1. An n-type silicon sample has a uniform donor concentration $N_D = 5 \times 10^{15} \text{cm}^{-3}$. Calculate the surface potential required (a) to make the surface intrinsic, and (b) to bring strong inversion at the surface.

2. An Au gate MOS capacitor is fabricated on an n-silicon substrate with $N_D = 10^{15} \text{cm}^{-3}$. The thickness of the gate oxide is 120 nm, and the charge density at the Si-SiO$_2$ interface is $3 \times 10^{11}$ charges cm$^{-2}$. Calculate (a) the flat-band voltage, (b) the threshold voltage, and (c) draw the energy band diagram of the system under thermal equilibrium and at the onset of strong inversion.

3. Consider a MOS capacitor of area 1 cm$^2$ made on n-silicon with $N_D = 1.5 \times 10^{14} \text{cm}^{-3}$ and an Al gate. The SiO$_2$ layer is 200 nm thick. The Si is 20 μm thick and is epitaxially grown on n$^+$-silicon substrate having $N_D = 10^{19} \text{cm}^{-3}$. Neglecting any interface charge between Si and SiO$_2$, determine the flat-band capacitance and $C_{\text{max}}$ for the structure, and sketch the C-V plot.

4. Derive an expression for the depletion width $x_d$ of an MOS capacitor that is valid for the depletion condition: $V_{\text{FB}} < V_{\text{GS}} < V_T$. Express $x_d$ in terms of $V_{\text{GS}}$, and oxide parameters such as $d_{\text{ox}}$, $\varepsilon_{\text{ox}}$, etc. The suggested approach is to set up the MOS charging equation: $V_{\text{ox}} + \Psi_s = V_{\text{GS}} - V_{\text{FB}}$, where $V_{\text{ox}} = -Q_{\text{dep}}/C_{\text{ox}}$, which depends linearly on $x_d$, and $\Psi_s = qN_A x_d^2/2\varepsilon_s$, which of course depends quadratically on $x_d$. Solve the resulting equation for $x_d$. Note that this result for $x_d$ can be used to yield the semiconductor contribution ($C_s = \varepsilon_s/x_d$) to the total gate capacitance in this region, by putting in series with $C_{\text{ox}}$.


Homework assignments will appear on the web at: http://www.ece.udel.edu/~kolodzey/courses/eleg646s09.html

Note: On each homework and report submission, please give your name, the due date, assignment number and the course number.