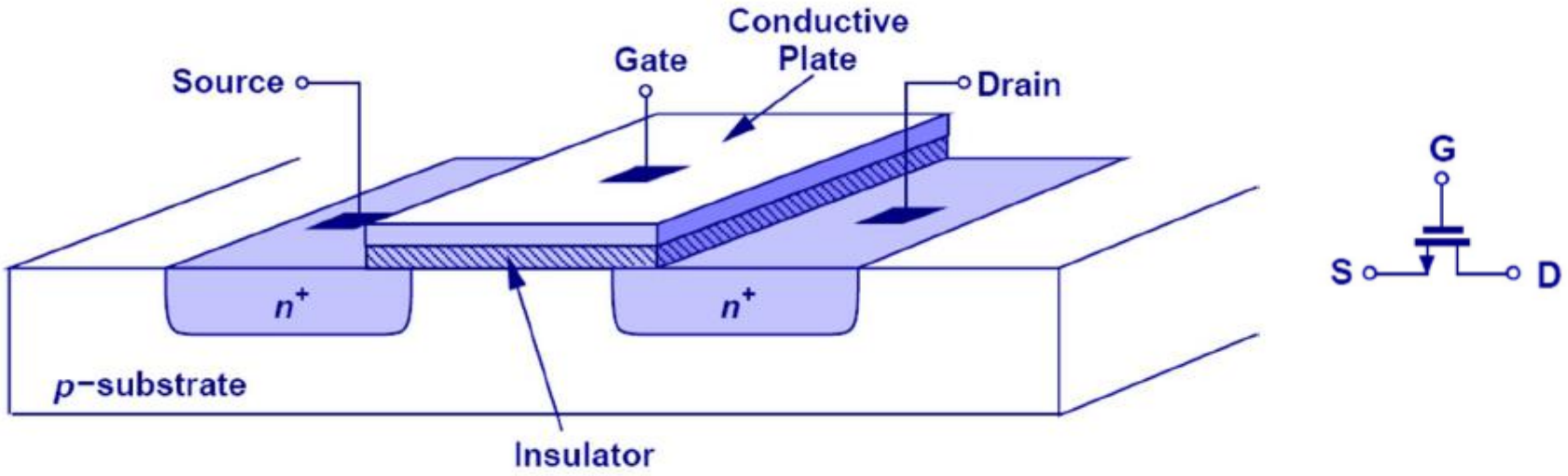
Lect. 2: MOS Transistors (1) (Razavi 6.2)

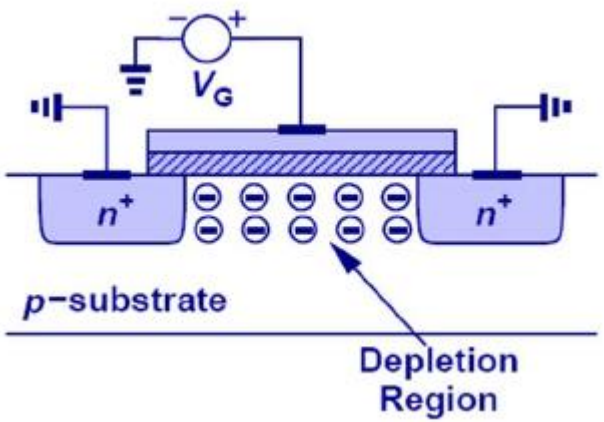
MOSFET Structure

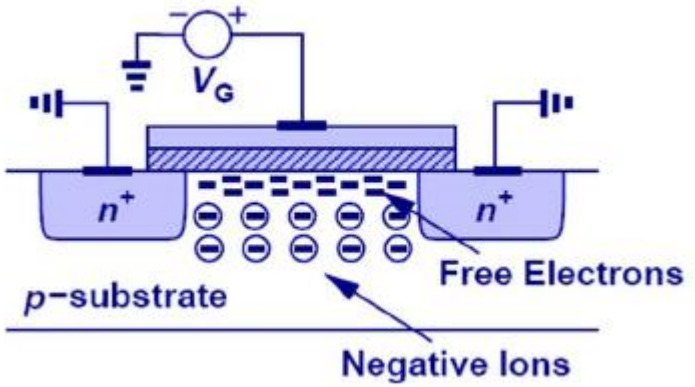


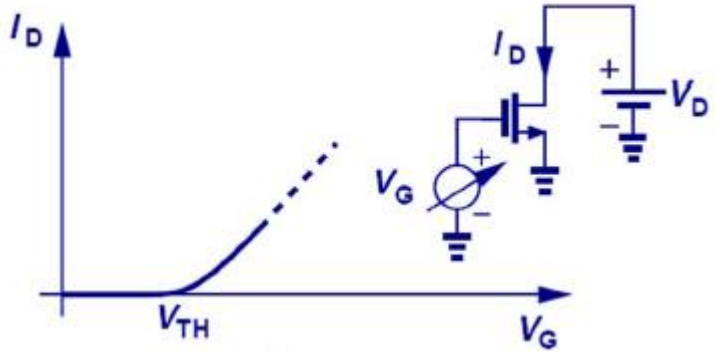
- Vertically: Metal Oxide Semiconductor ➔ Capacitor

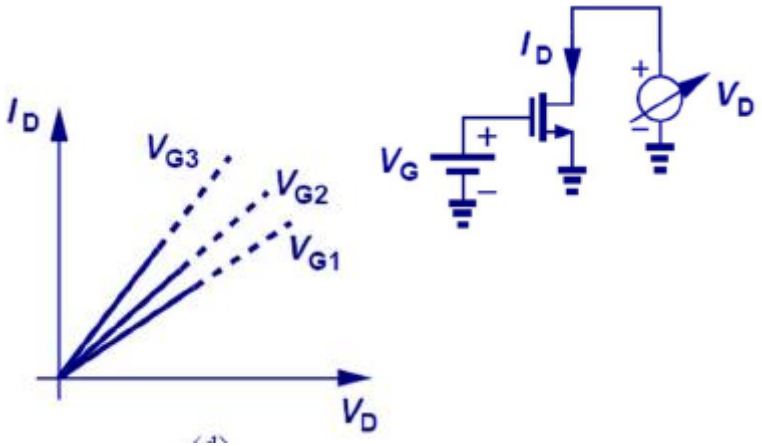
- Laterally: Source Channel Drain (NPN) Initially no conduction

Lect. 2: MOS Transistors (1)

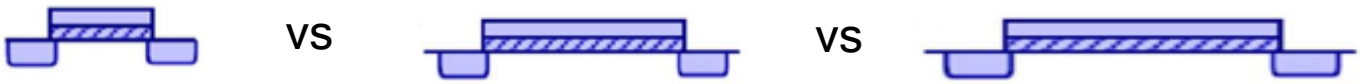


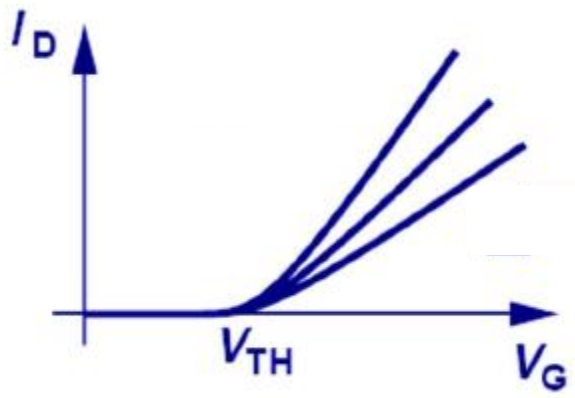


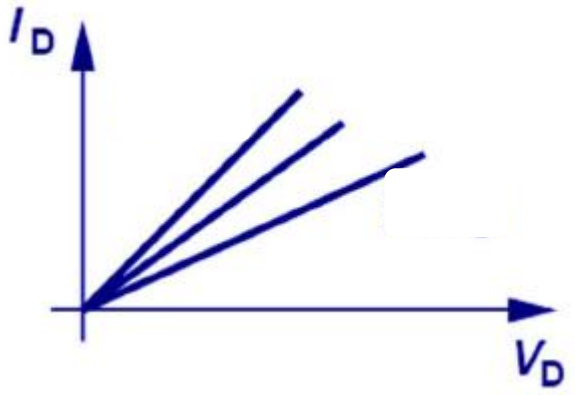




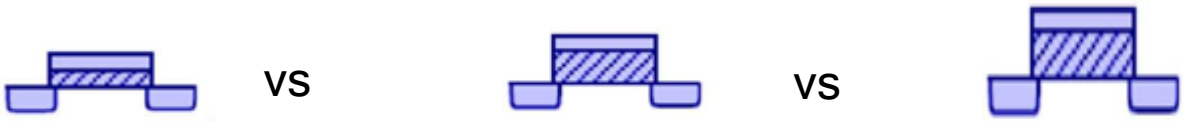
Lect. 2: MOS Transistors (1)

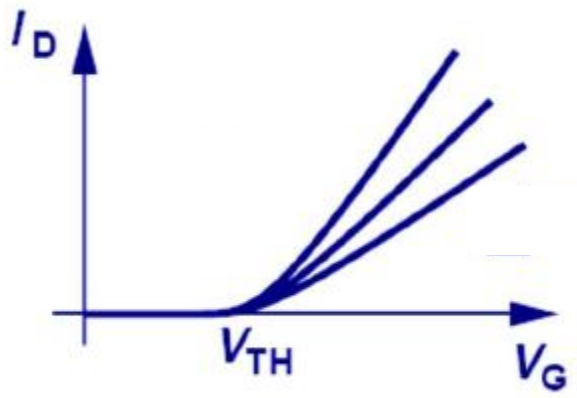


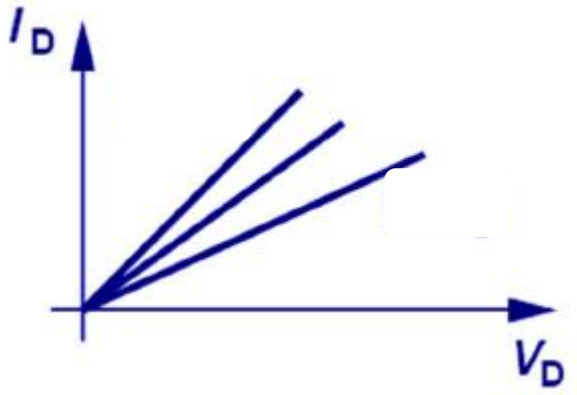




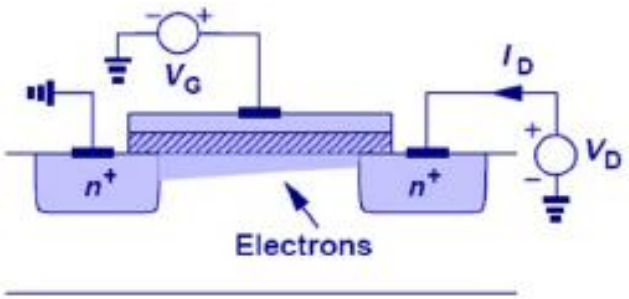
Lect. 2: MOS Transistors (1)

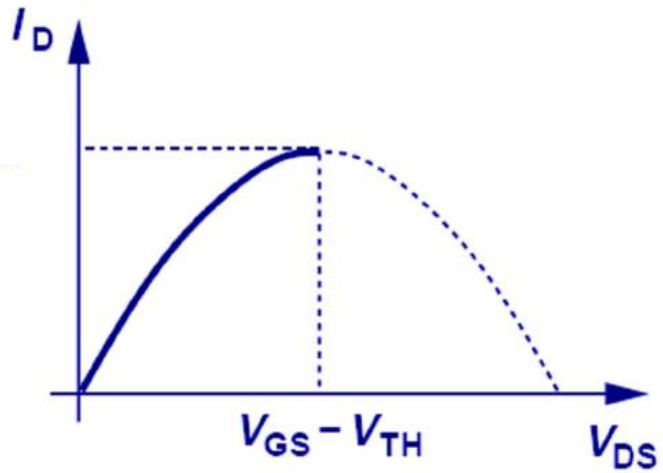






- Channel Potential Variation

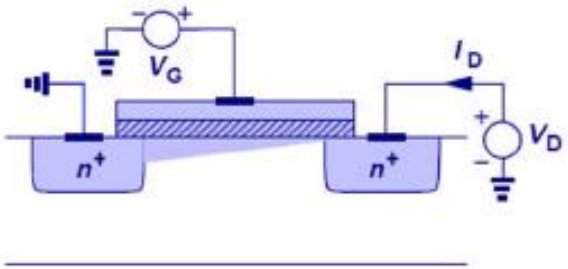


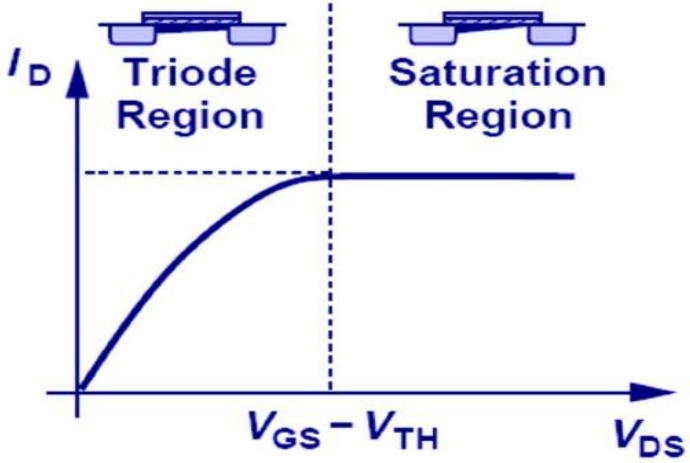


$$\frac{1}{2}\mu_n C_{ox}\frac{W}{L}[2(V_{GS}-V_{TH})V_{DS}+V_{DS}^2]$$

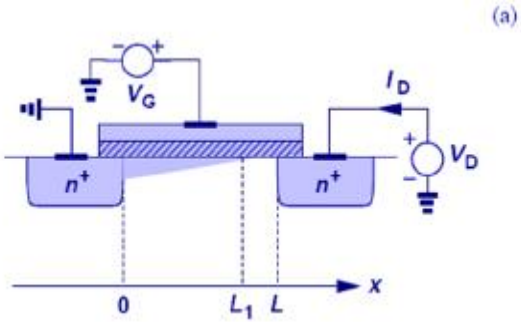
Lect. 2: MOS Transistors (1)

- Channel Pinch-Off





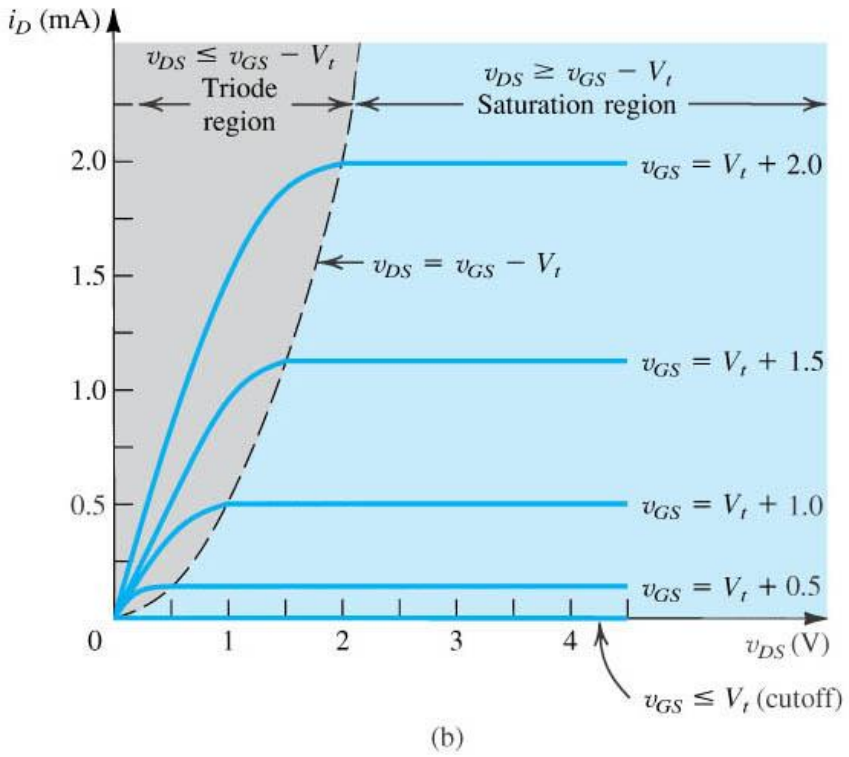
- MOSFET in Saturation



$$\frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left[2(V_{GS}-V_{TH})V_{DS}+V_{DS}^2\right]$$

Lect. 2: MOS Transistors (1)

- MOSFET I-V Characteristics



(b)

In cut-off ($v_{GS} < V_{TH}$), $i_D = 0$

In triode, ($v_{GS} > V_{TH}$ but $v_{DS} \le v_{GS} - v_{TH}$)

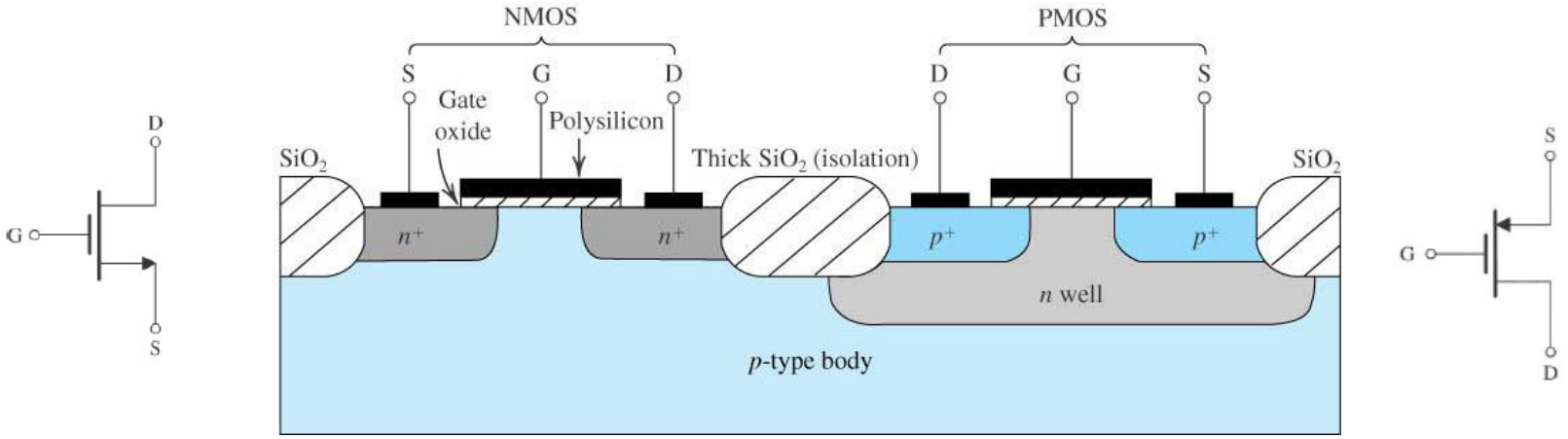
$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left[2(v_{GS} - V_t)\cdot v_{DS} - v_{DS}^{\,2}\right]$$

In saturation ($v_{GS} > V_{TH}$ and $v_{DS} \ge v_{GS} - v_{TH}$)

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(v_{GS} - V_{TH})^2$$

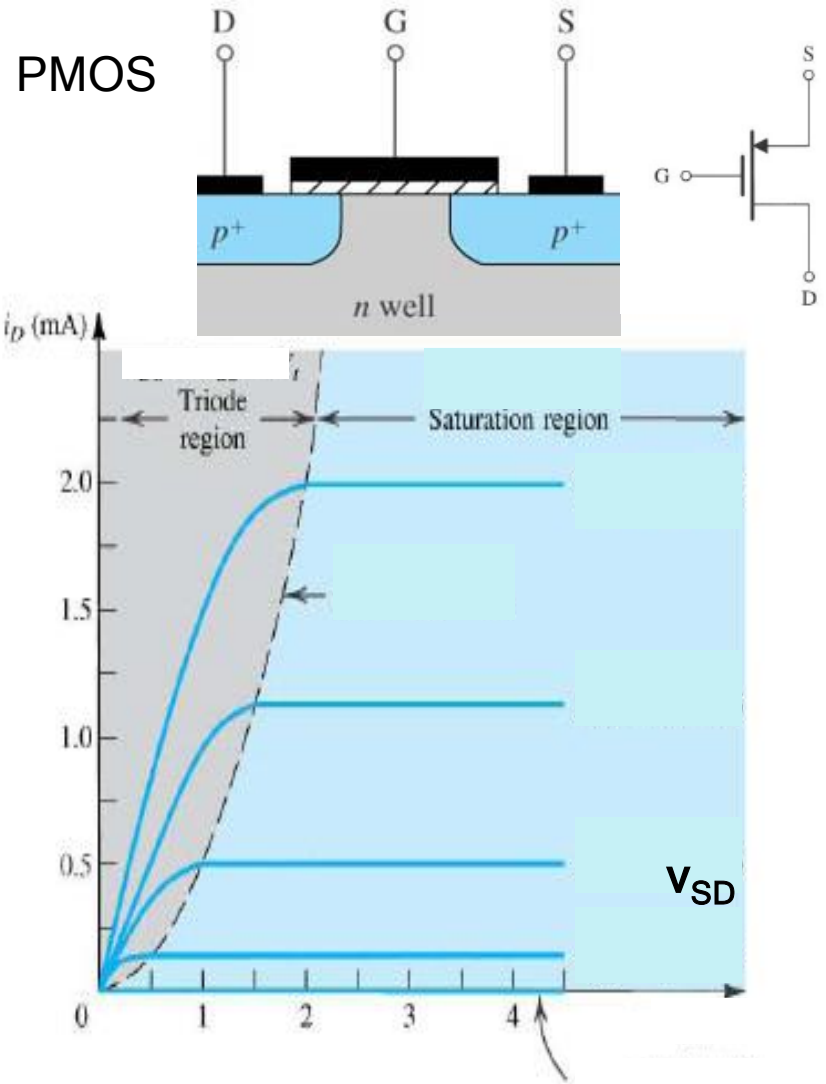
Lect. 2: MOS Transistors (1)

- NMOS vs PMOS



Lect. 2: MOS Transistors (1)

PMOS



$$v_{SG} < |V_{TH}| : \; i_D = 0$$

$$v_{SG} > |V_{TH}| \text{ and } v_{SD} < v_{SG} - |V_{TH}| \text{ (triode)}:$$

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}\left[2(v_{SG} - |V_{TH}|)\cdot v_{SD} - {v_{SD}}^2\right]$$

$$v_{SG} > |V_{TH}| \text{ and } v_{SD} > v_{SG} - |V_{TH}| \text{ (saturation):}$$

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(v_{SG} - |V_{TH}|)^2$$