6. Consider a p-channel silicon MOSFET with an aluminum gate.
   a) Draw the energy band diagram for \( V_G = V_{FB} \). Indicate the workfunction of the metal and the semiconductor, as well as the electron affinity.
   b) Draw the field distribution for \( V_G = V_T \) (onset of inversion).
   c) Calculate the depletion layer width and the field in the oxide at the onset of inversion. \( (N_d = 10^{16} \text{ cm}^{-3}, t_{ox} = 100 \text{ nm}, V_{FB} = -0.5V) \)

7. Calculate the depletion region width within a p-type bulk silicon MOS- capacitor with \( N_d = 10^{17} \text{ cm}^{-3} \), at the onset of inversion.

8. A silicon p-substrate (\( p \equiv N_a = 10^{16} \text{ cm}^{-3} \)) MOSFET with \( t_{ox} = 0.1 \mu\text{m} \), \( \varepsilon_{ox}/\varepsilon_0 = 3.9 \) and a negative interface charge per unit area of \( -10^{-8} \text{ C/cm}^2 \), has a threshold voltage which is 1 Volt smaller than desired. By what value should one change the oxide thickness to obtain the desired threshold voltage? Should one increase or decrease the oxide thickness?

9. A silicon MOSFET \( (n_i = 10^{10} \text{ cm}^{-3}, \varepsilon_s/\varepsilon_0 = 11.9 \text{ and } \varepsilon_{ox}/\varepsilon_0 = 3.9) \) is scaled by reducing all dimensions by a factor of 2 and by increasing the doping densities of the substrate by a factor of 4.

10. Calculate the ratio of the following parameters of the scaled device relative to that of the original device: (make approximations if necessary)
    • The transconductance at \( V_{GS} - V_T = 1 \text{ V} \).
    • The gate capacitance
    • The transit frequency at \( V_{GS} - V_T = 1 \text{ V} \). (Assume that \( C_{DS} = 0 \))
    • The threshold shift when increasing the reverse bias of the source-bulk diode from 1 Volt to 3 Volt.
    • The breakdown voltage of the oxide assuming the breakdown field to be constant.
    • The breakdown voltage of the drain-to-bulk p-n diode assuming the breakdown field to be constant.

11. A silicon p-substrate (\( p \equiv N_a = 10^{16} \text{ cm}^{-3} \)) MOSFET with \( t_{ox} = 0.1 \mu\text{m} \), \( \varepsilon_{ox}/\varepsilon_0 = 3.9 \) and \( V_{FB} = -0.2 \text{ V} \), has a threshold voltage which is 1 Volt smaller than desired. By what value should one change the oxide thickness, \( t_{ox} \), to obtain the desired threshold voltage? Should one increase or decrease the oxide thickness?