COLLEGE OF ENGINEERING & TECHNOLOGY

Department: Electronics and Communications Engineering

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Course Title: Advanced Devices

Course No.: EC738 **Problem Set #3 Ver. 2**

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MOS Capacitor

Question 1

For an PMOS capacitor:

- n-type silicon substrate, As doping with N_D = 1E18cm^{-3}
- Oxide: t_{ox} = 2 nm, ε_{oxr} = 3.9
- Gate: p-type polysilicon with phosphorus doping of N_A = 1E20cm^{-3}

a- Calculte Cox' (F/m2)
b- Calculate V_{bulk}, V_{FB}, V_{th}
b- Calculate the max. depletion width
c- Find V_{th} if the substrate is at +1V.

Question 2

For an MOS capacitor:

- p-type silicon substrate, Arsenic doping with N_A = 2E18 cm^{-3}
- Oxide: t_{ox} = 2 nm
- Gate: n-type polysilicon with phosphorus doping of N_D=1E20cm^{-3}.
- The thickness of the bottom electron layer in the substrate under the oxide is 1nm (with uniform charge concentration across channel thickness).
- V_{gate} = 2V, $V_{substrate}$ = 0V, find:

Assuming the depletion approximation holds (i.e. V_s in strong inversion = 2V_{Bulk})

a- The surface charge density (C/cm^2).
b- The surface electron density (cm^{-2})
c- Conductivity of bottom charge layer, if u_n = 400cm^2/V.sec
d- Surface field and potential just below the oxide.

Question 3

For the structure in Q2:
a- Plot the total charge/unit Vol. (C/cm^{-3}) as a function of distance for V_{surf} = 1V, 0.2V, 0V, -1V at x=0cm. (Hint: Total charge means both mobile and fixed)
b- Plot the band diagram for V_{surf} = 2$V_{bulk,}$ $V_{substarte}$ = 0V. Show E_{Fermi}, E_i, E_C, E_V
c- Repeat part b, with Vsubstrate = -1V.

Question 4

For the structure in Q2:
If V_{gate}= -3V, V_{FB}, Vg @ weak inversion, Vg @ strong inversion, Vg=+3V, while substrate is at ground:
a- Find V_{ox} across the oxide for these cases
b- Find the overall capacitance for the cases, as a function of applied gate voltage
c- Plot the Capacitance as a function of gate voltage (CV curve)