**VE320 Intro to Semiconductor Devices**
**Summer 2024 — Problem Set 7**
**Due: 11:59 pm 28th July**

1) Several conceptual questions

a) Explain the difference in the I-V relationship between the Schottky barrier diode and the Ohmic contact diode.

b) Explain the difference in the I-V relationship between the metal-semiconductor and the two-terminal MOS structure.

c) Explain the reason why there's a maximum depletion layer width.

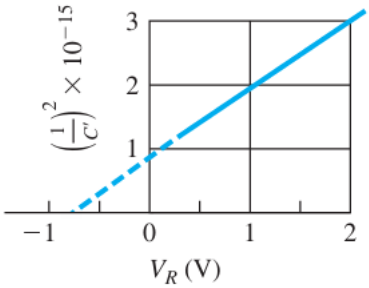
2) Energy band diagrams

a) Draw the equilibrium energy band diagram of a Schottky barrier diode and an Ohmic contact diode (both with an n-type semiconductor).

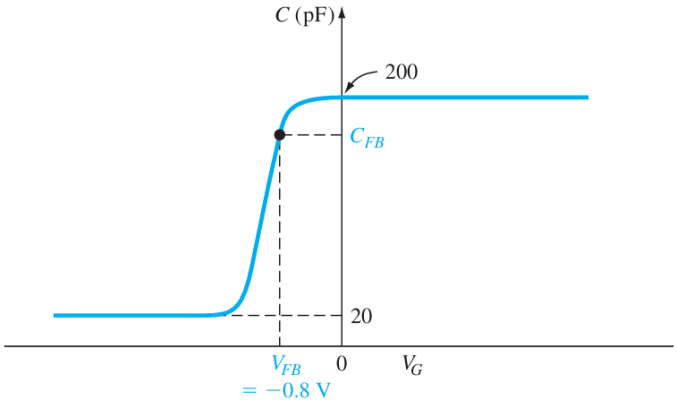
b) Draw the equilibrium energy band diagram of the two-terminal MOS structure if the work function of the metal is bigger than that of the semiconductor.

3) A Schottky diode at T =300K is formed with Pt on n-type silicon with a doping concentration of $N_d = 5 \times 10^{15} cm^{-3}$. The barrier height is found to be $\phi_{Bn} = 0.89V$. The effective Richardson constant is $A^* = 120 A/K^2\text{-}cm^2$. Determine (a) $\phi_n$, (b) $V_{bi}$, (c) $J_{sT}$, and (d) $V_a$ such that $J_n = 5A/cm^2$.

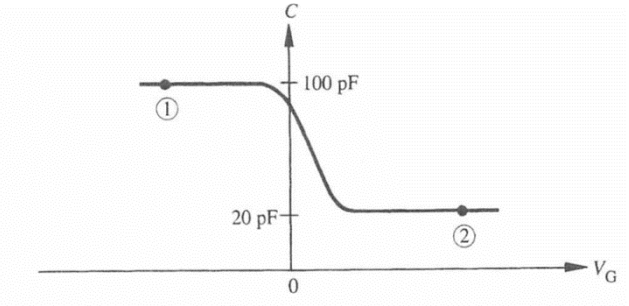
4) A Schottky diode with n-type GaAs at T = 300K yields the plot shown in the Figure below, where the unit of $C'$ is $fF/cm^2$. Determine (a) $V_{bi}$, (b) $N_d$, (c) $\phi_n$, and (d) $\phi_{B0}$. You can approximately read the graph below.




5) The high-frequency C–V characteristic curve of a MOS capacitor is shown in the figure below. The area of the device is $2 \times 10^{-3} cm^2$. The metal-semiconductor work function difference is $\phi_{ms} = -0.50V$, the oxide is SiO2, the semiconductor is silicon, and the semiconductor doping concentration is $2 \times 10^{16} cm^{-3}$. (a) Is the semiconductor n or p-type? (b) What is the oxide thickness? (c) What is the equivalent trapped oxide charge density?




6) The high-frequency C–V characteristic curve of a MOS capacitor is shown in the figure below. The oxide is SiO2 and the semiconductor is silicon. The area of the MOS capacitor is $3 \times 10^{-3} cm^2$. (a) Is the semiconductor component of the MOS capacitor doped n-type or p-type? (b) Draw the MOS capacitor energy band diagram corresponding to point (2) on the C – V characteristic. (c) Draw the block charge diagram corresponding to point (1) on the C – V characteristic. (d) What is the oxide thickness? (e) Determine $x_{dT}$ and the associated semiconductor doping concentration for the given MOS capacitor.




7) Consider an n-channel depletion mode MOSFET with an n polysilicon gate. The n-channel doping is $N_d = 10^{15} cm^{-3}$ and the oxide thickness is 500 Å. The equivalent fixed oxide charge is $Q'_{ss} = 10^{10} cm^{-2}$. The metal-semiconductor work function difference is $\phi_{ms} = -0.272V$. The n-channel thickness is equal to the maximum induced space charge width. (Disregard the space charge region at the n-channel–p-substrate junction.) (a) Determine the channel thickness and (b) calculate the threshold voltage.