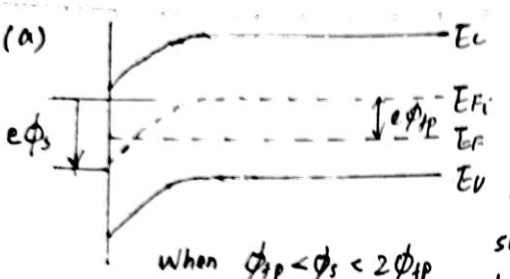
1. (a)



When $\phi_{fp} < \phi_s < 2\phi_{fp}$

Fermi level is closer to the conduction band than the valence band, so the semiconductor surface develops the properties of lightly doped n-type material and there some conduction between n^+ source and drain contacts through weak-inverted channel is expected.

(b) $S = kT/q \cdot \ln 10 \doteq 60\ mV$

2. $\phi_{fp} = V_t \ln\left(\frac{N_a}{n_i}\right) = 0.0259 \ln\left(\frac{2\times10^{16}}{1.5\times10^{10}}\right) = 0.3653\ V$

$V_{DS(sat)} = V_{GS} - V_T = 0.8 - 0.4 = 0.4\ V$

$\Delta V_{DS} = V_{DS} - V_{DS(sat)} = 2.5 - 0.4 = 2.1\ V$

$$\Delta L = \sqrt{\frac{2\varepsilon_s}{eN_a}}\left[\sqrt{\phi_{fp} + V_{DS(sat)} + \Delta V_{DS}} - \sqrt{\phi_{fp} + V_{DS(sat)}}\right]$$

$$= \sqrt{\frac{2\times11.7\times8.85\times10^{-14}}{1.6\times10^{-19}\times2\times10^{16}}}\left[\sqrt{0.3653+0.4+2.1} - \sqrt{0.3653+0.4}\right] = 2.08\times10^{-5}\ cm$$

We have $\frac{I_D'}{I_D} = \frac{L}{L-\Delta L} \le 1.35 \Rightarrow L \ge \frac{1.35}{0.35}\Delta L = 8.02\times10^{-5}\ cm$