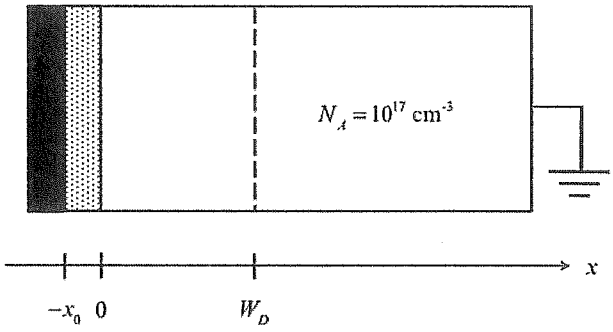
MN-3
August 2017 QE

This question has five parts (20 points each) and refers to the MOS capacitor shown below.



You should assume the following:

$N_A = 10^{17}$ cm^{-3} $\quad x_0 = 2\times10^{-7}$ cm $\quad W_D = 7.46\times10^{-6}$ cm

$n_i = 1\times10^{10}$ cm^{-3} $\quad k_BT/q = 0.026$ eV $\quad \varepsilon_0 = 8.854\times10^{-12}$ [F/m] $\quad K_S = 12$ $\quad K_{ox} = 4$

Assume there is no charge at the oxide-semiconductor interface.

Most of the questions depend on answers to previous questions, but you will receive most of the credit if your procedure is correct.

MN-3 Part 1: (20 points)
What is the electric field at x = 0? (i.e. at the oxide-semiconductor interface)? Be sure to include the sign and units.

MN-3 Part 2: (20 points)
What is the electrostatic potential, φ_S at x = 0? (i.e. at the oxide-semiconductor interface)? Be sure to include the sign and units. You should assume that the electrostatic potential in the bulk of the semiconductor is zero (i.e. $\varphi(x\to\infty)=0$.)

MN-3 Part 3: (20 points)
What is the electrostatic potential in the metallic gate? Be sure to include the sign and units.

MN-3 Part 4: (20 points)
If the applied gate voltage is zero, what is the metal-semiconductor workfunction difference in electron volts? Be sure to include the sign and units.

MN-3 Part 5 (20 points)

Now assume that a delta-function of **positive** charge is placed at $x = W_D/2$. The gate voltage is adjusted so that W_D does not change. The magnitude of the delta function is $N_I = N_A W_D/2$ cm^{-2}.

Plot the electric field vs. position for two cases: 1) before the delta function of charge was inserted, and b) after the delta- function of charge was inserted. Indicate the magnitude of the electric field at the oxide-semiconductor interface in both cases. To receive credit, you must (clearly) **explain** your plot.

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