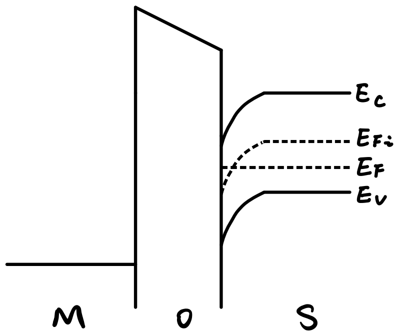
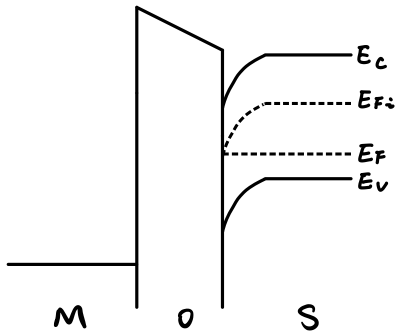
VE320 HW8 周[illegible]凯 518021911039

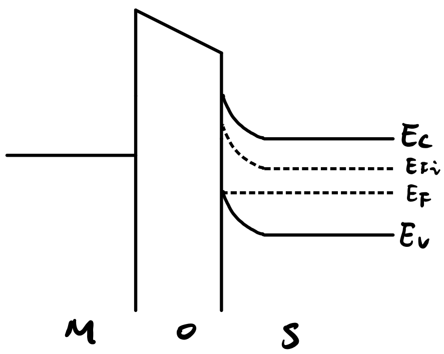
1\. (a). P type, inversion mode



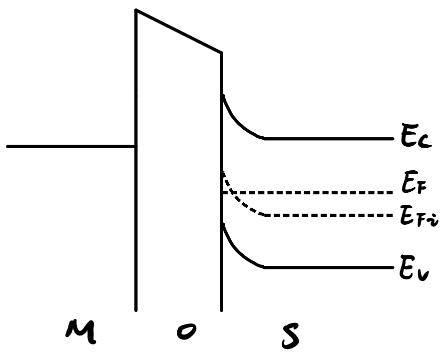
(b). P type, depletion mode



(c). P type, accumulation mode



(d). n type, inversion mode



2\. (a). $V_{FB} = \phi_{ms} - \frac{Q'_{ss}}{C_{ox}}$

From Fig. 10.16, we know $\phi_{ms} = -0.45\ V$

$V_{FB} = -0.45V$

(b). (i). $C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9 \times 8.85 \times 10^{-14}}{200 \times 10^{-8}} = 1.726 \times 10^{-7}\ F/cm^2$

$$\Delta V_{FB} = -\frac{Q'_{ss}}{C_{ox}} = -\frac{4 \times 10^{10} \times 1.6 \times 10^{-19}}{1.726 \times 10^{-7}} = -0.037\ V$$

(ii).

$$\Delta V_{FB} = -\frac{Q'_{ss}}{C_{ox}} = -\frac{10^{11} \times 1.6 \times 10^{-19}}{1.726 \times 10^{-7}} = -0.093\ V$$

(c). $V_{FB} = -0.45V$

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9 \times 8.85 \times 10^{-14}}{120 \times 10^{-8}} = 2.876 \times 10^{-7}\ F/cm^2$$

(i). $\Delta V_{FB} = -\frac{Q'_{ss}}{C_{ox}} = -\frac{4 \times 10^{10} \times 1.6 \times 10^{-19}}{2.876 \times 10^{-7}} = -0.022\ V$

(ii). $\Delta V_{FB} = -\frac{Q'_{ss}}{C_{ox}} = -\frac{10^{11} \times 1.6 \times 10^{-19}}{2.876 \times 10^{-7}} = -0.056\ V$

3. $V_T = \left(|Q'_{SD}(max)| - Q'_{ss}\right)\left(\frac{t_{ox}}{\varepsilon_{ox}}\right) + \phi_{ms} + 2\phi_{fp}$

$Q'_{ss} = 4\times10^{10} \times 1.6\times10^{-19} = 6.4\times10^{-9}$ c/cm²

$\phi_{fp} = 0.0259 \ln\left(\frac{Na}{1.5\times10^{10}}\right)$

$\frac{t_{ox}}{\varepsilon_{ox}} = \frac{220\times10^{-8}}{3.9\times8.85\times10^{-14}} = 6.374\times10^{6}$

$|Q'_{SD}(max)| = eNa\, x_{dT} = 1.6\times10^{-19} Na \sqrt{\frac{4\varepsilon_s \phi_{fp}}{eNa}}$

The relation between ϕ_{ms} and Na is on Fig. 10.16.

$$0.45 = \left(1.6\times10^{-19} Na \sqrt{\frac{4\times11.7\times8.85\times10^{-14}\times0.0259 \ln\left(\frac{Na}{1.5\times10^{10}}\right)}{1.6\times10^{-19} Na}} - 6.4\times10^{-9}\right)\left(6.374\times10^{6}\right) + \phi_{ms} + 2\times0.0259 \ln\left(\frac{Na}{1.5\times10^{10}}\right)$$

And $Na \approx 4\times10^{16}$ cm⁻³

4.(a). $V_{FB} = \phi_{ms} - \frac{Q'_{ss}}{C_{ox}}$

From Fig. 10.16, $\phi_{ms} \approx -1.05$

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.9\times8.85\times10^{-14}}{180\times10^{-8}} = 1.9175\times10^{-7}$ F/cm²

$Q'_{ss} = 6\times10^{10}\times1.6\times10^{-19} = 9.6\times10^{-9}$ c/cm²

$V_{FB} = -1.05 \quad \frac{9.6\times10^{-9}}{1.9175\times10^{-7}} = -1.10$ V

(b). $\phi_{fp} = 0.0259 \ln\left(\frac{10^{15}}{1.5\times10^{10}}\right) = 0.2877$ V

$|Q'_{SD}(max)| = eNa\, x_{dT} = 1.6\times10^{-19} Na \sqrt{\frac{4\varepsilon_s \phi_{fp}}{eNa}} = 1.381\times10^{-8}$ c/cm²

$V_{TN} = \left(|Q'_{SD}(max)| - Q'_{ss}\right)\left(\frac{t_{ox}}{\varepsilon_{ox}}\right) + \phi_{ms} + 2\phi_{fp}$

$= \left(1.381\times10^{-8} - 9.6\times10^{-9}\right) \times \frac{1}{1.9175\times10^{-7}} - 1.05 + 2\times0.2877$

$= -0.45$V

5. (a). n-type

(b). $C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$

Also, $C_{ox} = \frac{200\times10^{-12}}{2\times10^{-3}} = 10^{-7}$

$$\frac{3.9\times8.85\times10^{-14}}{t_{ox}} = \frac{200\times10^{-12}}{2\times10^{-3}} = 10^{-7}$$

$t_{ox} = 3.45\times10^{-6}$ cm

(c). $V_{FB} = \phi_{ms} - \frac{Q'_{ss}}{C_{ox}}$

$-0.8 = -0.5 - \frac{Q'_{ss}}{10^{-7}}$

$Q'_{ss} = 3\times10^{-8}\ c/cm^{-2}$

$Q'_{ss} = \frac{3\times10^{-8}}{1.6\times10^{-19}} = 1.875\times10^{11}\ cm^{-2}$

(d). $$C'_{FB} = \frac{\varepsilon_{ox}}{t_{ox} + \frac{\varepsilon_{ox}}{\varepsilon_s}\sqrt{\frac{kT}{e}\cdot\frac{\varepsilon_s}{e\cdot N_a}}} = \frac{3.9\times8.85\times10^{-14}}{3.45\times10^{-6} + \frac{3.9\times8.85\times10^{-14}}{11.7\times8.85\times10^{-14}}\sqrt{0.0259\times\frac{11.7\times8.85\times10^{-14}}{1.6\times10^{-19}\times2\times10^{16}}}}$$

$= 7.82\times10^{-8}\ F/cm^2$

$C_{FB} = A\,C'_{FB} = 1.56\times10^{-10}$ F

6. (a). $I_D = \frac{k'_p}{2}\cdot\frac{W}{L}(V_{SG}+V_T)^2$

$100\times10^{-6} = \frac{0.12\times10^{-3}}{2}\times20\times(0+V_T)^2$

$V_T = 0.29\ V$, satisfying $V_{SD} > V_{SG}+V_T$

(b). $V_{SD} > V_{SG}+V_T$, saturation region

$I_D = \frac{k'_p}{2}\cdot\frac{W}{L}(V_{SG}+V_T)^2 = 0.57\ mA$

(c). $V_{SD} < V_{SG}+V_T$

$I_D = \frac{k'_p}{2}\cdot\frac{W}{L}\left(2(V_{SG}+V_T)V_{SD} - V_{SD}^2\right) = 0.29\ mA$

7.(a). $\phi_{fp} = 0.0259 \ln\left(\frac{10^{15}}{1.5\times10^{10}}\right) = 0.2877\ V$

$|Q'_{SD}(max)| = eN_a x_{dT} = 1.6\times10^{-19} N_a \sqrt{\frac{4\varepsilon_s \phi_{fp}}{eN_a}} = 1.381\times10^{-8}\ C/cm^2$

$Q'_{ss} = 5\times10^{10}\times1.6\times10^{-19} = 8\times10^{-9}\ c/cm^2$

From Fig. 10.16, $\phi_{ms} \approx -1.05V$

$V_T = \left(|Q'_{SD}(max)| - Q'_{ss}\right)\left(\frac{t_{ox}}{\varepsilon_{ox}}\right) + \phi_{ms} + 2\phi_{fp}$

$= \left(1.381\times10^{-8} - 8\times10^{-9}\right)\times\frac{400\times10^{-8}}{3.9\times8.85\times10^{-14}} - 1.05 + 2\times0.2877$

$= -0.407\ V$

(b). $\Delta V_T = \frac{\sqrt{2e\varepsilon_s N_a}}{C_{ox}}\left(\sqrt{2\phi_{fp} + V_{SB}} - \sqrt{2\phi_{fp}}\right)$

$0.407 = \frac{\sqrt{2\times1.6\times10^{-19}\times11.7\times8.85\times10^{-14}\times10^{15}}}{\frac{3.9\times8.85\times10^{-14}}{400\times10^{-8}}}\left(\sqrt{2\times0.2877+V_{SB}} - \sqrt{2\times0.2877}\right)$

$0.407 = 0.210956\left(\sqrt{2\times0.2877+V_{SB}} - \sqrt{2\times0.2877}\right)$

$V_{SB} = 6.65V$