown below (x_{ox} = 0.2 µm). The applied gate voltage causes band bending such that $E_F = E_i$ at the Si-SiO$_2$ interface. Answer the following.



   a. Sketch electrostatic potential ϕ inside the semiconductor as a function of position.

   b. Is the semiconductor in depletion, accumulation or in strong-inversion?

   c. N_D =? ϕ_S =?

   d. Calculate the depletion layer width, W.

   e. Sketch $\mathcal{E}$-field inside the semiconductor as a function of position, and mark the numerical value of maximum $\mathcal{E}$ -field inside Si.

f. What is the electron concentration at the Si-SiO_2 interface?

g. What is the voltage drop across the oxide?

h. V_G =?

i. Plot both the high frequency and low frequency C-V_G characteristics as V_G is varied from – 5 V to + 5 V. Mark important points in the graph.

2. (Do this if time permits).The figure below shows the gate capacitance (C_g) versus gate voltage (V_G) measured at high frequency (1 MHz) on a silicon MOS-capacitor with SiO_2 as the insulator. The doping in Si is 10^{16} cm^{-3}. Assume an area $A = 1$ cm^2.

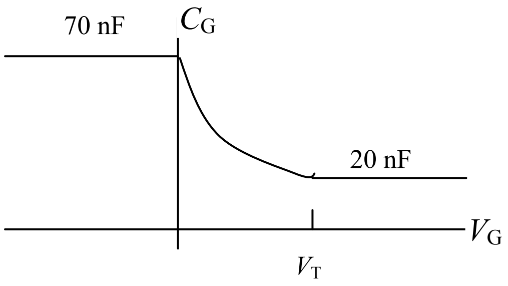
   a. Is the semiconductor n-type or p-type? How did you tell?

   b. Which part of the curve corresponds to accumulation, depletion and inversion? Identify these regions in the figure.

   c. What is the oxide thickness?

   d. What is the semiconductor capacitance, C_s, at inversion?

   e. If the gate voltage V_G equals V_T in the figure shown below this corresponds to the start of inversion. Calculate V_T.



   f. Suppose we apply a gate voltage of 4 V. Calculate the inversion charge Q_{inv} in Coulombs. (Hint: use the relation $CV = Q$; if $V_G = V_T$, the inversion layer charge is almost zero. For $V_G > V_T$ you build up inversion charges).