

Lecture 17

ANNOUNCEMENTS

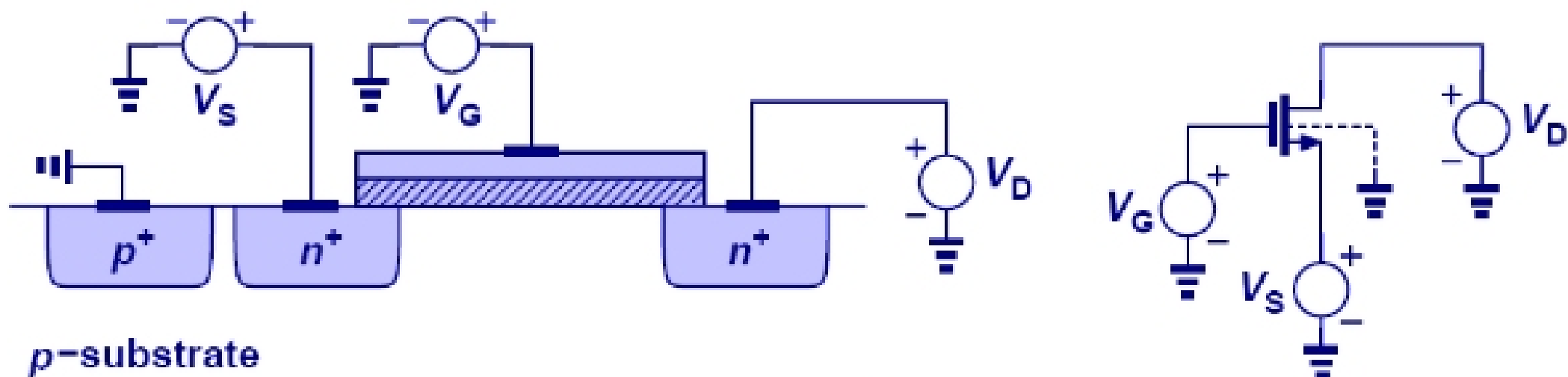
- Wed. discussion section moved (again) to 6-7PM in 293 Cory

OUTLINE

- NMOSFET in ON state (cont'd)
 - Body effect
 - Channel-length modulation
 - Velocity saturation
- NMOSFET in OFF state
- MOSFET models
- PMOSFET

Reading: Finish Chapter 6

The Body Effect



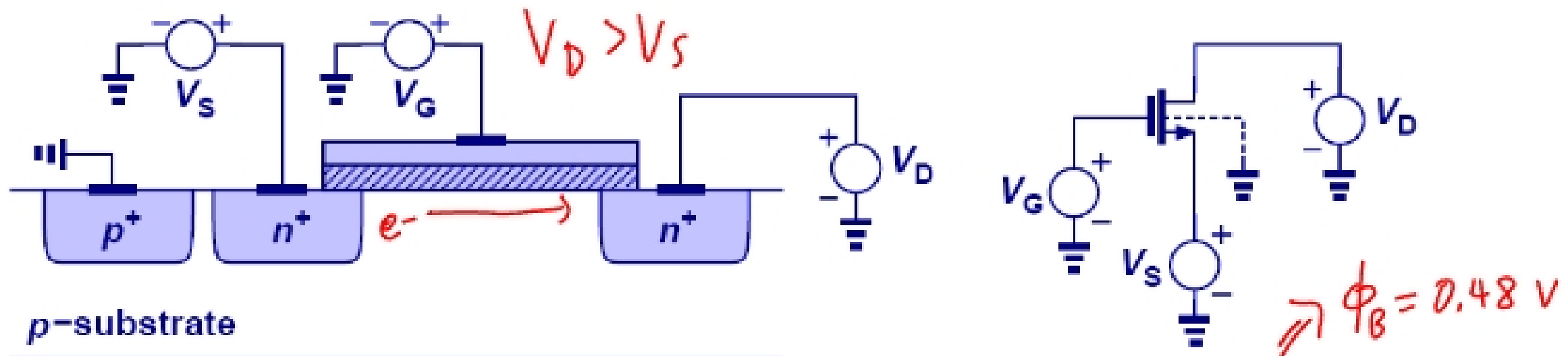
- V_{TH} is increased by reverse-biasing the body-source PN junction:

$$\begin{aligned}
 V_{TH} &= V_{FB} + 2\phi_B + \frac{\sqrt{2qN_A\epsilon_{Si}(2\phi_B + V_{SB})}}{C_{ox}} \\
 &= V_{FB} + 2\phi_B + \frac{\sqrt{2qN_A\epsilon_{Si}(2\phi_B)}}{C_{ox}} - \frac{\sqrt{2qN_A\epsilon_{Si}(2\phi_B)}}{C_{ox}} + \frac{\sqrt{2qN_A\epsilon_{Si}(2\phi_B + V_{SB})}}{C_{ox}} \\
 &= V_{TH0} + \frac{\sqrt{2qN_A\epsilon_{Si}}}{C_{ox}} \left(\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B} \right) = V_{TH0} + \gamma \left(\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B} \right)
 \end{aligned}$$

γ is the **body effect parameter**. *← Usually, we want this to be small.*

prefer low N_A & small t_{ox}

Body Effect Example



$$V_{TH} = V_{TH0} + \gamma \left(\sqrt{2\phi_B + V_{SB}} - \sqrt{2\phi_B} \right)$$

$$\text{where } \gamma = \frac{\sqrt{2qN_A \epsilon_{Si}}}{C_{ox}}$$

$$\frac{\partial V_{TH}}{\partial V_{SB}} = \frac{1}{2} \gamma \frac{1}{\sqrt{2\phi_B + V_{SB}}}$$

$$\approx 0.2$$

For $t_{ox} = 3 \text{ nm}$, $N_A = 10^{18} \text{ cm}^{-3}$

(Previously found $V_{TH0} = 0.44 \text{ V}$)

$$\gamma = 0.49$$

$$V_{SB} = 0.5 \text{ V} : V_{TH} = 0.55 \text{ V}$$