Lecture10: MOSFET

Sung-Min Hong (smhong@gist.ac.kr)
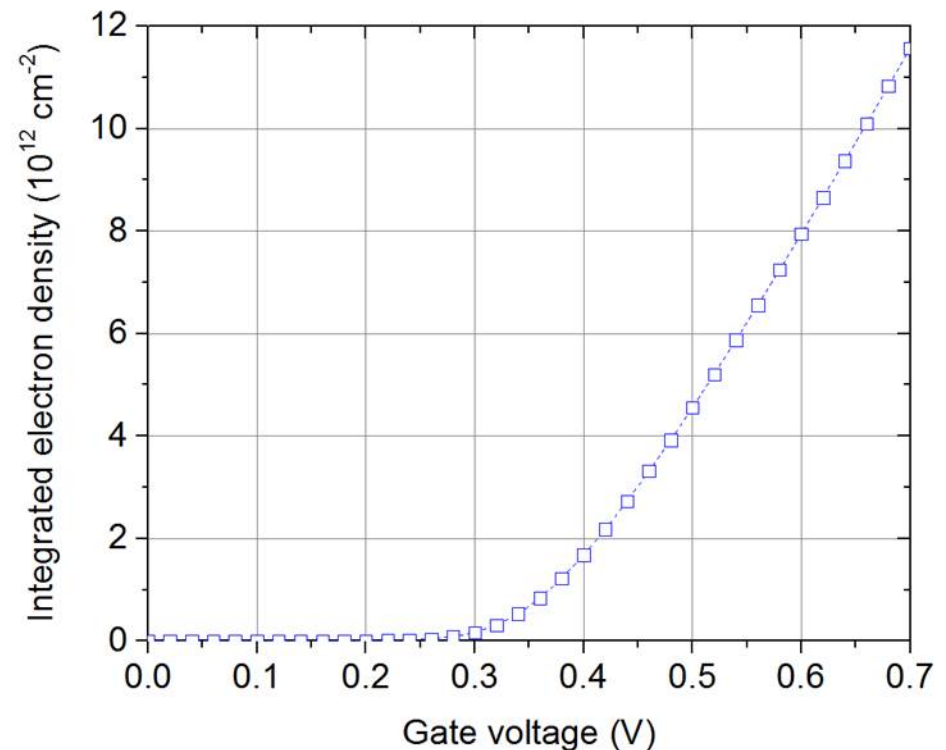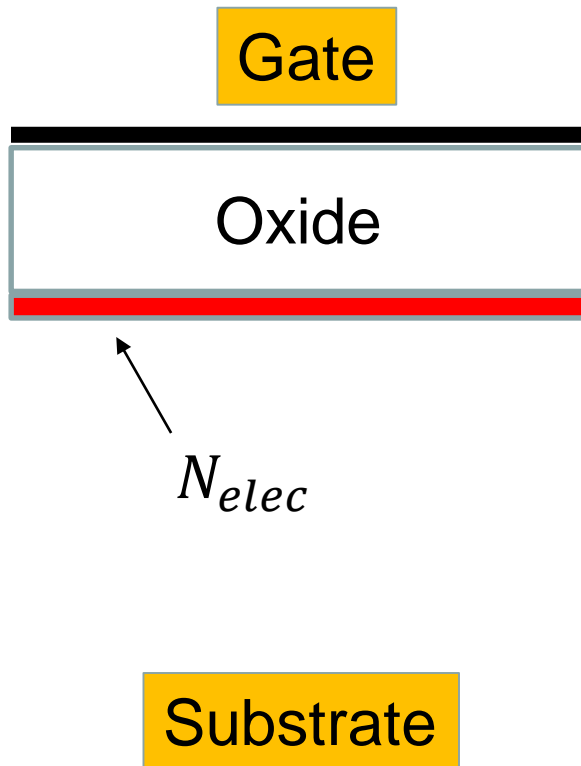
Semiconductor Device Simulation Lab.
School of Electrical Engineering and Computer Science
Gwangju Institute of Science and Technology
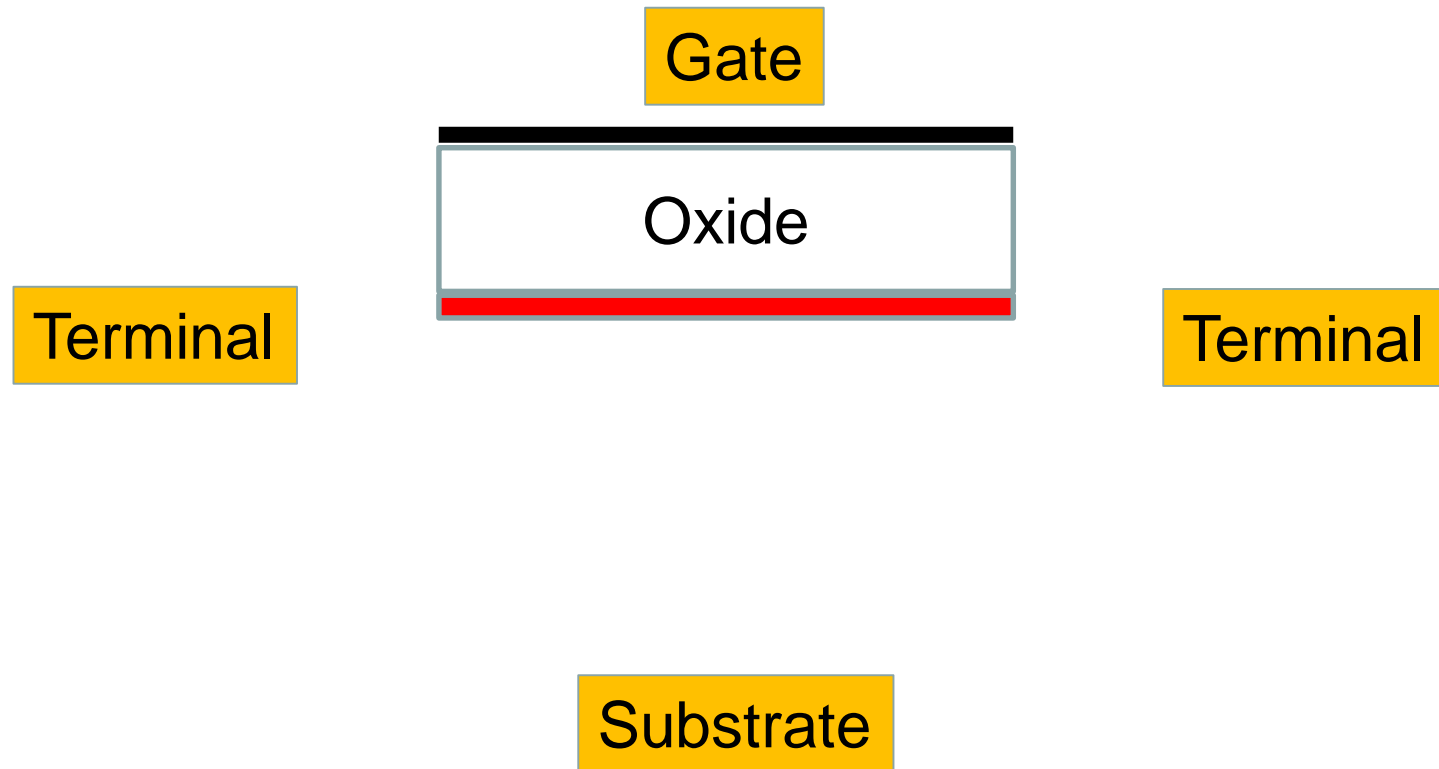
MOS

- Metal-Oxide-Semiconductor
  - V_G controls the total number of mobile electrons.
 $$qN_{elec} = C_{ox}(V_G - V_{TH})$$

MOSFET

- MOS + FET (Field-Effect Transistor)
    - Another electric field for the current conduction
    - We need two additional terminals.
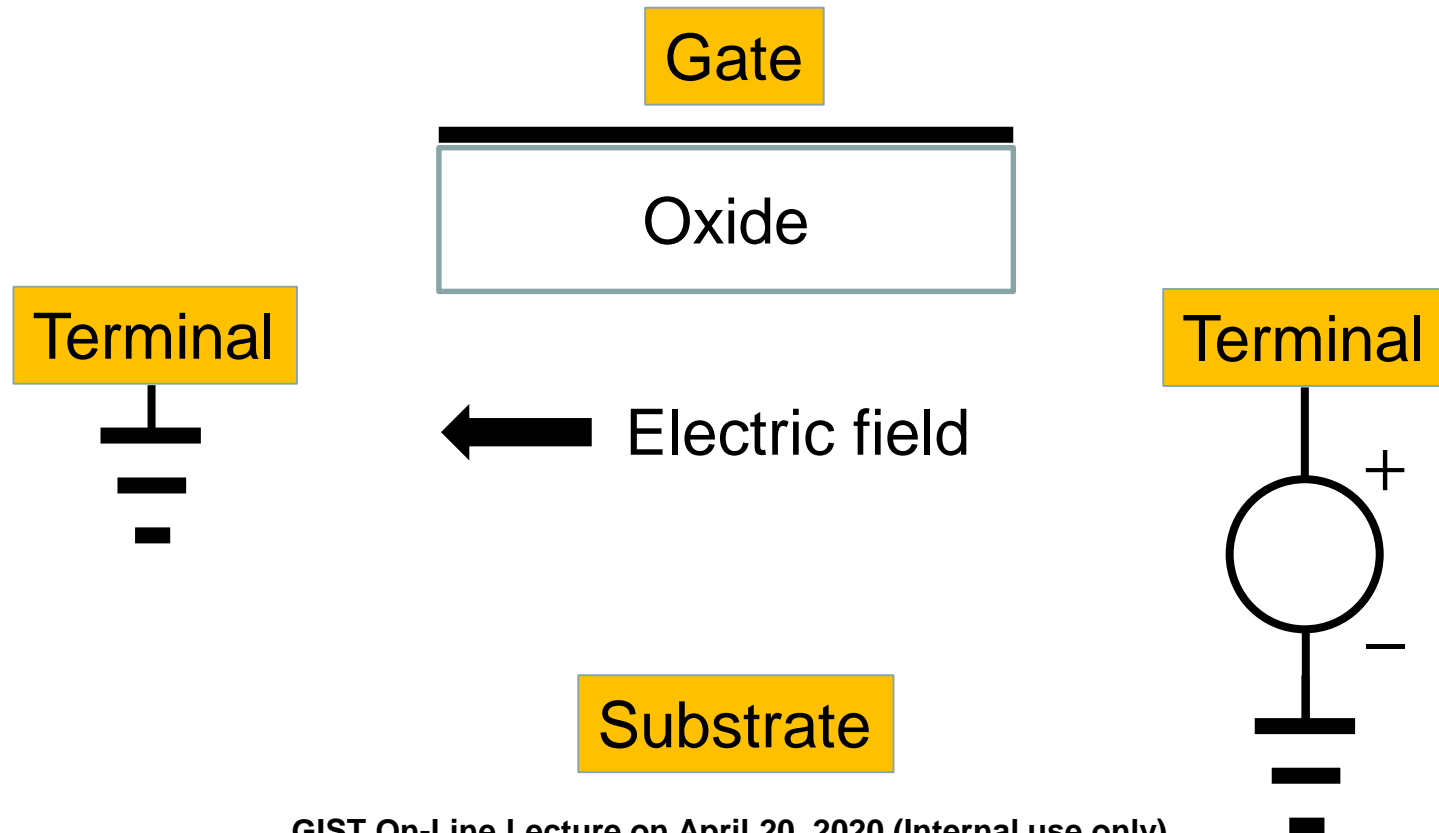
Gate

Oxide

Terminal

Terminal

Substrate

Electron transport

- Assume that one terminal is positively biased.
 - Electron moves from the grounded terminal to the positively biased terminal.

Gate

Oxide

Terminal

Terminal

← Electric field

⇨ Electron drift

Substrate

+

−
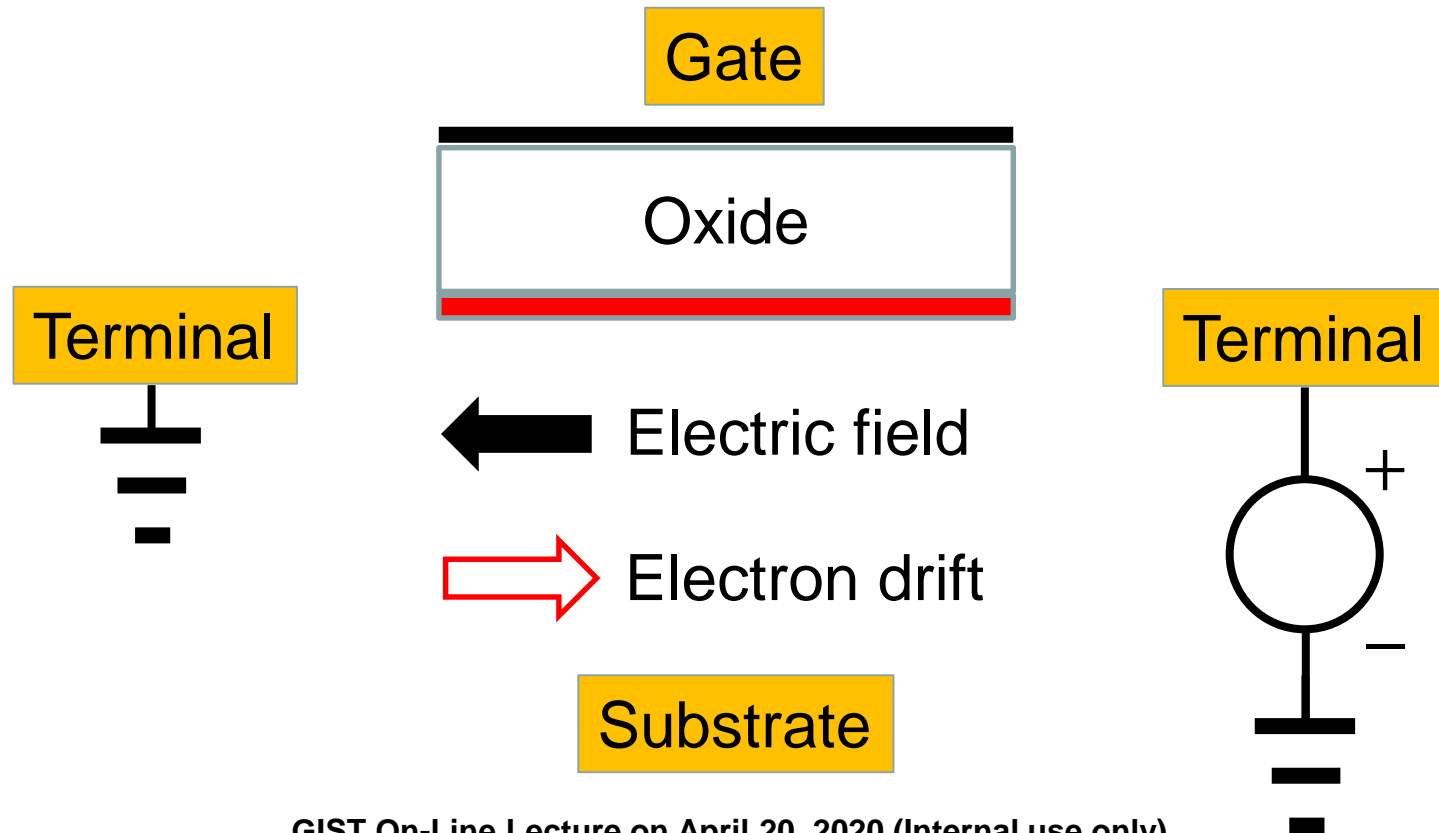
Of course,

- When the gate voltage is lower than the threshold voltage,
  - There is no electric current.

Gate

Oxide

Terminal

Terminal

⬅ Electric field

+

−

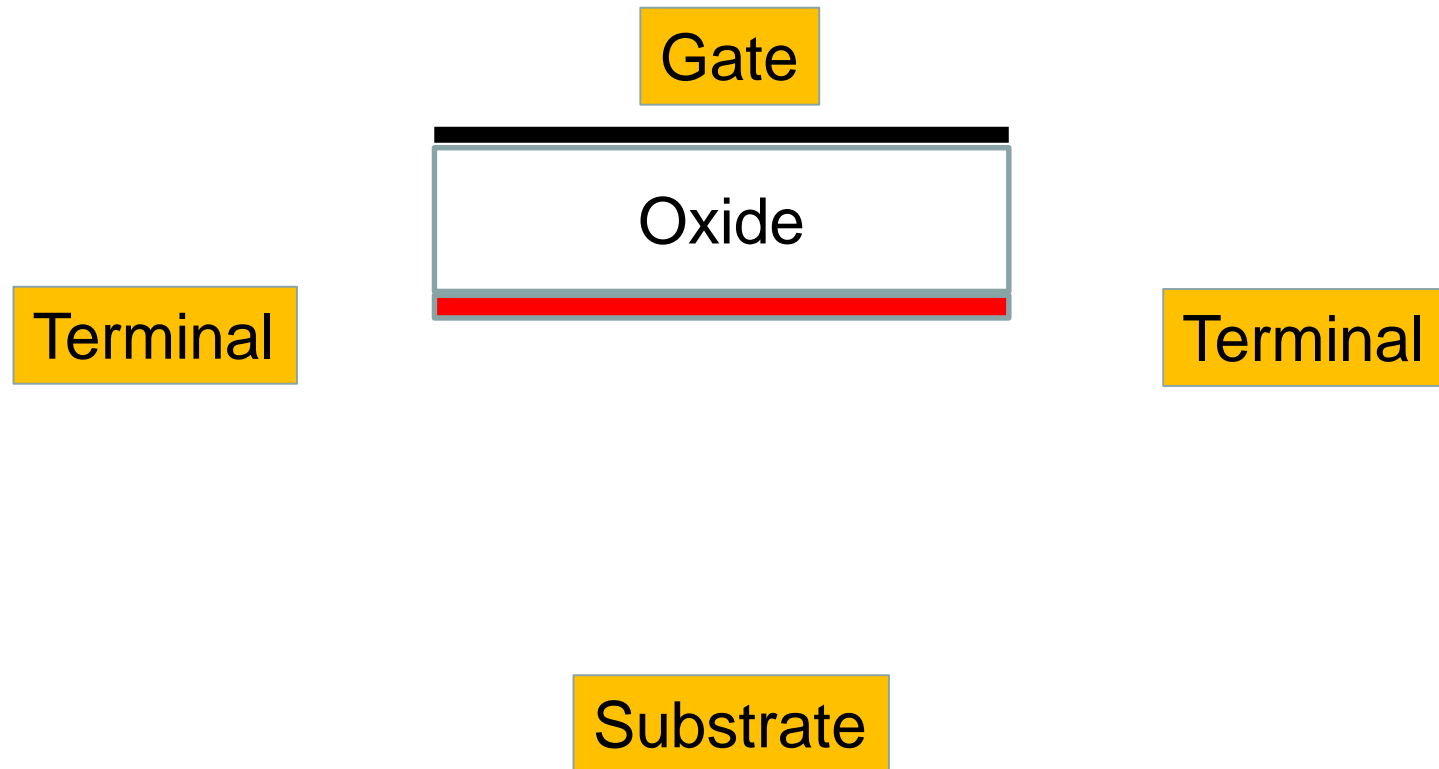Substrate

I (of which one?) versus V_G

- Draw an IV curve.
  - Based upon the previous discussion, we can draw it partially.

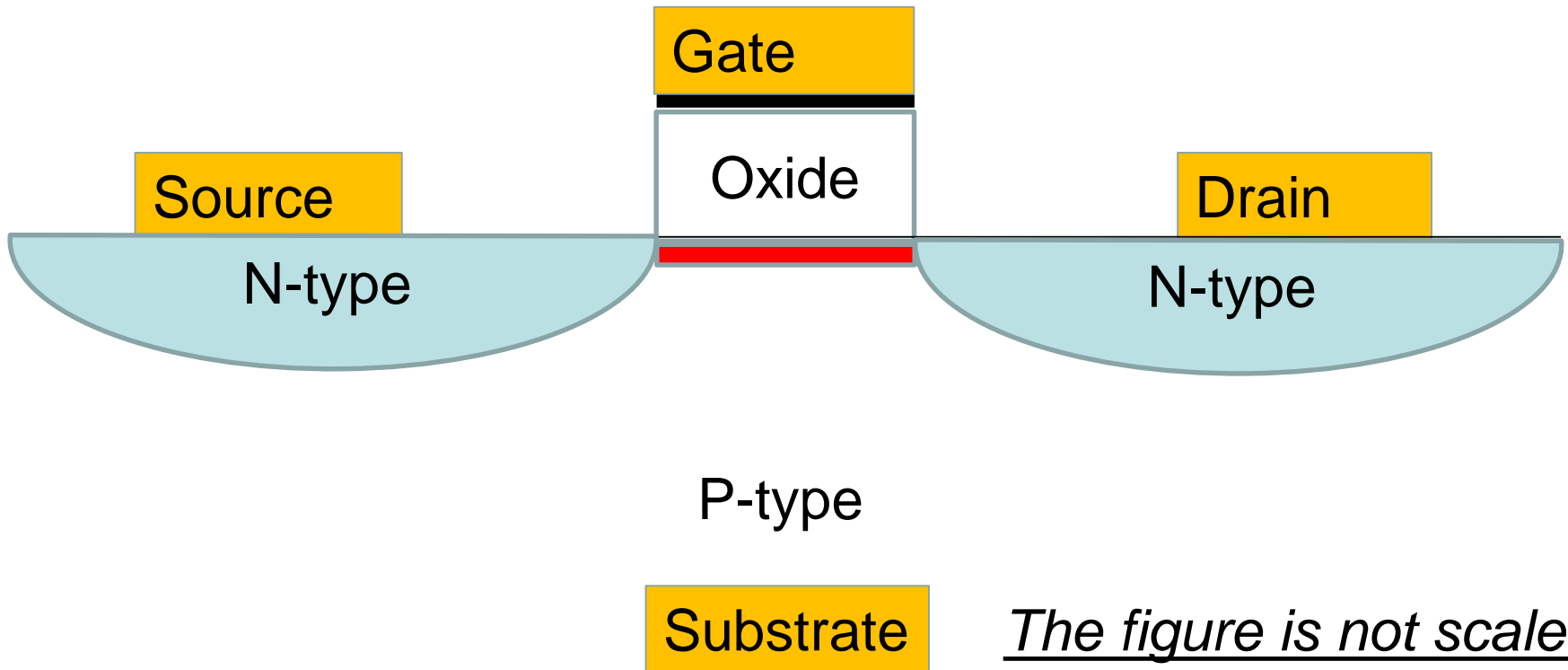I of the positively biased terminal (A)
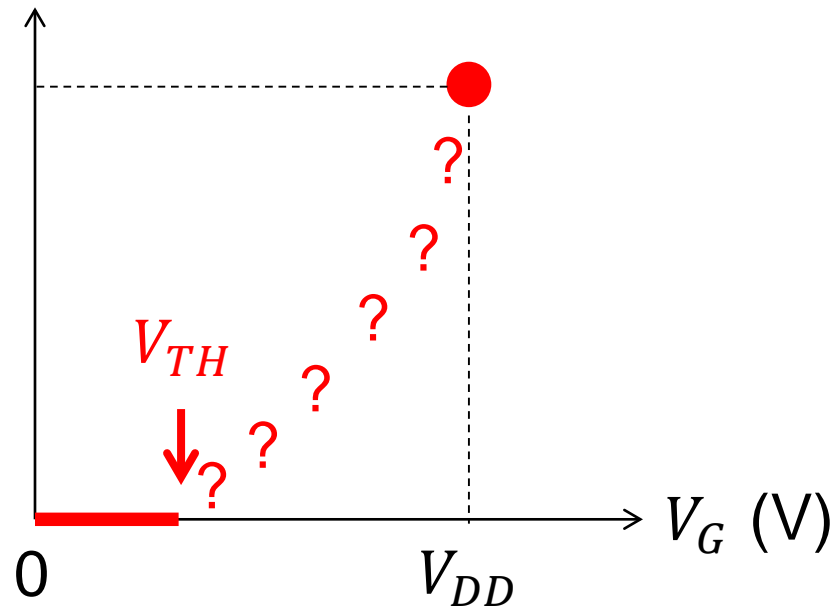
Electric isolation

- How can we isolate terminals?
  - The gate terminal is perfectly isolated. No problem.
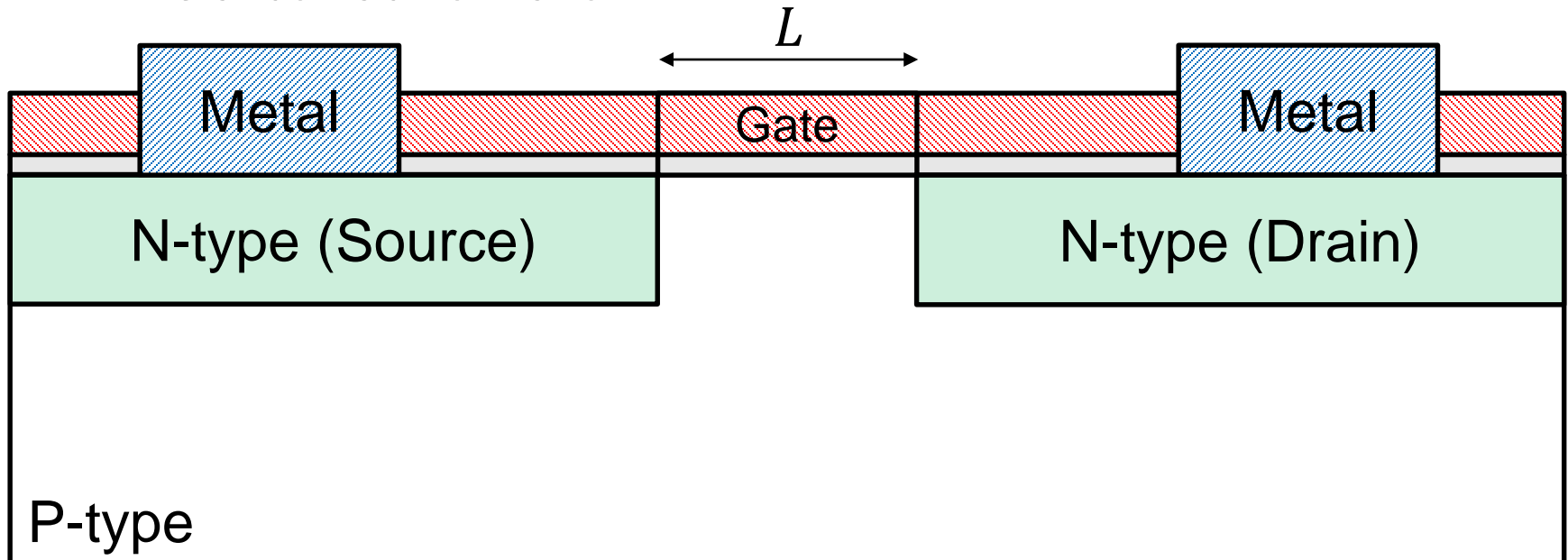 - Substrate? Remember that it is P-type.

Structure

- PN junctions for the electric isolation
  - Source/Drain terminals on N-type regions
 - Substrate terminal connected to P-type substrate

Fabrication (Much simplified)

- Patterning by the photolithography
  - Oxide layer and gate material
  - Gate patterning
  - Source/Drain implantation
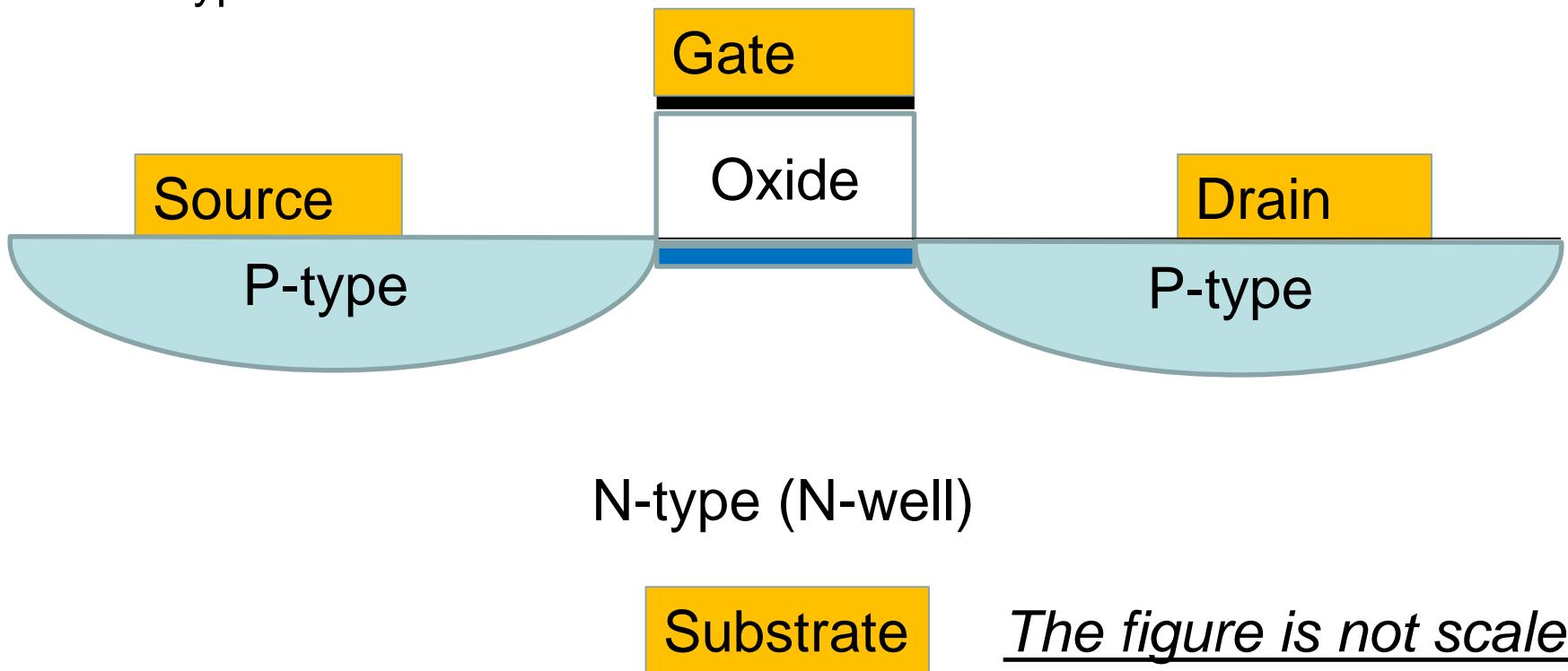 - Metal contact formation

Layout

- Layout designers draw the MOSFET with two boxes.
  - One for the diffusion region and the other for the gate material
  - Their intersection (length L and width W) is important.
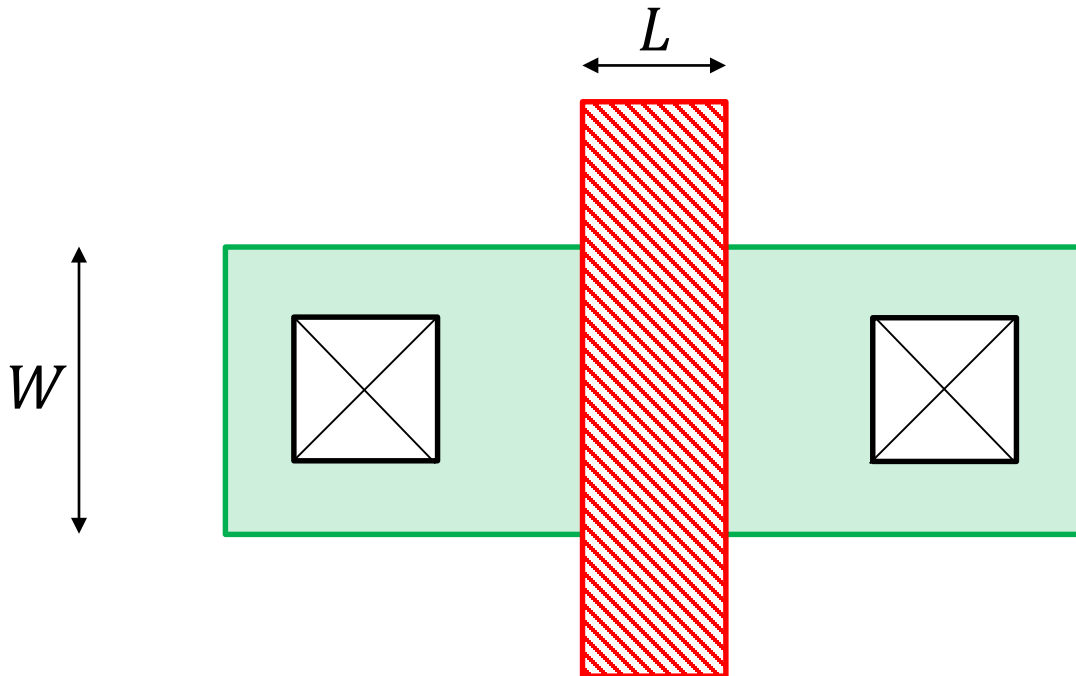
PMOSFET

- A dual device to the NMOSFET
  - N-type substrate
  - Inversion holes for negative V_G values
  - P-type source/drain

Gate

Oxide

Source

Drain

P-type

P-type

N-type (N-well)

Substrate

The figure is not scaled!