Lecture9: Inversion charge

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Inversion?

- Remember that the substrate is doped with the p-type dopants.
  - We expect that the holes are found in the silicon substrate.
  - However, when a sufficiently large gate voltage is applied, the electrons are found, as if it is doped with the n-type dopants.
  - Those electrons are called as the “inversion electrons.”

Electron charge density

- When $V_G < V_{TH}$,
  - The electron charge density vanishes.

$$Q_{elec} = 0$$

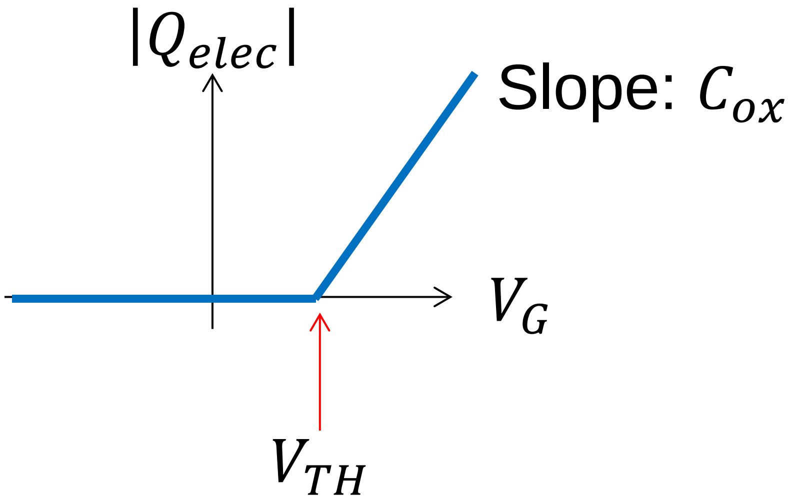
- When $V_G > V_{TH}$,
  - The electron charge density is proportional to $V_G - V_{TH}$.

$$|Q_{elec}| = C_{ox}(V_G - V_{TH})$$

  - (Here, Q_{elec} and C_{ox} are quantites *per area*.)

$|Q_{elec}|$ versus V_G

- It is piecewise linear. Therefore, it is nonlinear.
  - Digital application: ON ($V_G = V_{DD}$) / OFF ($V_G = 0$)
  - Analog application: Linear part



Engineering questions

- Which one is good?
  - Large C_{ox} or small C_{ox}?
  - High V_{TH} or low V_{TH}?

- Answers
  - We want to have a large C_{ox}. Therefore, a thin oxide layer is desirable.
  - Depending on V_{DD}, an appropriate value of V_{TH} should be chosen. By changing the metal or the substrate doping, we can control V_{TH}.