V_T $\qquad$ $V_D,\ V_s,\ V_G$

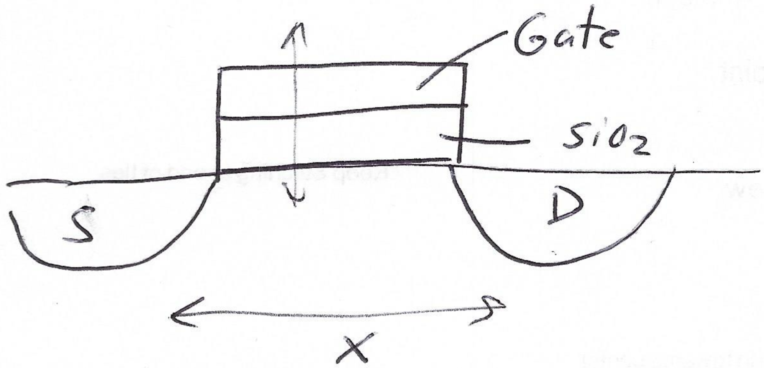
$$V_G = V_{FB} - \frac{Q_s}{C_i} + \phi_s$$

$$Q_s = Q_n + Q_d$$

$Q_n \rightarrow$ electrons

$Q_d \rightarrow$ dopants

(1) $$Q_n = -C_i\left[V_G - \left(V_{FB} + \phi_s - \frac{Q_d}{C_i}\right)\right]$$



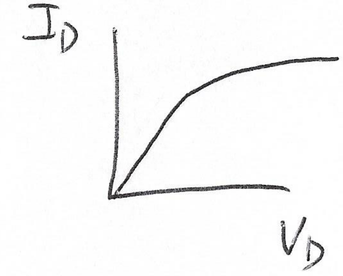
$V_D \rightarrow V_x$

$\phi_s = 2\phi_F$ for strong inversion

$$Q_n = -C_i\left[V_G - V_{FB} - 2\phi_F - V_x - \frac{1}{C_i}\sqrt{2q\epsilon_s N_a (2\phi_F + V_x}\right]$$

$$= -C_i\left[V_G - V_T - V_x\right]$$

$$I_D = \frac{\bar{\mu}_n Z C_i}{L}\left[(V_G - V_T)V_D - \frac{1}{2}V_D^2\right]$$



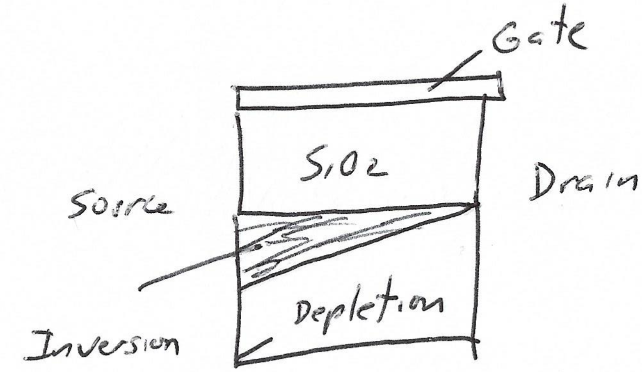
Assume $V_D \lll (V_G - V_T)$

$$\text{Conductance} \equiv g = \frac{\partial I_D}{\partial V_D} \approx \frac{Z}{L}\bar{\mu}_n C_i (V_G - V_T) \qquad 6\text{-}51$$

$V_D \rightarrow V_X$

Channel : $V_G > V_T$

Pinch-off $\rightarrow$ saturation



saturation $V_D(\text{sat}) \approx V_G - V_T$

$$I_{D(SAT)} \approx \frac{1}{2}\bar{\mu}_n C_i \frac{Z}{L}(V_G - V_T)^2 = \underline{\frac{1}{2}\mu_n C_i \frac{Z}{L}\left(V_{D(SAT)}\right)^2}$$