Assignment 1 (EE620) (23-01-2019)

Values for reference:
Tox = 5 nm
$N_A = 10^{17}$ /cm^3
Fermi level of gate is at the conduction band of n+ type Si.
(Note: If any data is missing then assume an appropriate value and clearly mention your assumption)

1. Obtain a plot for total substrate charge,|Q| versus potential at oxide/semiconductor interface (band bending ψ_S) , for an MOS capacitor. [5 M]

$$Q = -\varepsilon_{si}\left(-\frac{d\psi_s}{dx}\right) = \pm\sqrt{2\varepsilon_{si}kTN_A}\left[\left(e^{-q\psi_s/kT} + \frac{q\psi_s}{kT} - 1\right) + \frac{n_i^2}{N_A^2}\left(e^{q\psi_s/kT} - \frac{q\psi_s}{kT} - 1\right)\right]^{1/2}$$

2. Obtain a plot for potential at oxide/semiconductor interface (i.e. band bending ψ_S) versus gate bias (V_G) for an MOS capacitor. slide33 [5 M]

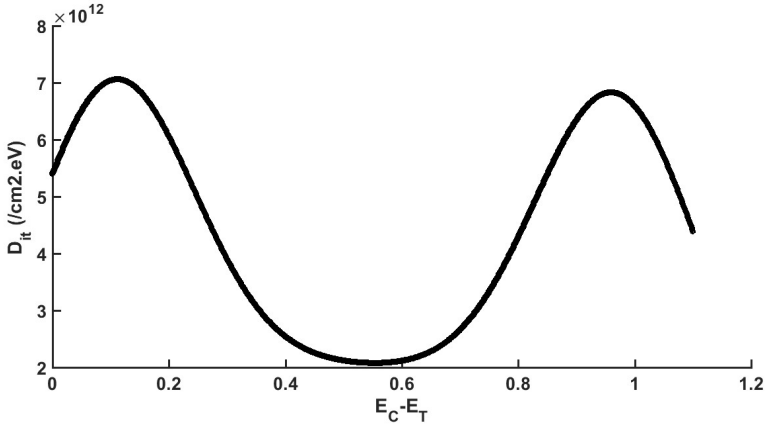
3. Obtain LFCV (low frequency C-V) and HFCV (High frequency C-V) curves using the equation for Q. Do the derivative manually and then compare with the numerical derivation. [10 M]

4. Vary oxide thickness (T_{ox}=3, 5, 7nm for N_A=1e17) and doping (N_A=1e14,1e16 &1e18 /cc for T_{ox}=5nm) and see the variations in C-V. Try to explain your observations. [10 M]

5. Do the above calculations (Q1 to Q4) using depletion approximation and show the comparative plots. [10 M]

6. Assume a fixed uniform oxide charge density ρ(x) =1e18/cc throughout the oxide. Show the shift in the C-V curves . [5 M]

7. An interface trap profile is shown in the figure below. Using a similar D_{it} profile and assuming the charge neutrality point to be located at mid gap, calculate G_P and C_P for the frequencies (1e3, 1e4, 1e5, 1e6) Hz . To calculate τ use n_i=1.5e10, v_{th}=2.6e7, σ=1e-15. From this, calculate C_M and G_M. Plot Vg vs $C_M(\omega)$ (Both LFCV and HFCV). (Note : You should obtain a stretch in C-V). (Meaning of the terms and required equations can be found in the lecture slide 'Set_04.pdf'.



Equation for D_{it} is given blow

$$\sum_{i=1}^{3} A_i \exp\left(-\left(\frac{E_{it}-B_i}{C_i}\right)^2\right)$$

where; A1=A2=6e12,A3=2e12; B1=0.1,B2=0.97,B3=0.5; C1=C2=0.2,C3=0.5. (You can have your own similar 'U' shaped D_{it}). [15 M]