

Strong Inversion

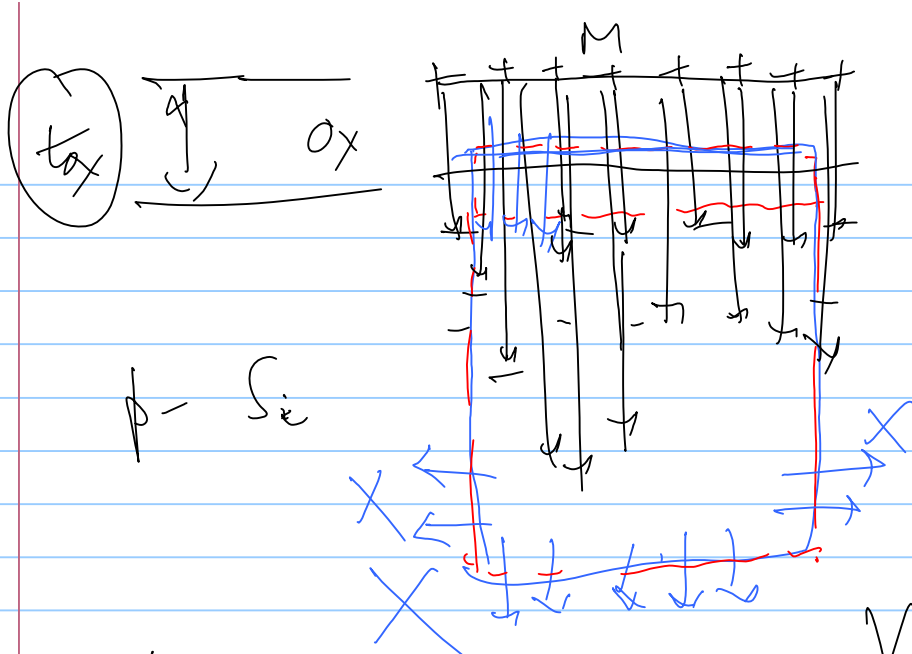
31/10/2014

Electron density at the surface
= hole density in the body

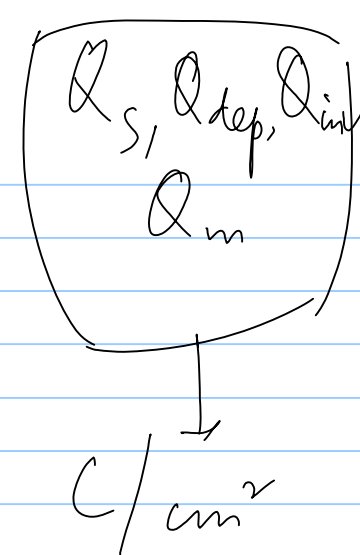
$$n_s = p_0$$

$$\phi_s = 2\phi_F$$

$$Q_m = -Q_s = -(Q_{dep} + Q_{inv})$$

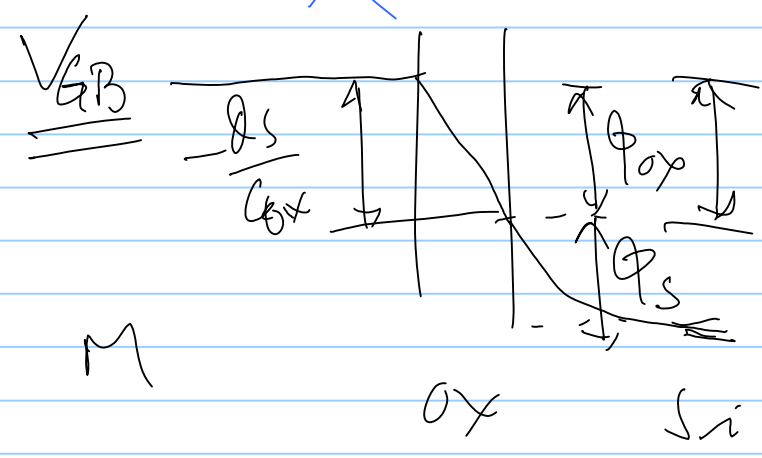


$$A \times \epsilon_{ox} \epsilon_{ox} = -Q_s$$



$$\epsilon_{ox} \epsilon_{ox} = -Q_s$$

$$V_{GB} = \phi_{tox} + \phi_s$$



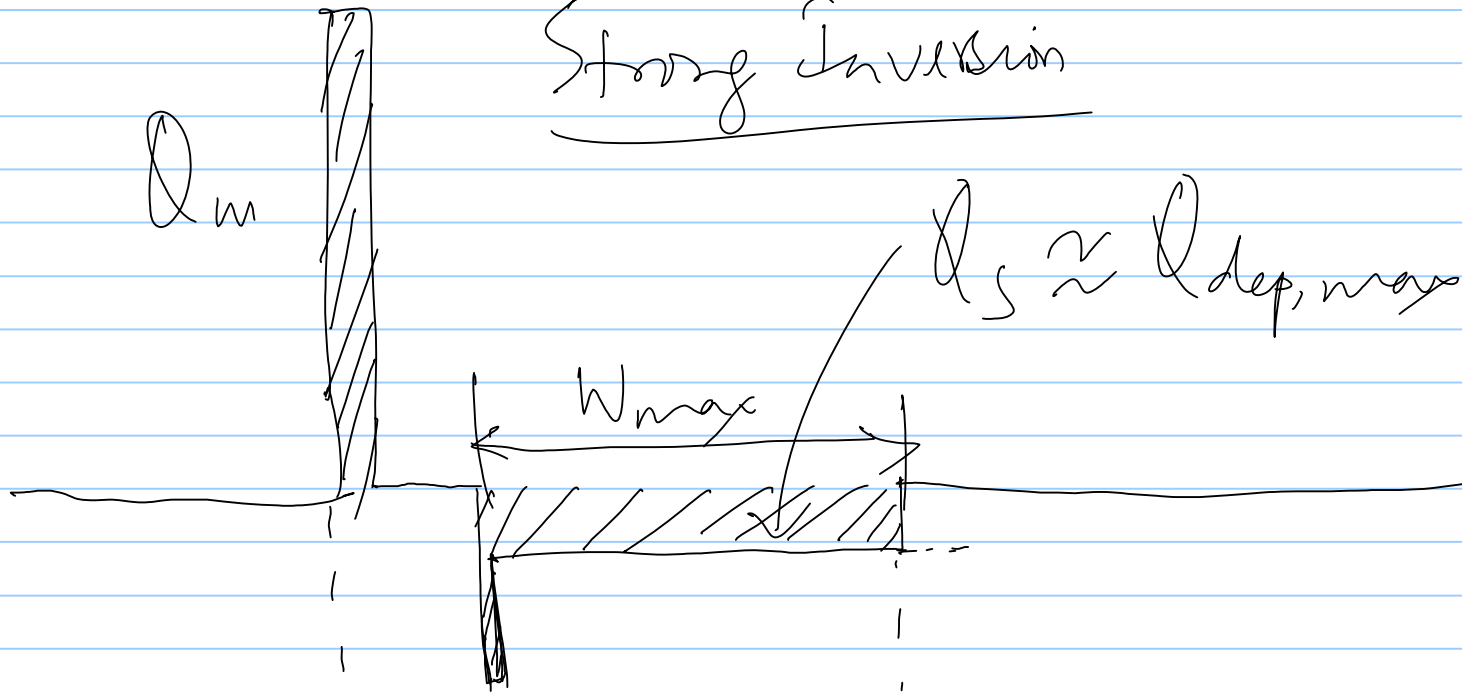
$$\phi_{tox} = \epsilon_{ox} t_{ox}$$

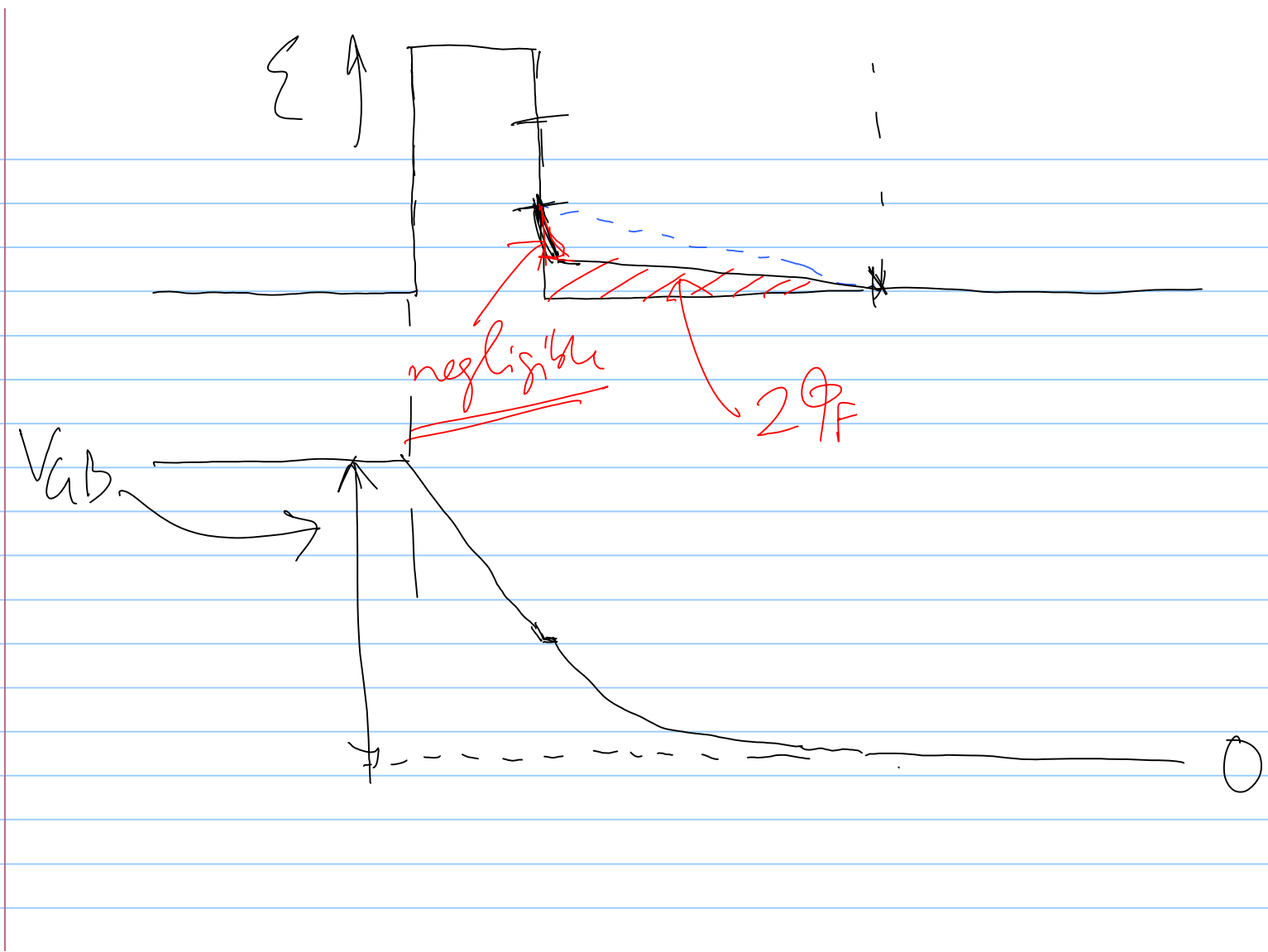
$$\frac{\epsilon_{ox} \phi_{tox}}{t_{ox}} = -Q_s \Rightarrow \phi_{tox} = \frac{-Q_s}{C_{ox}}$$

$$\Phi_F = f(N_a) \Rightarrow p = n_i e^{(E_i - E_F)/kT}$$

$$\Phi_F = \frac{kT}{q} \ln\left(\frac{N_a}{n_i}\right) \quad N_a = n_i e^{q\Phi_F/kT}$$

Strong Inversion





$$V_{GB} = \phi_{ox} + \phi_s$$

$$V_{TH} \cong - \frac{Q_{dep}}{C_{ox}} + 2\phi_F$$

↑
Threshold Voltage (V_{th} , V_T)

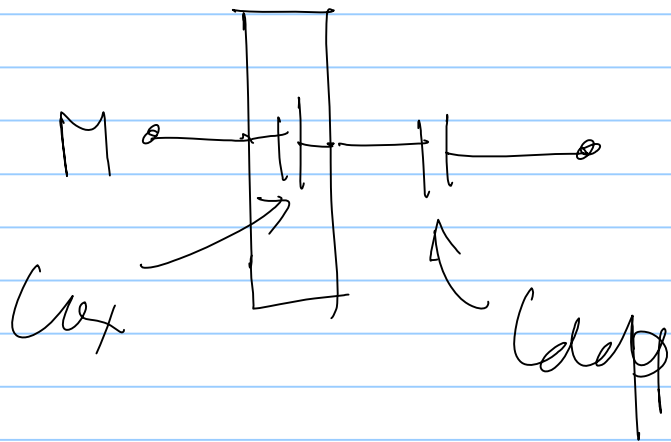
$$V_T = \frac{kT}{q} \neq V_{TH}$$

Oxide Capacitance
(F/cm²)

$$C_{ox} = \frac{\epsilon_{ox}}{t_{ox}}$$

Deplⁿ Capacitance,

$$C_{dep} = \frac{\epsilon_{si}}{W}$$



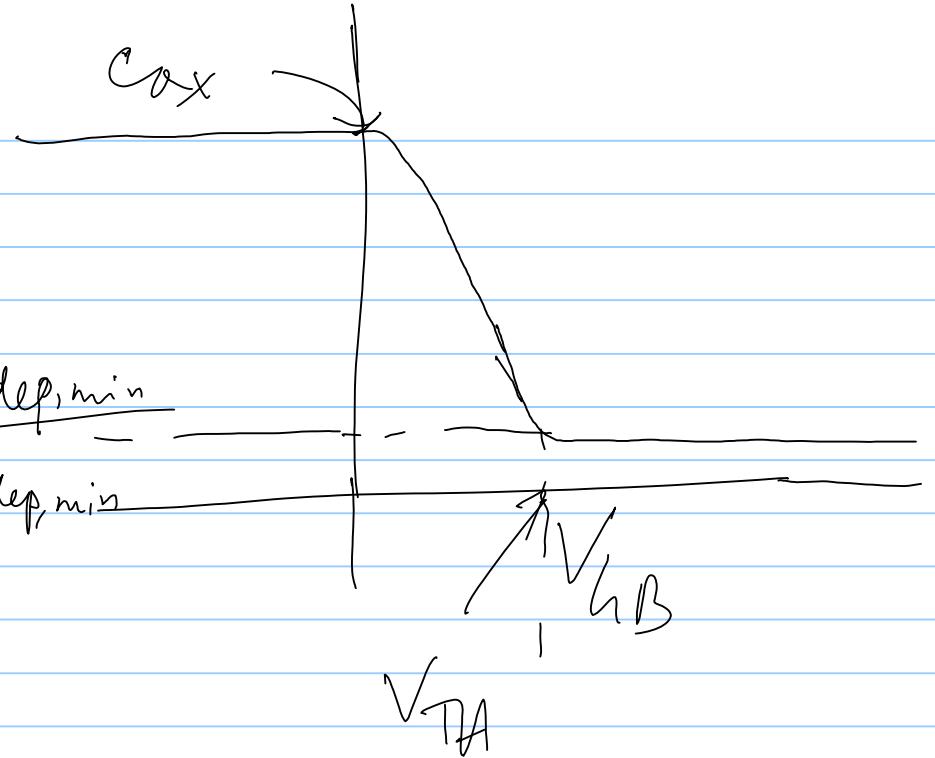
$$C_{MOS} = \frac{C_{ox} C_{dep}}{C_{ox} + C_{dep}}$$

$V_{GS} \rightarrow$ v_{GS} accumulation

$$C_{ROS} = C_{ox}$$

$$C_{dep,min} = \frac{\epsilon_{Si}}{W_{max}}$$

$$\frac{C_{ox} C_{dep,min}}{C_{ox} + C_{dep,min}}$$



p-type Si $\rightarrow N_a = 10^{16}$

$$\Phi_F = \frac{kT}{q} \ln \left(\frac{N_a}{n_i} \right) = 0.347 \text{ V}$$

$$W_{max} = \sqrt{\frac{2 \epsilon_{Si} (2\Phi_F)}{q N_a}} = 0.301 \mu\text{m}$$

$$t_{ox} = 100 \text{ \AA}, \quad C_{ox} = \frac{\epsilon_{ox}}{t_{ox}} = 3.45 \times 10^{-7} \text{ F/cm}^2$$

$$Q_{dep, max} = -q N_a \cdot W_{max} = -4.82 \times 10^{-8} \text{ C/cm}^2$$

$$V_{TH} = - \frac{Q_{dep, max}}{C_{ox}} + 2\Phi_F = 0.834 \text{ V}$$

$$\epsilon_{Si} = 11.8 \epsilon_0$$

$$\epsilon_0 = 8.85 \times 10^{-14} \text{ F/cm}$$

$$\epsilon_{ox} = 3.9 \epsilon_0$$

$$C_{dep, min} = \frac{t_{Si}}{W_{max}} = \underline{\underline{3.47 \times 10^{-8} \text{ F/cm}^2}}$$

$$C_{min} = C_{MOS, min} = \frac{C_{ox} C_{dep, min}}{C_{ox} + C_{dep, min}} = 3.15 \times 10^{-8} \text{ F/cm}^2$$