Semiconductor Device Theory:
MOS Capacitors –Theoretical Exercise 1

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1. Sketch the energy band diagram and the charge distribution in a MOS capacitor with *n*-type semiconductor for the following bias conditions:
   (a) Accumulation
   (b) Depletion
   (c) Inversion

2. The field distribution in an ideal MOS capacitor is shown in the figure below.

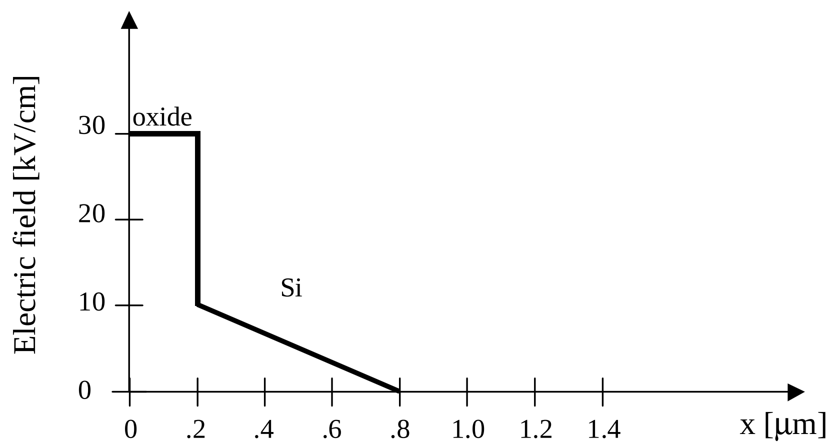
   (a) Sketch the potential and the charge distribution profiles. Is the MOS capacitor biased in accumulation, depletion or inversion regime?

   (b) Calculate the voltage drop in the semiconductor and in the oxide.

   (c) What is the magnitude of the oxide capacitance C_{ox}?

   (d) Calculate the threshold voltage V_{TH} for the MOS capacitor.

   The dielectric permittivity of silicon is $\varepsilon_s = 1.05\times10^{-10}$ F/m, the oxide permittivity is $\varepsilon_{ox} = 3.45\times10^{-11}$ F/m, the intrinsic carrier concentration equals to $n_i = 1.5\times10^{10}$ cm^{-3} and the temperature is T=300 K.



3. Using the exact analytical model, plot the gate-voltage dependence and the sheet-charge dependence of the surface potential for a MOS capacitor with N_A=5×10^{17} cm^{-3} and d_{ox}=3 nm. For the relative permittivity of silicon and SiO_2 use 11.8 and 3.9, respectively. Assume that the intrinsic carrier concentration is n_i=1.5×10^{10} cm^{-3}. The temperature is T=300 K.

4. Plot the high-frequency CV-curves for the three structures shown in the figure below on the same plot. Explain how did you arrive to your answer. In your analysis assume that the gate voltage is swept very slowly.