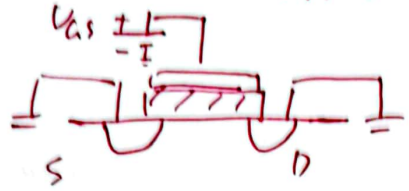
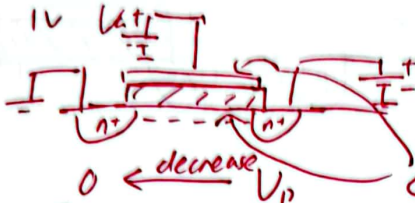
Behaviour of channel

Case I: $V_{GS} > V_{TH}$, $V_S = V_D = 0$



Turned on, but has no current

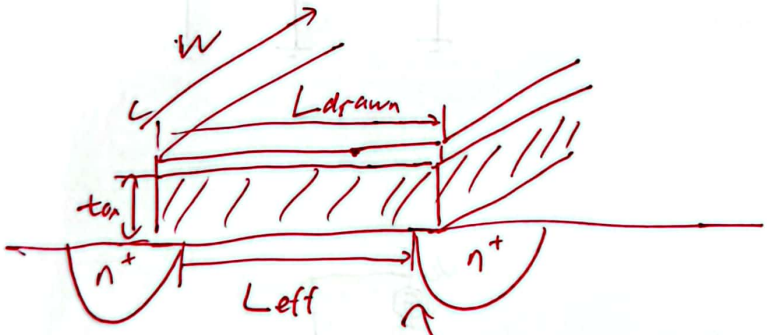
Case II: $V_{GS} > V_{TH}$, $V_S = 0$, $V_D > 0$



$Q = CV$

0 ← decrease V_D → 0V (夹断).

Dimensions of MOSFET



制造工艺引起的侧向扩散. Left < Ldrawn

P-sub

Derivation of I/V characteristic

① Channel Charge Density

Case I, $V_{GS} > V_{TH}$, $V_D = 0$

$Q_{ch,total0} = WL_{eff} \cdot \underbrace{C_{ox}}_{\text{capacitance per unit area}} (\underbrace{V_{GS} - V_{TH}}_{\text{overdrive voltage}})$

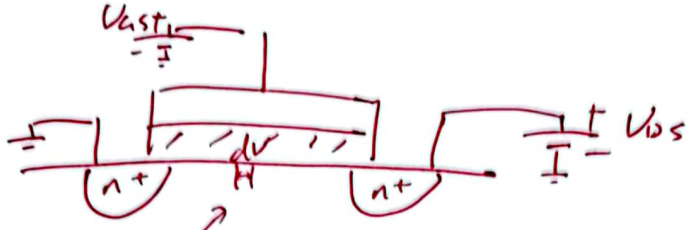
根据 $Q_{ch,den} = WC_{ox}(V_{GS} - V_{TH})$

Case II: $V_{GS} > V_{TH}$, $V_D > 0$

$Q_{ch,den} = WC_{ox}(V_{GS} - V_{TH} - V_{(x)})$

③ Drain Current

$v = \mu E$ μ: 电子迁移率 电场的比例



$E = -\frac{dV}{dx}$

$\therefore v = -\mu \frac{dV}{dx}$

$Q_{ch,den} = W C_{ox} (V_{GS} - V_{TH} - V(x))$

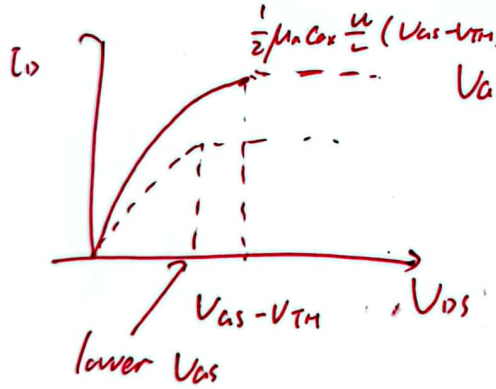
$I_D = -v\, Q_{ch,den} = -\left(-\mu_n \frac{dV}{dx} W C_{ox} (V_{GS} - V_{TH} - V(x))\right)$

沿 L 积分 Left

$\int_0^L I_D\, dx = \mu_n W C_{ox} \int_0^{V_{DS}} (V_{GS} - V_{TH} - V(x))\, dV$

$I_D L = \mu_n W C_{ox} \left((V_{GS} - V_{TH})V - \frac{1}{2}V^2\right)\Big|_0^{V_{DS}}$

$I_D = \mu_n \frac{W}{L} C_{ox} \left((V_{GS} - V_{TH})V_{DS} - \frac{1}{2}V_{DS}^2\right)$ $(V_{GS} \geq V_{TH})$



饱和状态