Quiz 8

Q. A MOS Capacitor has a charge of $+2\times1.6\times10^{12}$ C/cm^2 on the metal plate (doping $N_A = 6\times10^{15}$ cm^{-3}).

$n_i = 10^{10}$ cm^{-3} $\quad t_{ox} = 5$ nm.

$\epsilon_{Si} = 11.8 \times 8.854\times10^{-14}$ F/cm

$\epsilon_{ox} = 3.9 \times 8.854\times10^{-14}$ F/cm

Evaluate

(A) Bias on the gate (V_G)

(B) Draw the E-B Diagram.

(C) Plot charge density Vs 'x' (Mention Different charge components & their magnitude.

(D) Estimate the capacitance for the Above bias ($\omega = 10^6$ rad/s).

Sol (A) $Q_m = 1.6\times10^{-19}\times1.6\times10^{12} = 2.56\times10^{-7}$ C/cm^2

$2\phi_F = \frac{2KT}{q}\ln\left(\frac{N_A}{n_i}\right) = 2\times0.0259\times\ln\left(\frac{6\times10^{15}}{10^{10}}\right) = 0.67$

at $\psi_s = 2\phi_F$; $Q_d = \sqrt{2qN_a\epsilon_{Si}2\phi_F} = \sqrt{2\times1.6\times10^{-19}\times6\times10^{15}\times8.854\times10^{-14}\times11.8\times0.67}$

at threshold.

$Q_d = 3.72\times10^{-8}$

this charge will be less than Q_m.

So, Capacitor is in inversion.

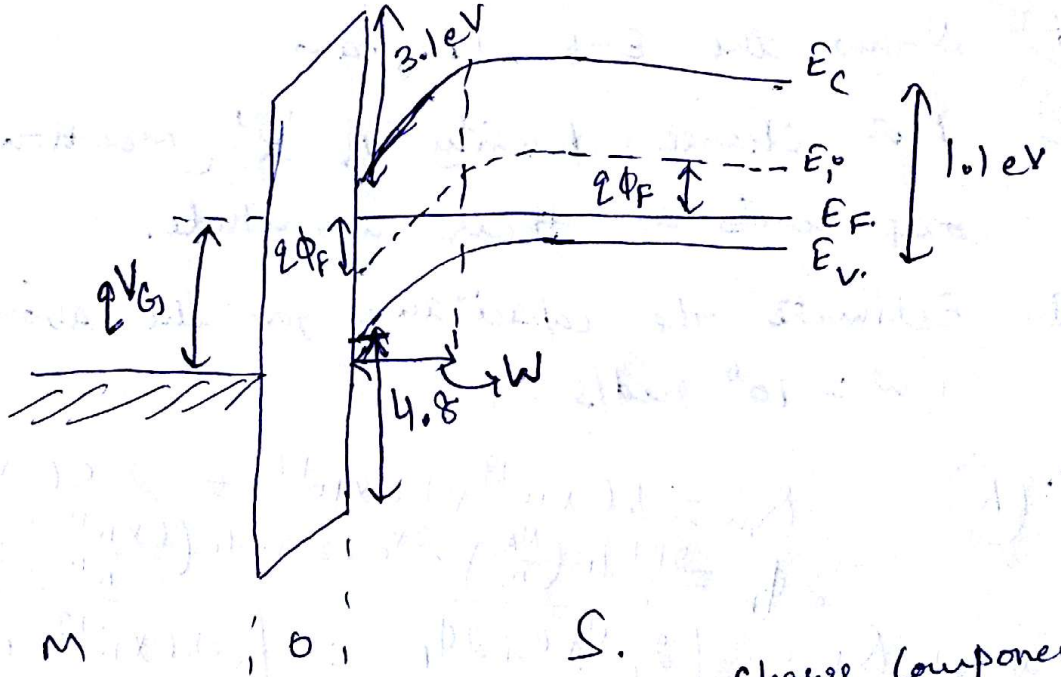
$$V_G = V_{FB} + 2\phi_F + \frac{Q_d}{C_{ox}} + \frac{Q_{inv}}{C_{ox}}$$

$$V_G = 0 + 0.67 + \frac{Q_T}{C_{ox}} = 0.67 + \frac{2.56 \times 10^{-7}}{3.9 \times 8.854 \times 10^{-14} / 5 \times 10^{-7}}$$

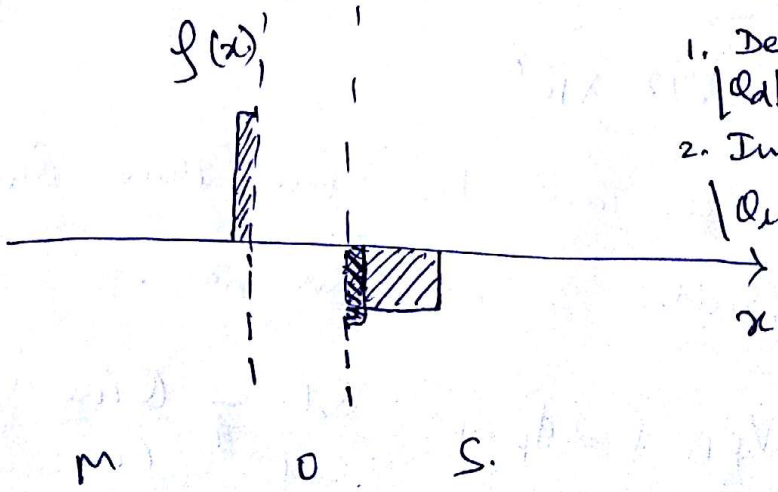
$$= 0.67 + 0.37$$

$$\boxed{V_G = 1.04 \text{ V}}$$

(B) Energy Band diagram.



(C)



Charge Components

1. Depletion charge.
$|Q_d| = 3.72 \times 10^{-8}$ C cm^{-2}.
2. Inversion charge.
$|Q_{inv}| = Q_T - Q_d$.
$= 2.188 \times 10^{-7}$ C cm^{-2}

(D) $\omega = 10^6$ rad/s.

The frequency is very high.

$$\therefore \frac{1}{C} = \frac{1}{C_{ox}} + \frac{1}{C_{dep}} = \frac{1}{C_{ox}} + \sqrt{\frac{2(2\phi_F)}{qN_A \epsilon_{Si}}}$$

$$= \frac{1}{6.91 \times 10^{-7}} + \sqrt{\frac{2 \times 0.67}{1.6 \times 10^{-19} \times 6 \times 10^{15} \times 11.8 \times 8.854 \times 10^{-14}}}$$

$$C = 2.63 \times 10^{-6} \text{ F/cm}^2$$