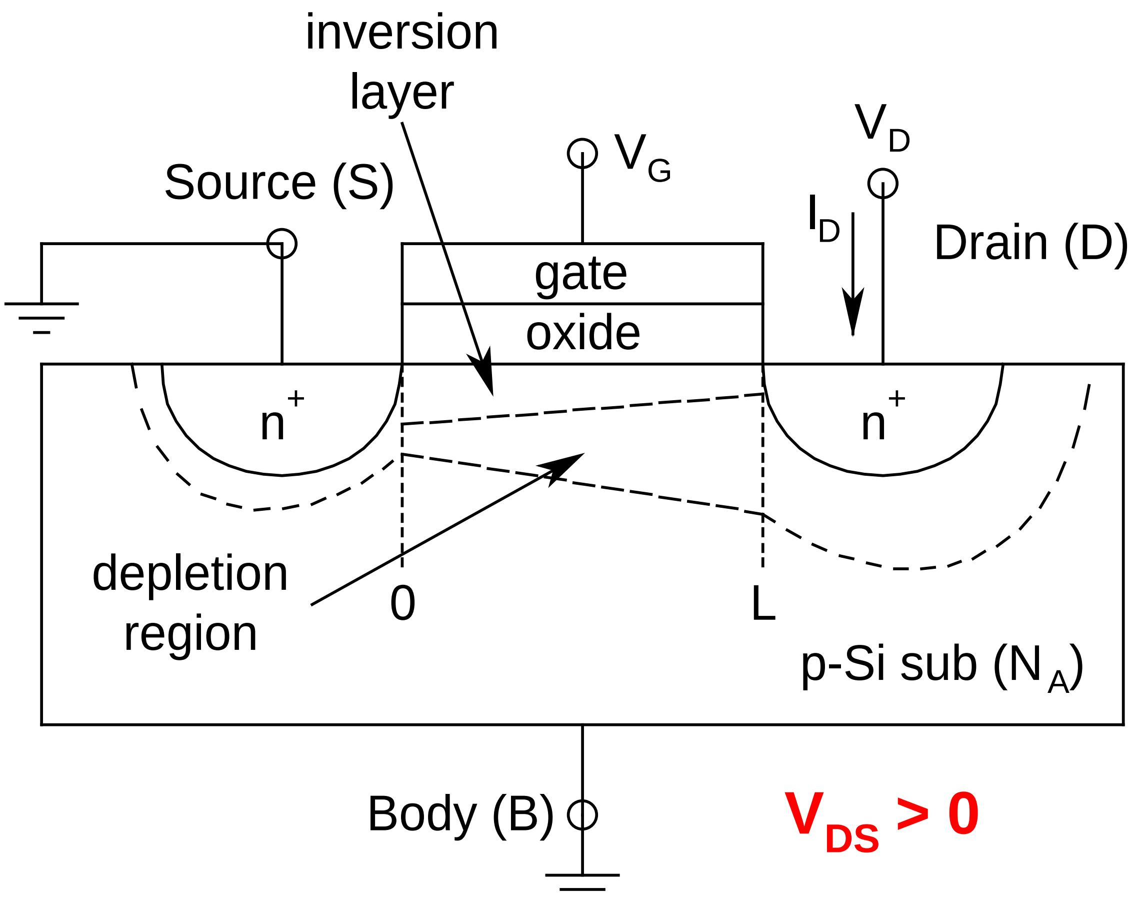

inversion layer
Source (S)
V_G
V_D
I_D
Drain (D)
gate
oxide
n^+
n^+
depletion region
0
L
p-Si sub (N_A)
Body (B)

$V_{DS} > 0$

- With $V_{DS} > 0$, ***inversion layer electrons*** will ***move*** towards the ***higher potential***, i.e., D
  - The ***drain current*** I_D would ***flow from D to S***
- ***Note***:
  - The ***depletion charge*** would ***increase*** as we move ***towards the D*** (since the ***DB junction*** is ***more reverse biased***)
    - The ***inversion charge*** would ***decrease*** as we move ***towards the D***
    - For ***sufficiently high*** V_{DS}, it may ***disappear altogether***

Body Effect

- The ***threshold voltage*** V_{TN} is a ***function*** of the ***SB voltage*** V_{SB}
- As $V_{SB}\uparrow$, the ***SB junction depletion charge*** would ***increase***
  - ➢ For the ***same*** V_{GS}, ***inversion charge*** would ***decrease*** (to maintain ***charge balance***)
  - ➢ Thus, to ***restore*** the ***original level*** of ***inversion***, V_{GS} has to be ***increased***
  - ➢ Implies that V_{TN} has ***increased***

- Expressed as:

$$V_{TN} = V_{TN0} + \gamma\left(\sqrt{2\phi_F + V_{SB}} - \sqrt{2\phi_F}\right)$$

$$V_{TN0} = V_{TN}\big|_{V_{SB}=0} = \textit{\textbf{Zero back-bias threshold voltage}}$$

$$\gamma = \frac{\sqrt{2q\varepsilon_s N_A}}{C'_{ox}} = \textit{\textbf{Body-effect coefficient}}$$

$$C'_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \textit{\textbf{Oxide capacitance per unit area}}$$

$$\phi_F = V_T \ln\left(\frac{N_A}{n_i}\right) = \textit{\textbf{Bulk potential}}\ (\sim 0.3\text{ - }0.45\text{ V})$$