Lecture10:
Physics of MOS transistors (2)

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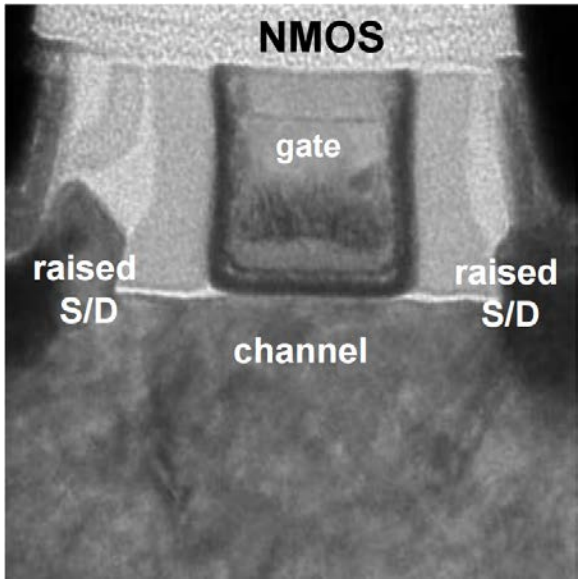
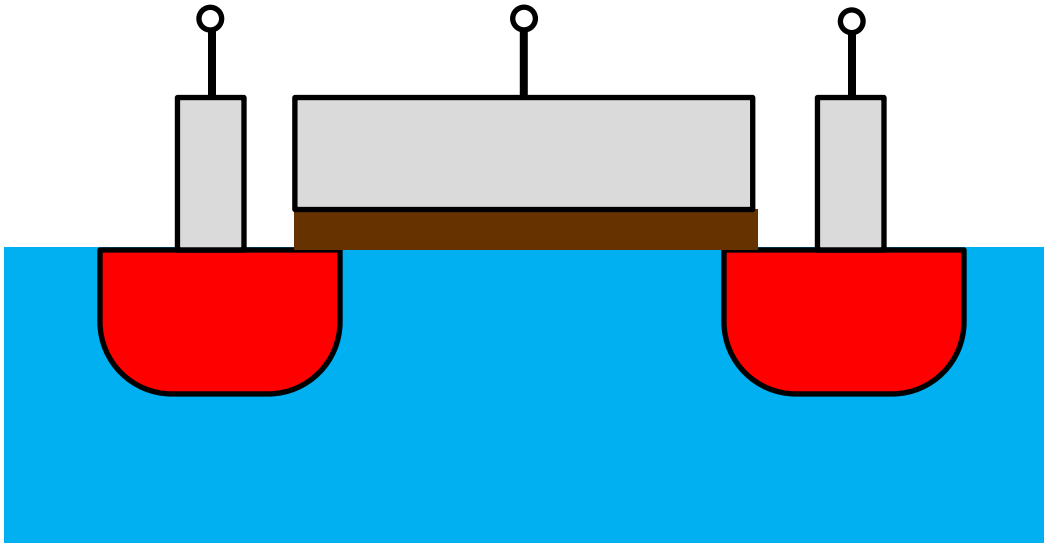
My feedback

- **M**etal-**O**xide-**S**emiconductor **F**ield-**E**ffect **T**ransistor
- Structure of MOSFET



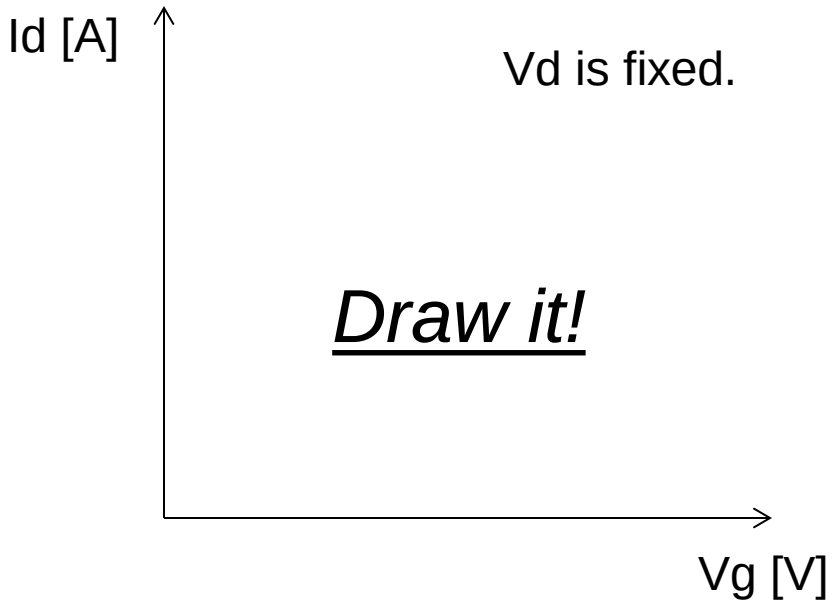


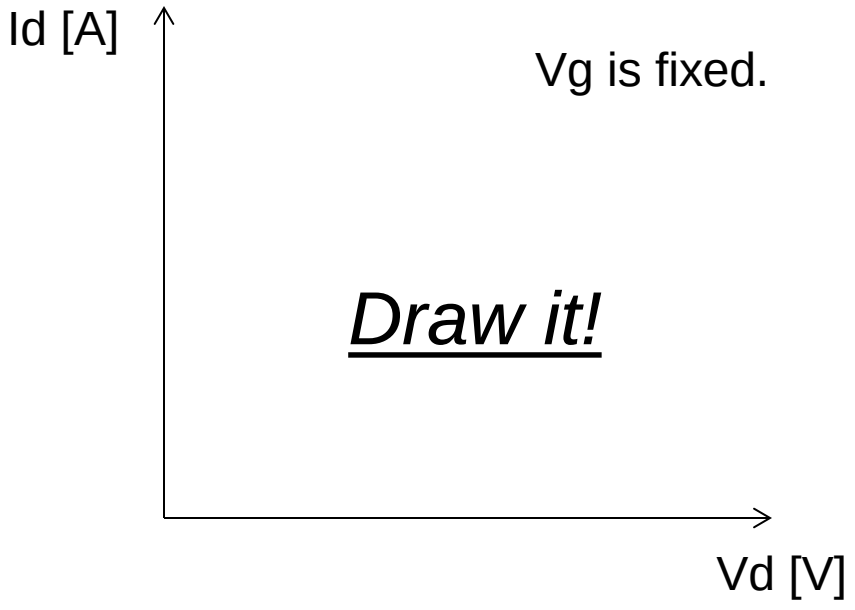
Review (1/2)

- The MOSFET has three terminals.
  - (Low-frequency) gate current is zero. (Isolated by the dielectric material)
  - Source current + drain current = 0
  - Source is connected to the GND.
  - Gate voltage and drain voltage are variables.

Review (2/2)

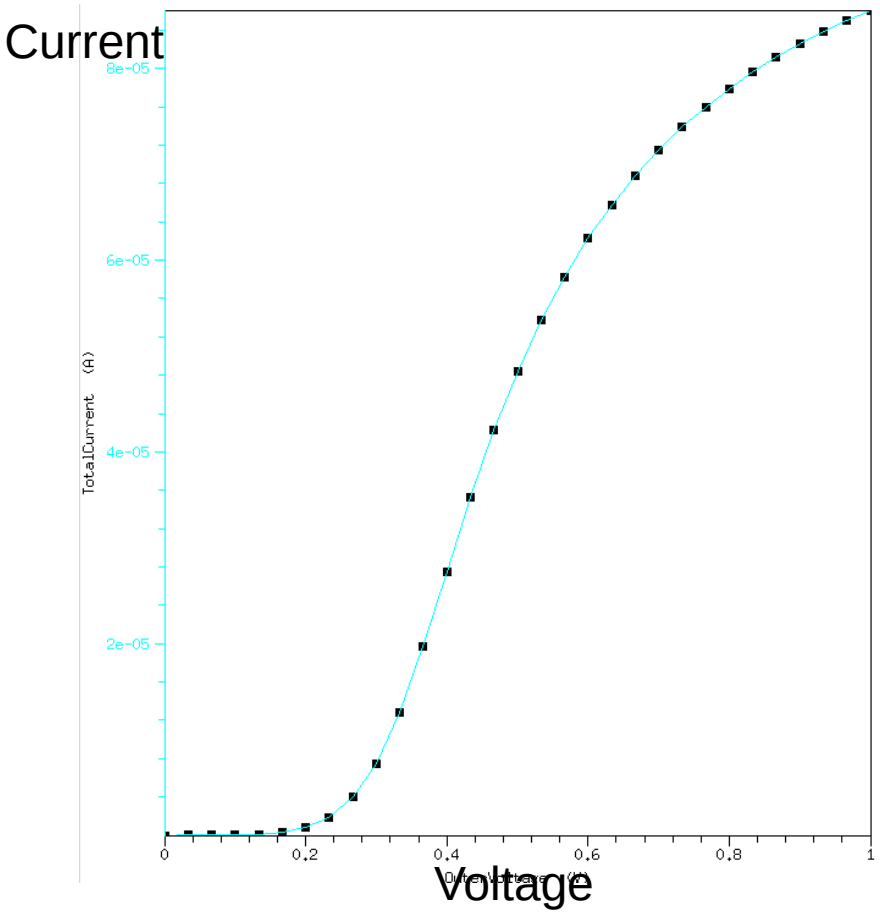
- Typical graphs
  - Id-Vg for given Vd values
  - Id-Vd for given Vg values





Threshold voltage

- Threshold behavior
  - Physical reason? (*See p. 248*)



A door threshold and a dog (Google images)

← A typical Id-Vg curve

Derivation of IV (1/2)

- Drain current
  - First of all, the current is given by

$$I = Q\,v \tag{6.4}$$

  - Here, Q is the charge density *per unit length*.
  - It follows

$$Q = WC_{ox}[V_G - V(x) - V_{TH}] \tag{6.3}$$

  - Also v is the electron velocity.

$$v = -\mu_n E = +\mu_n \frac{dV}{dx} \tag{6.5 and 6.6}$$

  - The drain current is

$$I_D = WC_{ox}[V_G - V(x) - V_{TH}]\mu_n \frac{dV}{dx} \tag{6.7}$$

Derivation of IV (2/2)

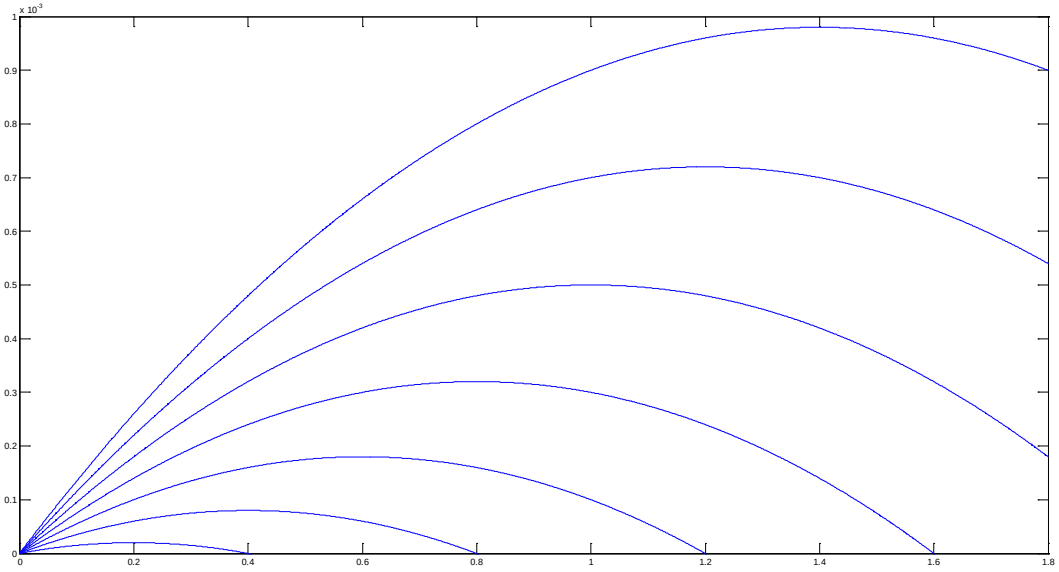
- Integration over the channel
  - Simply re-arranging,

$$I_D dx = \mu_n C_{ox} W [V_G - V(x) - V_{TH}] dV$$

  - When integrated,

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

Current



Voltage

← Is it acceptable?

Read your textbook!

- Today, we have studied the IV characteristic of a MOSFET.
  - Up to p. 262

- In Lecture11, we will study the short-channel effect of the MOSFET.
  - Up to p. 267