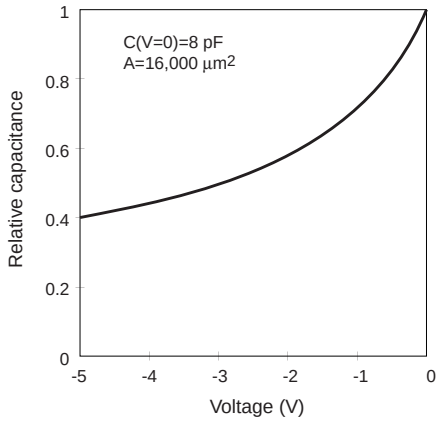
Homework #4 - September 30, 2005

Due: October 7, 2005 at recitation (2 PM latest)
(late homework will not be accepted)

Please write your recitation session time on your problem set solution.

1. *[30 points]* In a paper on Si p-n junction varactors, you see the following graph with the capacitance-voltage characteristics of the diode at room temperature:



Assuming that the diode is highly asymmetrically doped, reverse engineer the diode.

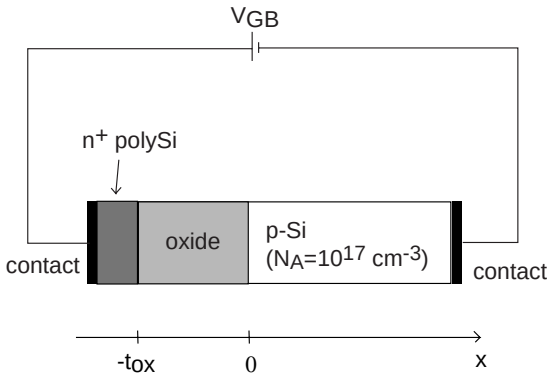
a) *[10 points]* Estimate the built-in potential of the junction.

b) *[10 points]* Estimate the depletion region thickness at $V = -5\ V$.

c) *[5 points]* Estimate the doping level of the lowly-doped side, N_L.

d) *[5 points]* Estimate the doping level of the highly-doped side, N_H.

2. *[40 points]* Consider the following MOS structure:



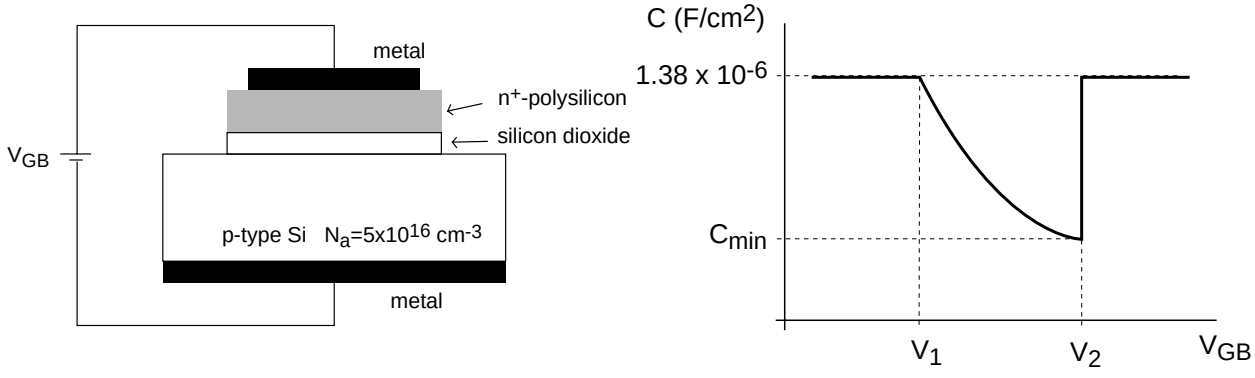
a) *[10 points]* Calculate the flatband voltage.

b) *[10 points]* Calculate the extent of the depletion region in the semiconductor at threshold.

c) *[10 points]* Calculate the electric field in the oxide at threshold.

d) *[10 points]* Calculate the inversion layer sheet charge when the electric field in the oxide is $\mathcal{E}_{ox} = 10^6\ V/cm$.

3. *[30 points]* You are given an MOS capacitor fabricated with a n^+ polysilicon gate and a p-type substrate with a doping concentration of $N_a = 5 \times 10^{16}\ cm^{-3}$, as sketched below on the left. The capacitance-voltage curve for this device is shown below on the right.



a) *[5 points]* Calculate $V_{GB} = V_1$.

b) *[5 points]* Calculate the oxide thickness.

c) *[5 points]* Calculate $V_{GB} = V_2$.

d) *[5 points]* Calculate C_{min}.

e) *[5 points]* Calculate the electric field in the oxide when $V_{GB} = V_2 + 1\ V$.

f) *[5 points]* Calculate the electric field in the oxide when $V_{GB} = V_1 - 1\ V$.