Lecture8:
MOSFET, IV

Sung-Min Hong (smhong@gist.ac.kr)

Semiconductor Device Simulation Lab.
School of Electrical Engineering and Coumputer Science
Gwangju Institute of Science and Technology

GIST Lecture on March 28, 2018 (Internal use only)

Drain current

- It is easy to guess that
  - When $V_{GS} < V_{TH}$, no drain current is allowed.

$$I_D = 0$$

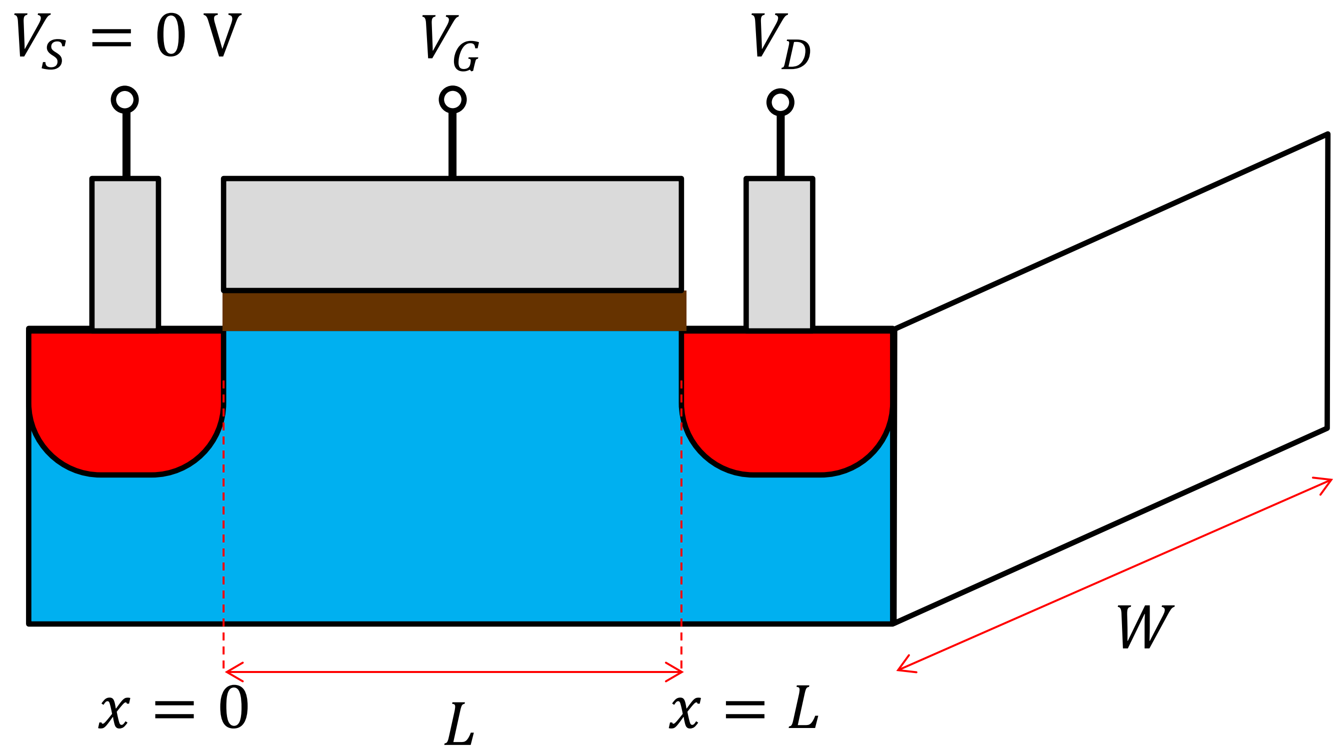
  - When $V_{GS} > V_{TH}$,

$$I_D \propto C_{ox}(V_{GS} - V_{TH})$$

- In this lecture, we derive an appropriate expression for I_D.

Device structure

- Two-dimensional cross-section
  - Potential can be dependent on the position, $V(x)$.



Derivation of IV (1/2)

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

$$I(x) = Q_{elec}(x)\, v(x) \tag{6.4}$$

  - Here, Q_{elec} is the electron charge density *per unit length*.
  - It follows

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

  - Also v is the electron velocity.

$$v = -\mu_n E = +\mu_n \frac{dV}{dx} \qquad \text{(6.5 and 6.6)}$$

  - It is easy to understand that $I_D = I(x)$. 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)

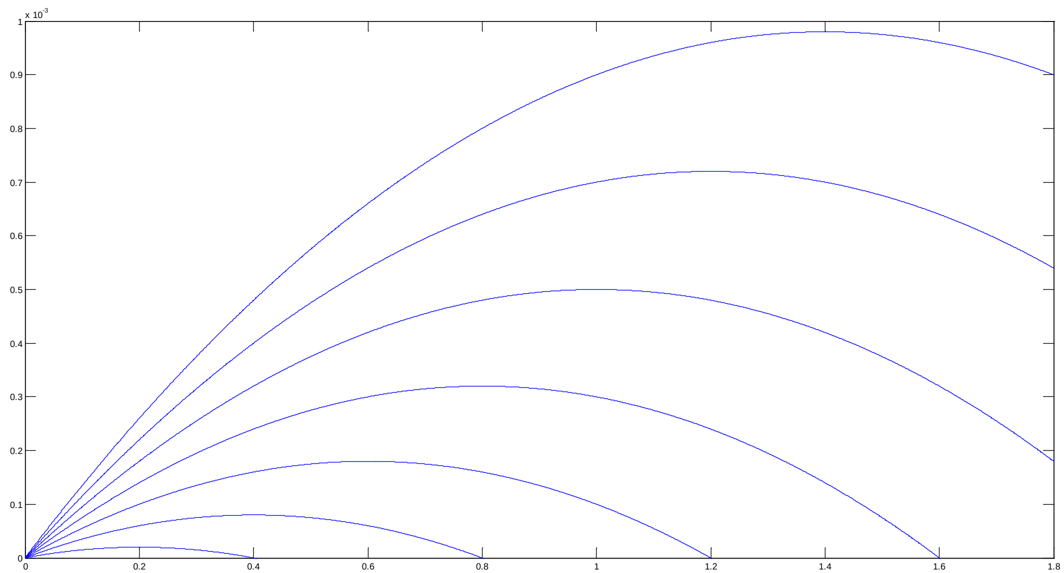
- Integration over the channel
  - Simply re-arranging,

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

  - 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?