Classical MOS Capacitors Electrostatic

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1. It is well known that the threshold voltage shift in the semiconductor is affected by the workfunction of the gate material. Namely $\Delta V_G = \Phi_{MS}$. For n+ and p+ polysilicon gates that difference is on the order of the bandgap. How does the change in the workfunction difference reflect itself on the low-frequency CV-curves of single-gate MOS capacitor?

2. It is well known that the sheet electron density is proportional to the applied bias and the oxide capacitance, i.e. $N_S = C_{OX}(V_G-V_T)$. Since $C_{OX}=\varepsilon_{ox}/t_{ox}$, one can increase the sheet density by either:

   (a) Reducing the oxide thickness
   (b) Using dielectrics with higher dielectric constant

   The later is in fact the state of the art in industry where high-k dielectrics are used to prevent gate leakage but at the same time act as they are electrically thin insulators. Verify (a) and (b) by using for the case

   (a) oxide thickness of 2 nm, 4 nm and 6 nm, and for the case
   (b) use dielectric constant of 3.9, 8 and 15.

   Comment on the results obtained.

3. It is well known that under high frequency the inversion charge might form but can not respond so under these circumstances the total gate capacitance equals the series combination of the oxide C_{OX} and depletion layer (C_{depl}) capacitances. The depletion layer capacitance on the other hand depends upon the substrate doping. Vary the substrate doping (10^{16} cm^{-3}, 10^{17} cm^{-3} and 10^{18} cm^{-3}) and plot the high-frequency capacitance. Comment on the results obtained based on physical reasoning.