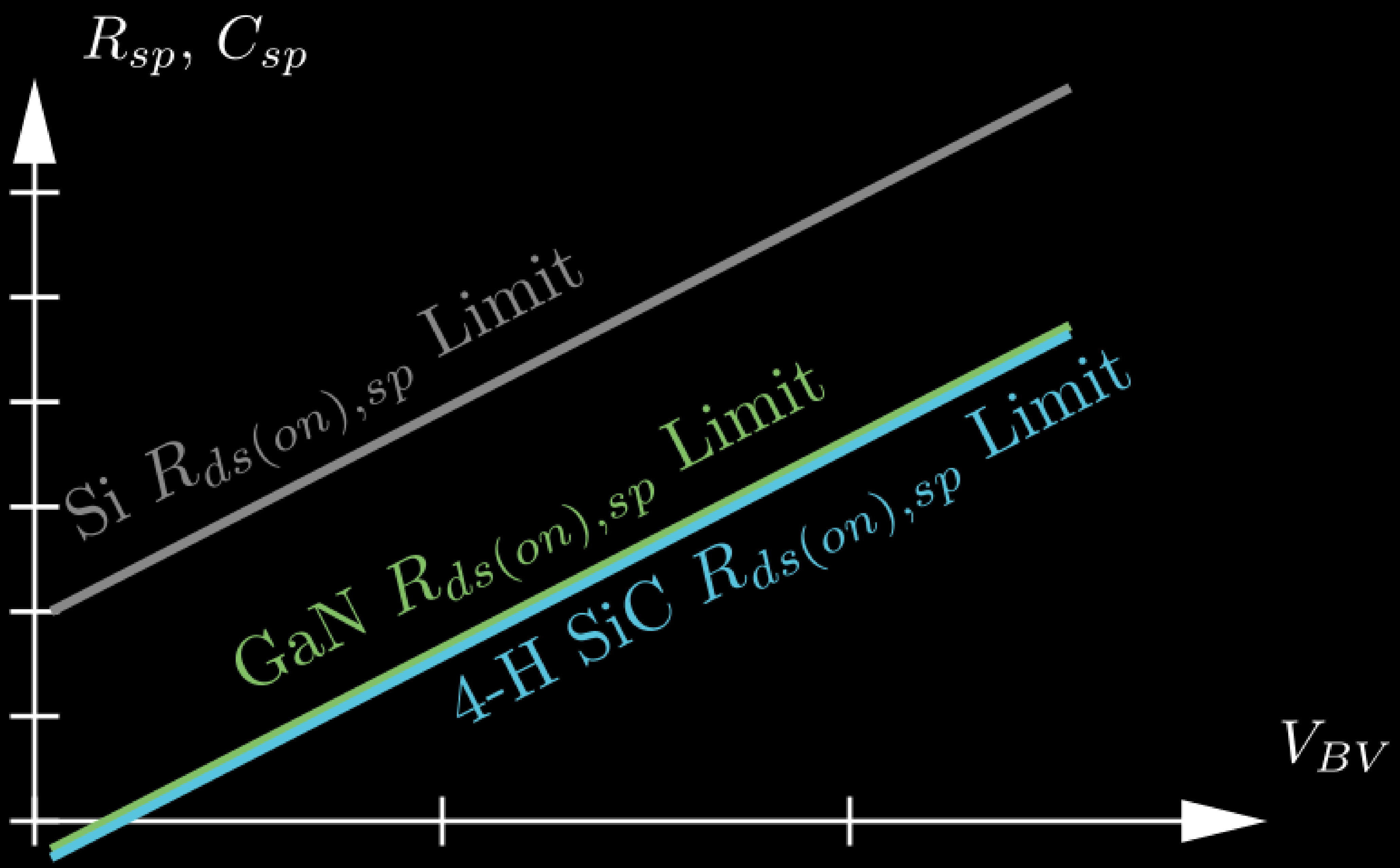
# Pushing Beyond Silicon

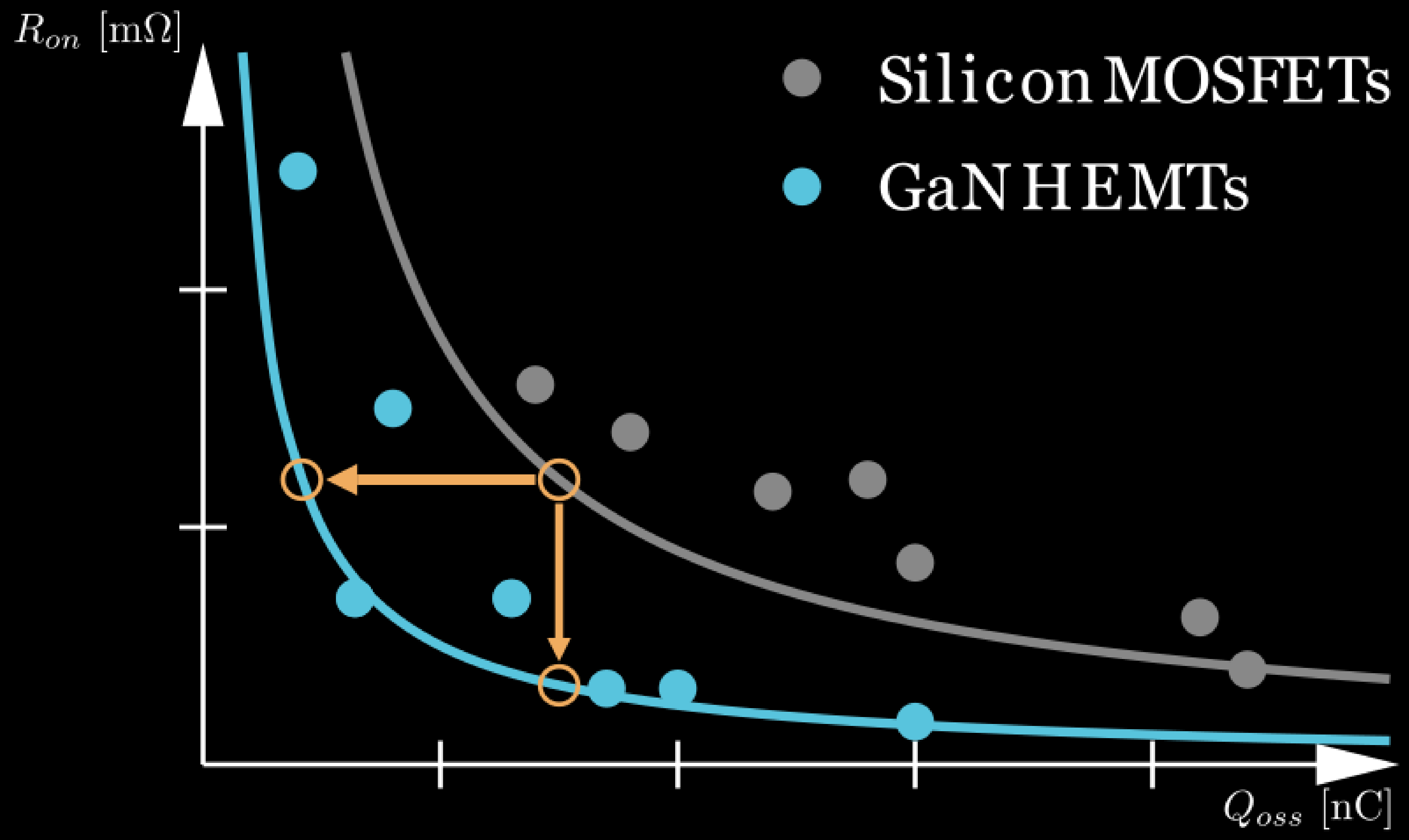
$$R_{sp} = \text{Resistance} \times \text{Area} = \frac{4}{\mu_n \epsilon {E_{\text{crit}}}^3} {V_{BV}}^2$$

$$C_{sp} = \text{Capacitance/Area} = \frac{\epsilon E_{\text{crit}}}{2\sqrt{|V_r V_{BV}|}}$$

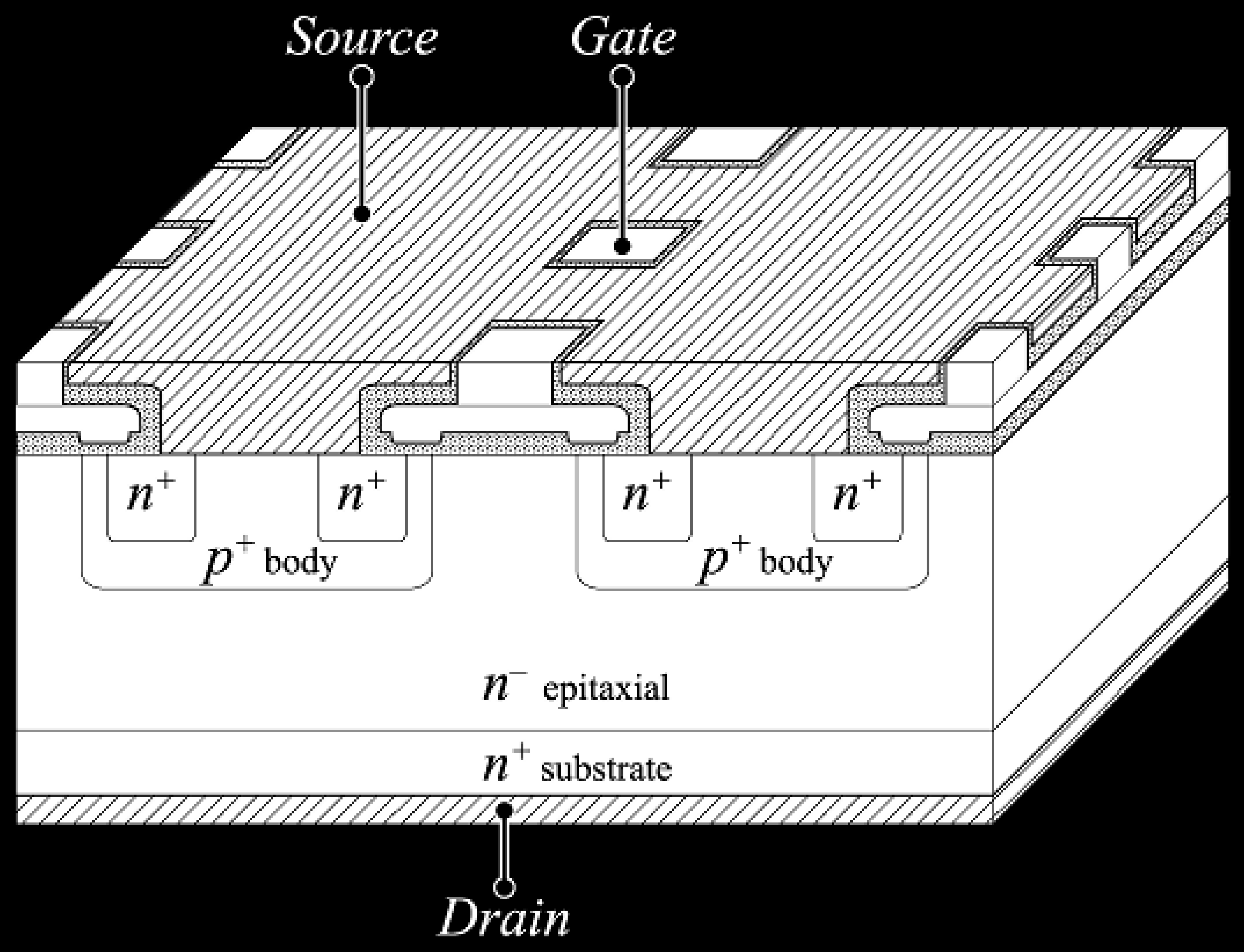
$$R_{sp} \cdot C_{sp} = \frac{2V_{BV}}{\mu_n {E_{\text{crit}}}^2}$$

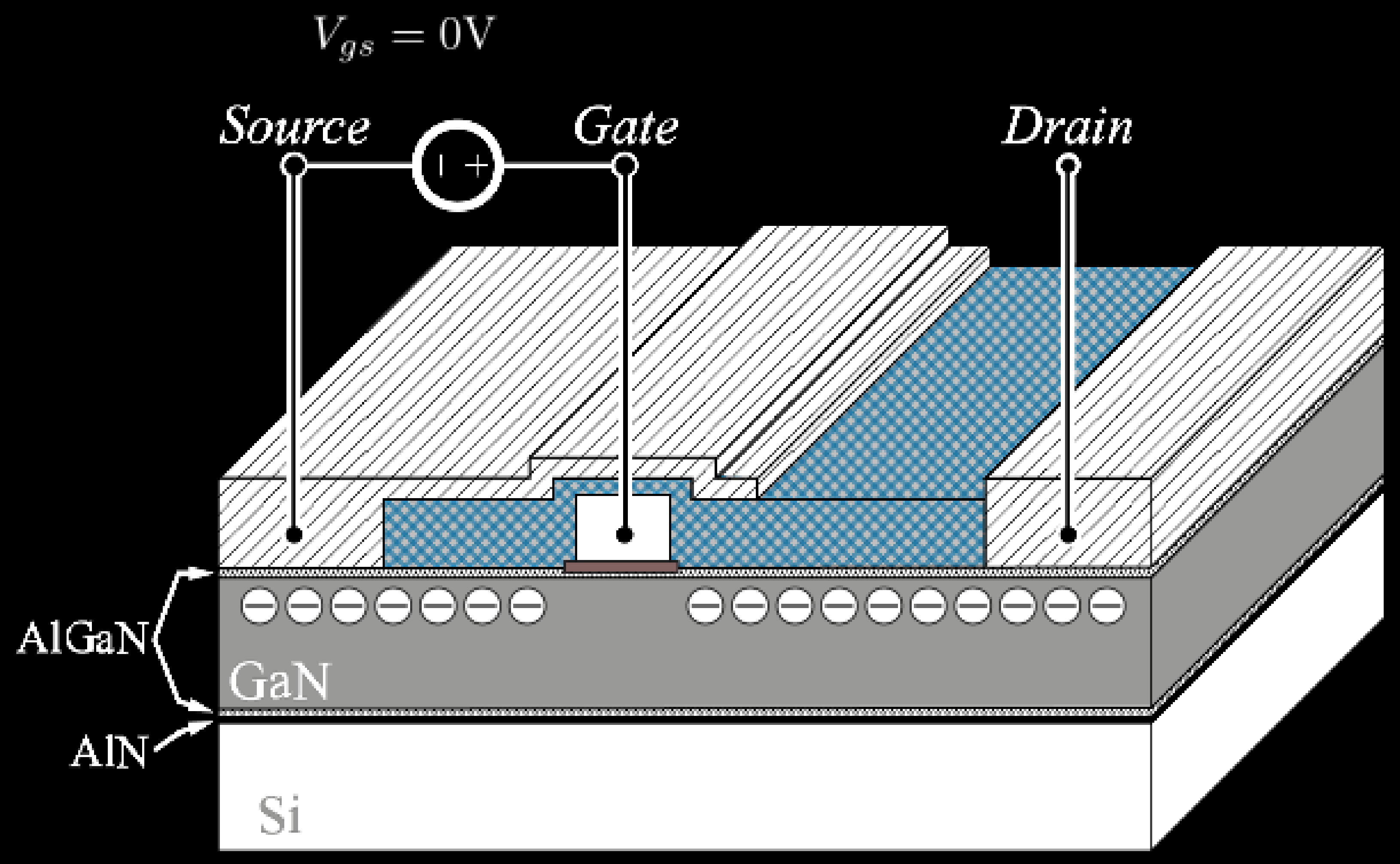
| Material | $E_g$ [eV] | $\epsilon_r$ | $E_c$ [MV/cm] | $\mu_n$ [cm$^2$/Vs] | $\mu_p$ [cm$^2$/Vs] | $\lambda$ [W/cm K] | $v_{\text{sat}}$ [$10^7$ cm/s] |
|---|---|---|---|---|---|---|---|
| Silicon | 1.12 | 11.9 | 0.3 | 1500 | 600 | 1.5 | 1 |
| Gallium Arsenide | 1.43 | 13.1 | 0.4 | 8500 | 400 | 0.46 | 1.2 |
| 6H-Silicon Carbide | 3.03 | 9.66 | 2.5 | 500 / 80 | 101 | 4.9 | 2 |
| 4H-Silicon Carbide | 3.26 | 10.1 | 2.2 | 1000 | 115 | 4.9 | 2 |
| Gallium Nitride | 3.45 | 9 | 2 | 1250 | 850 | 1.3 | 2.2 |
| Aluminum Nitride | 6.01 | 9 | 1.5 | 300 | 13 | 1.6 | 1.85 |
| Diamond | 5.45 | 5.5 | 10 | 2200 | 850 | 22 | 2.7 |

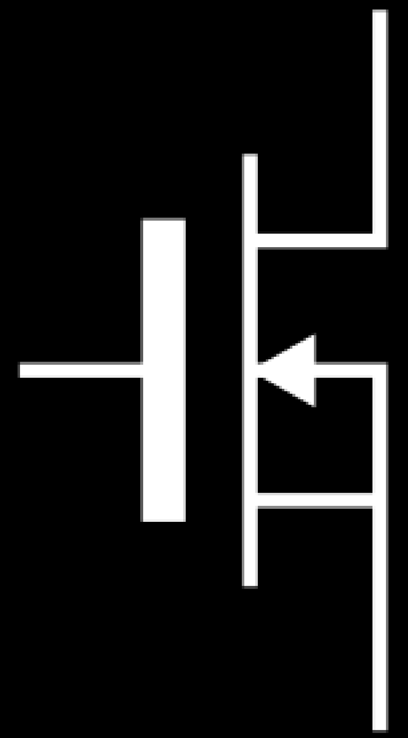


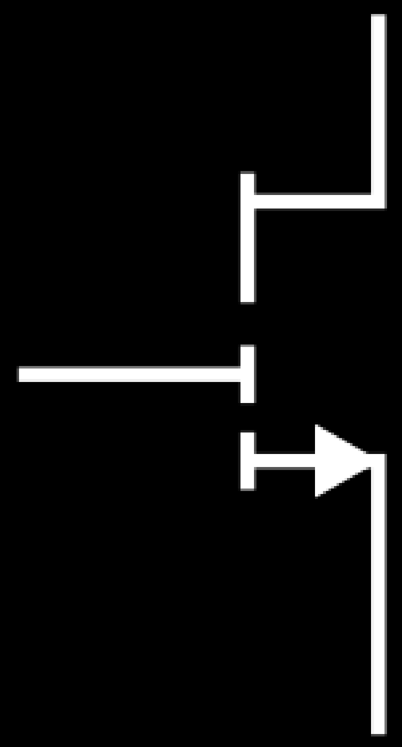


# The Lateral HEMT

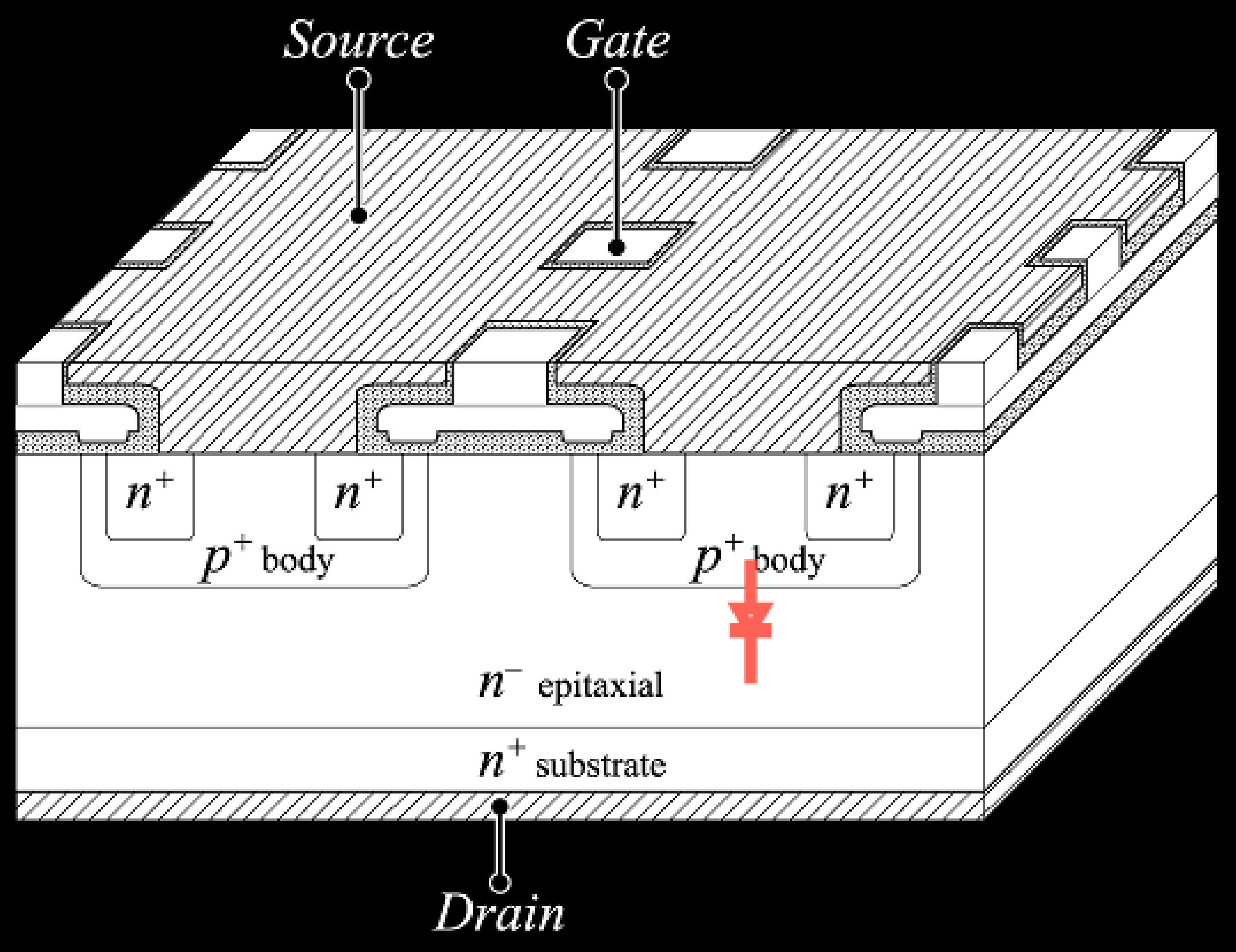


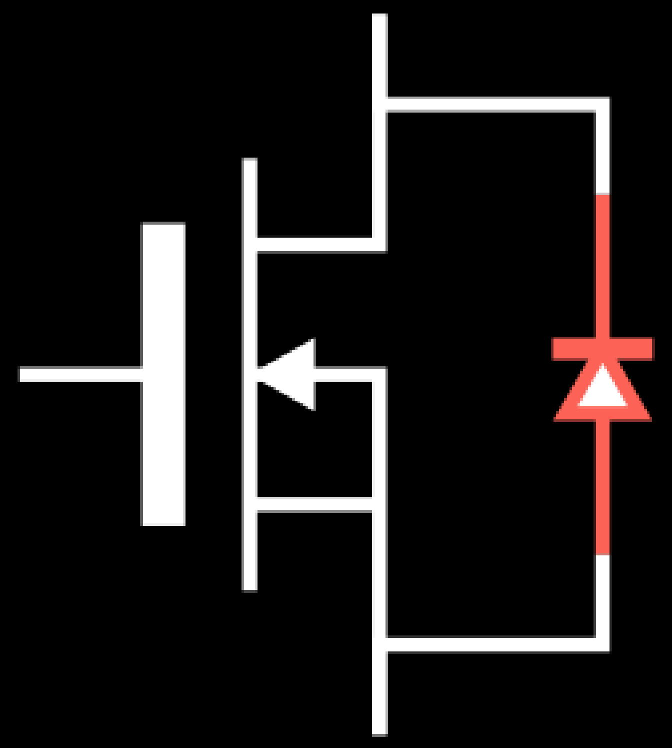


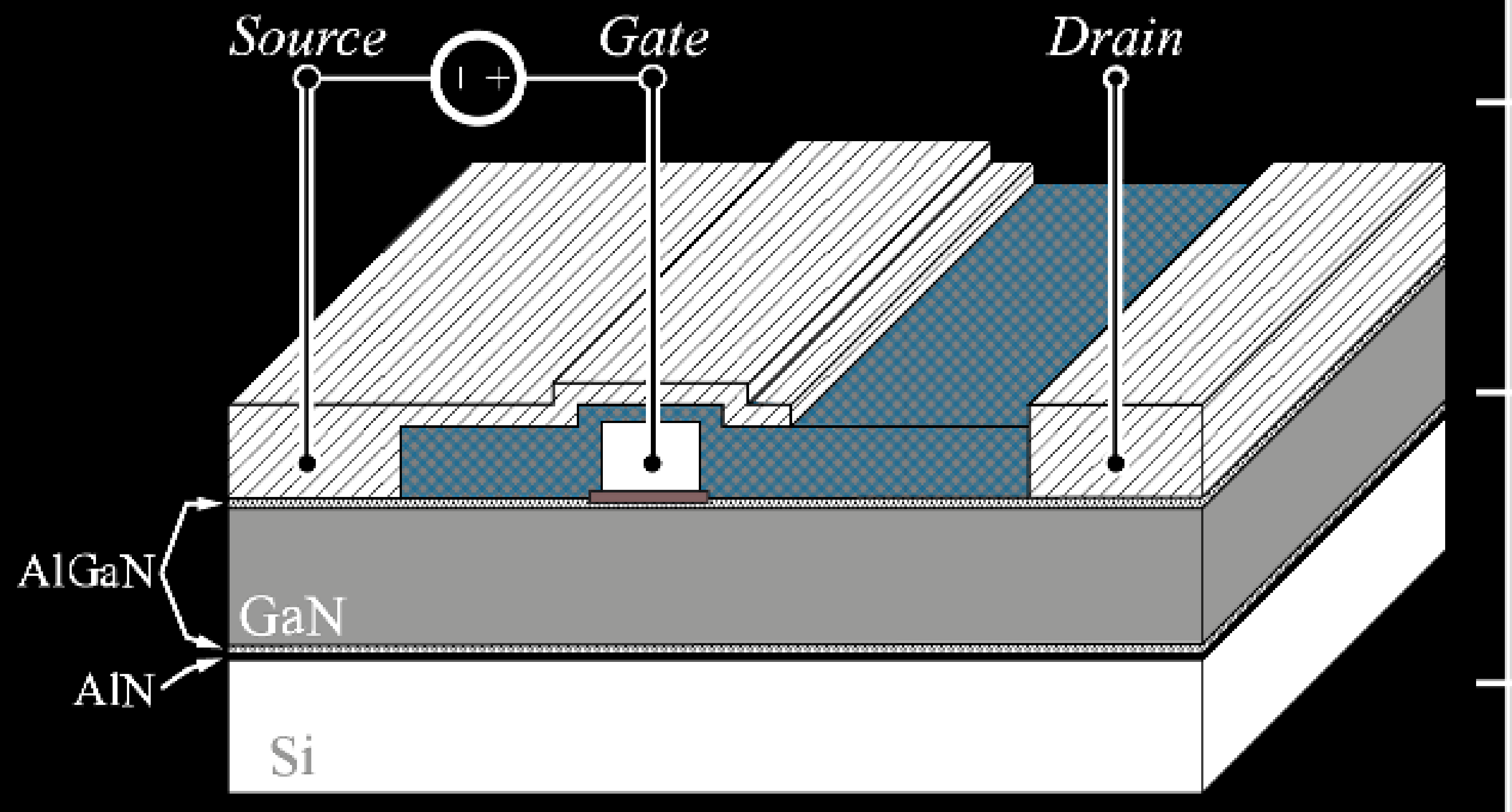


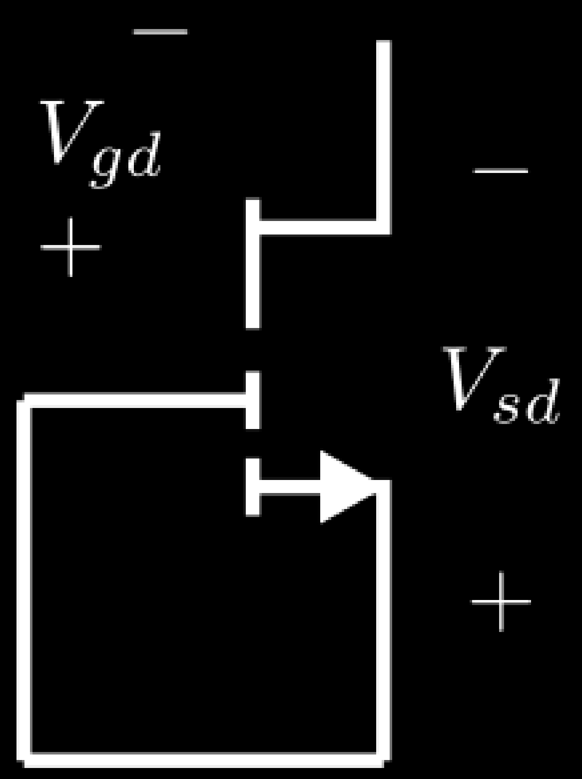


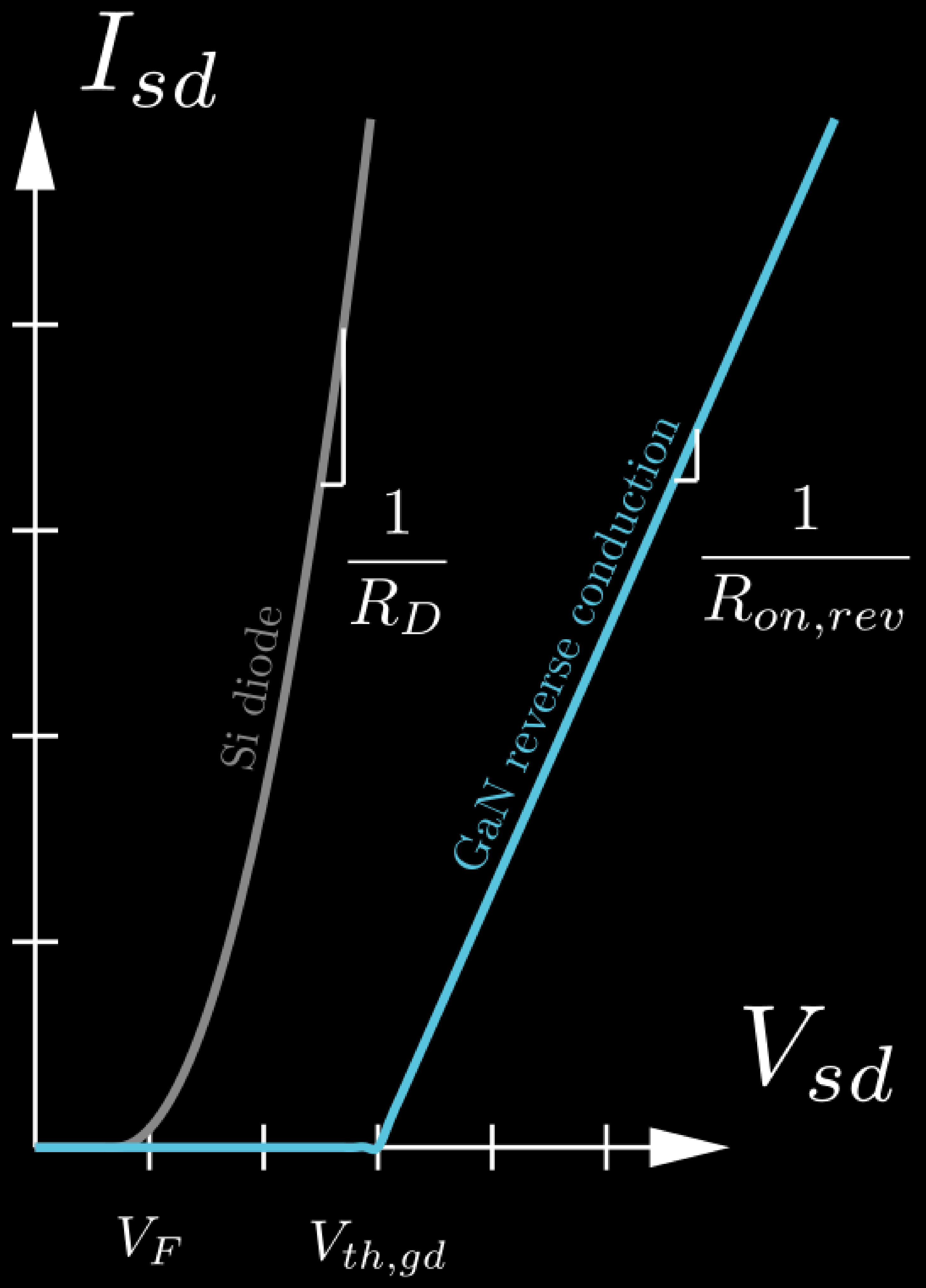
# Reverse Conduction Mechanism





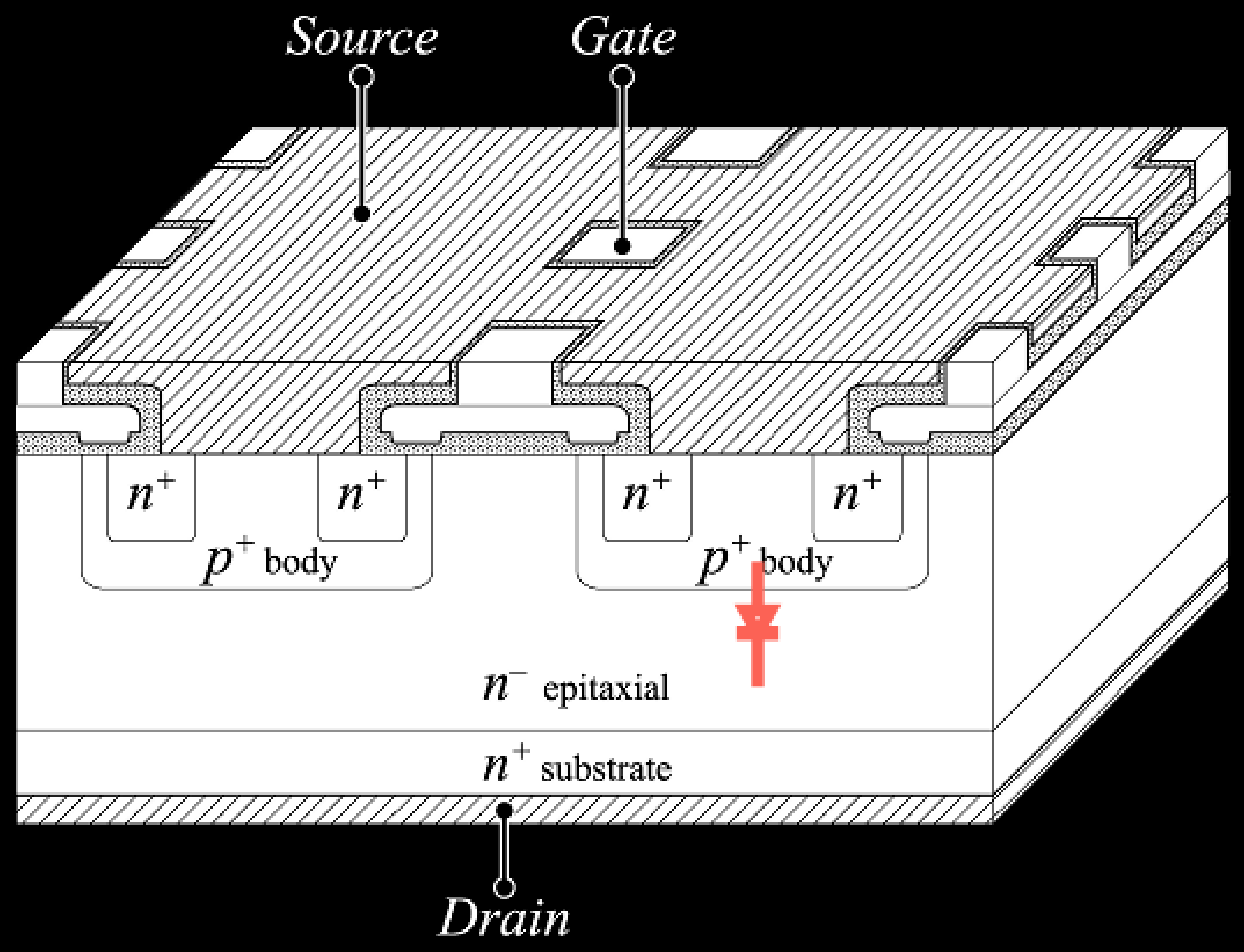


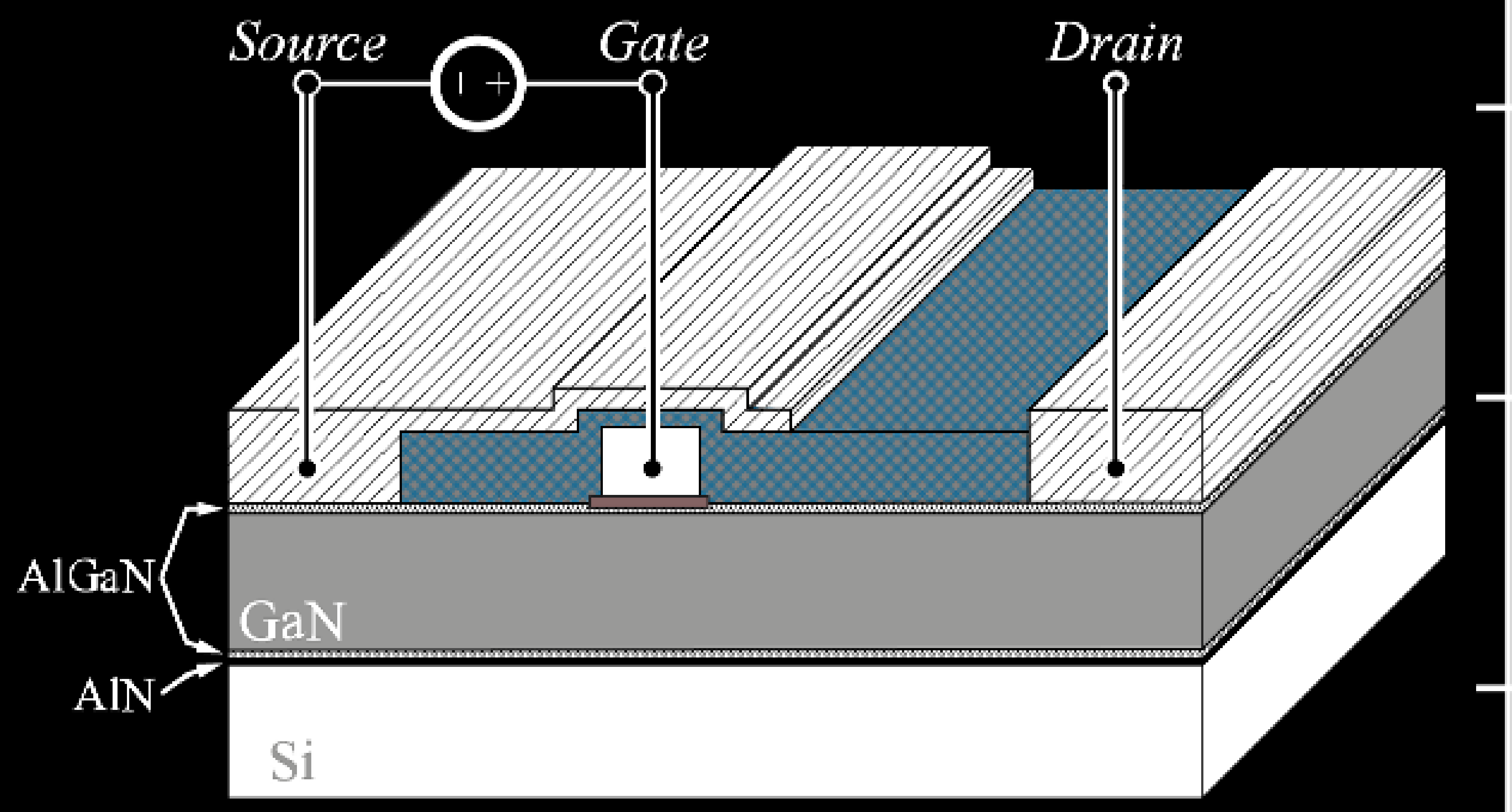


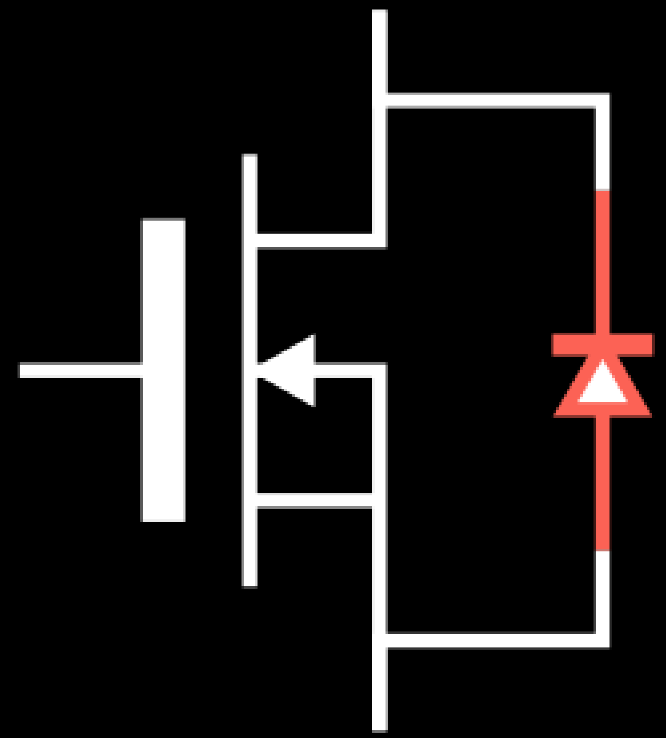


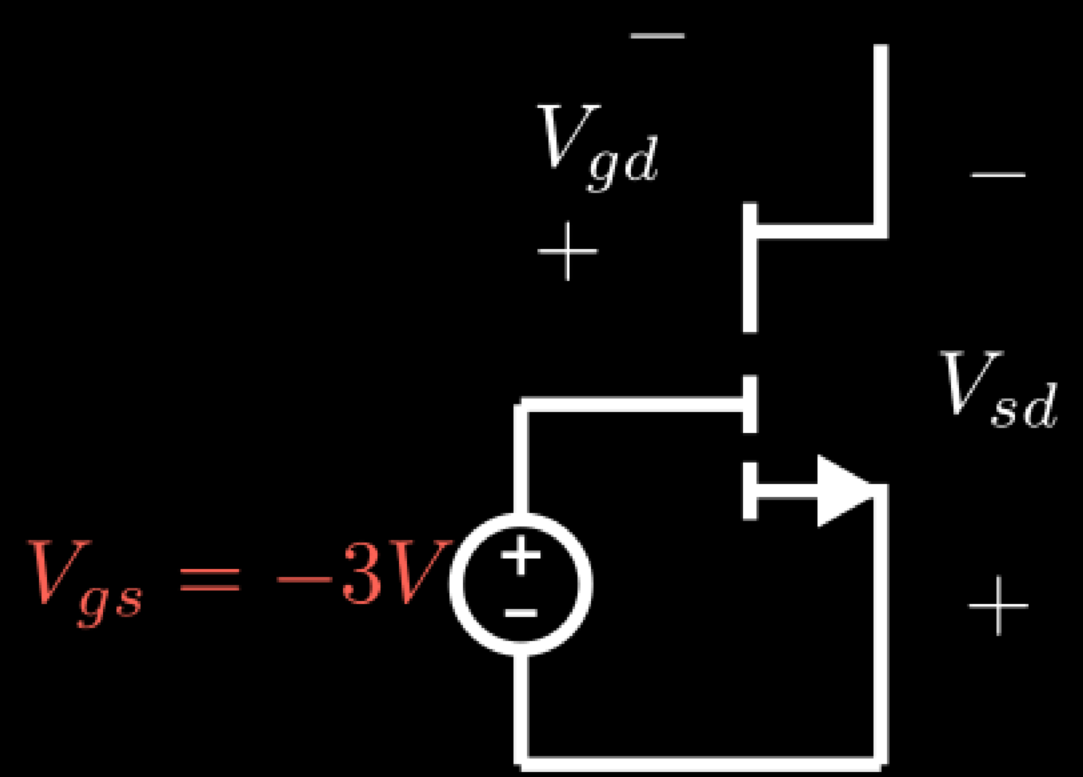
$V_{gd} = V_{sd}$

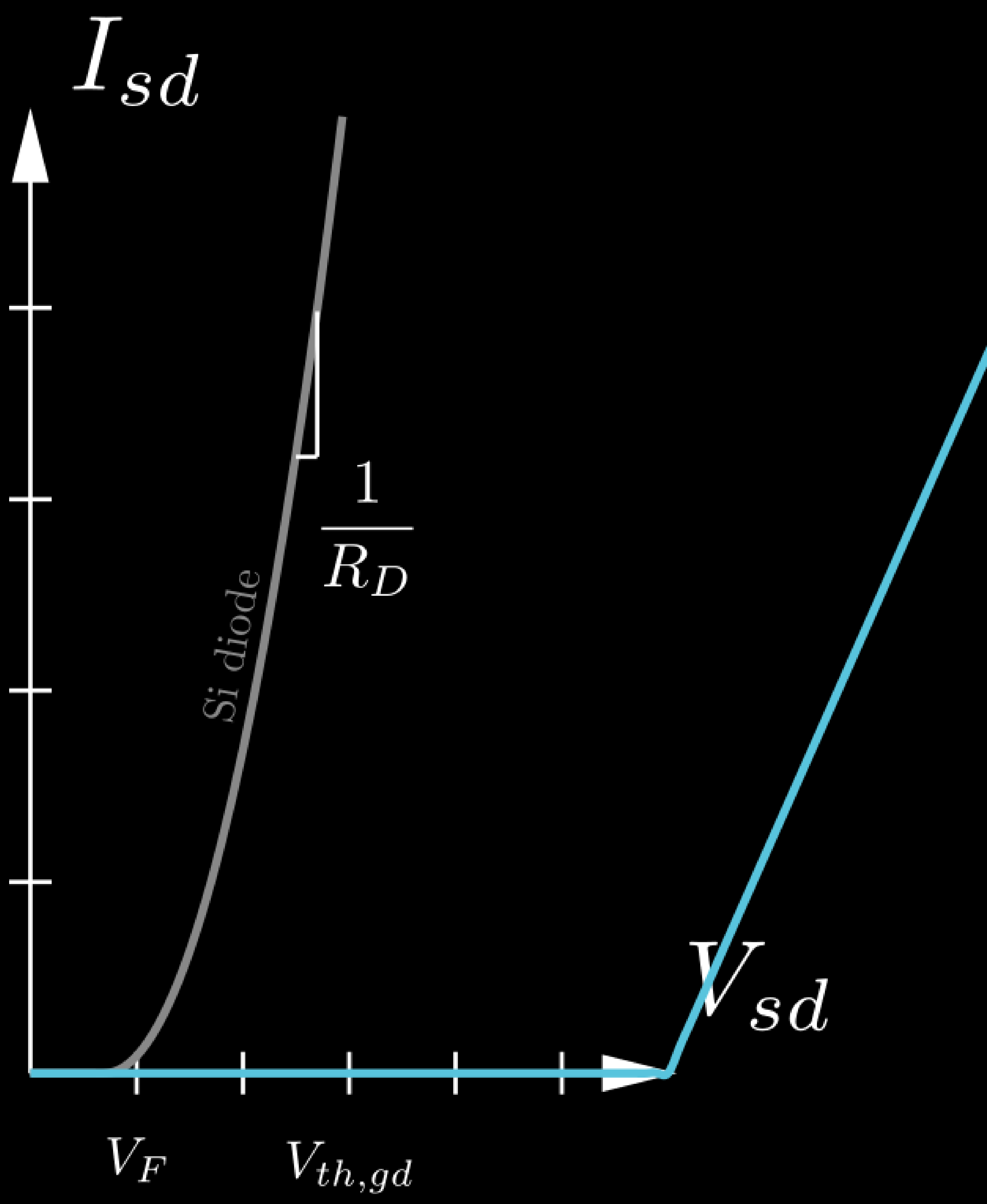
# Negative Gate Drive





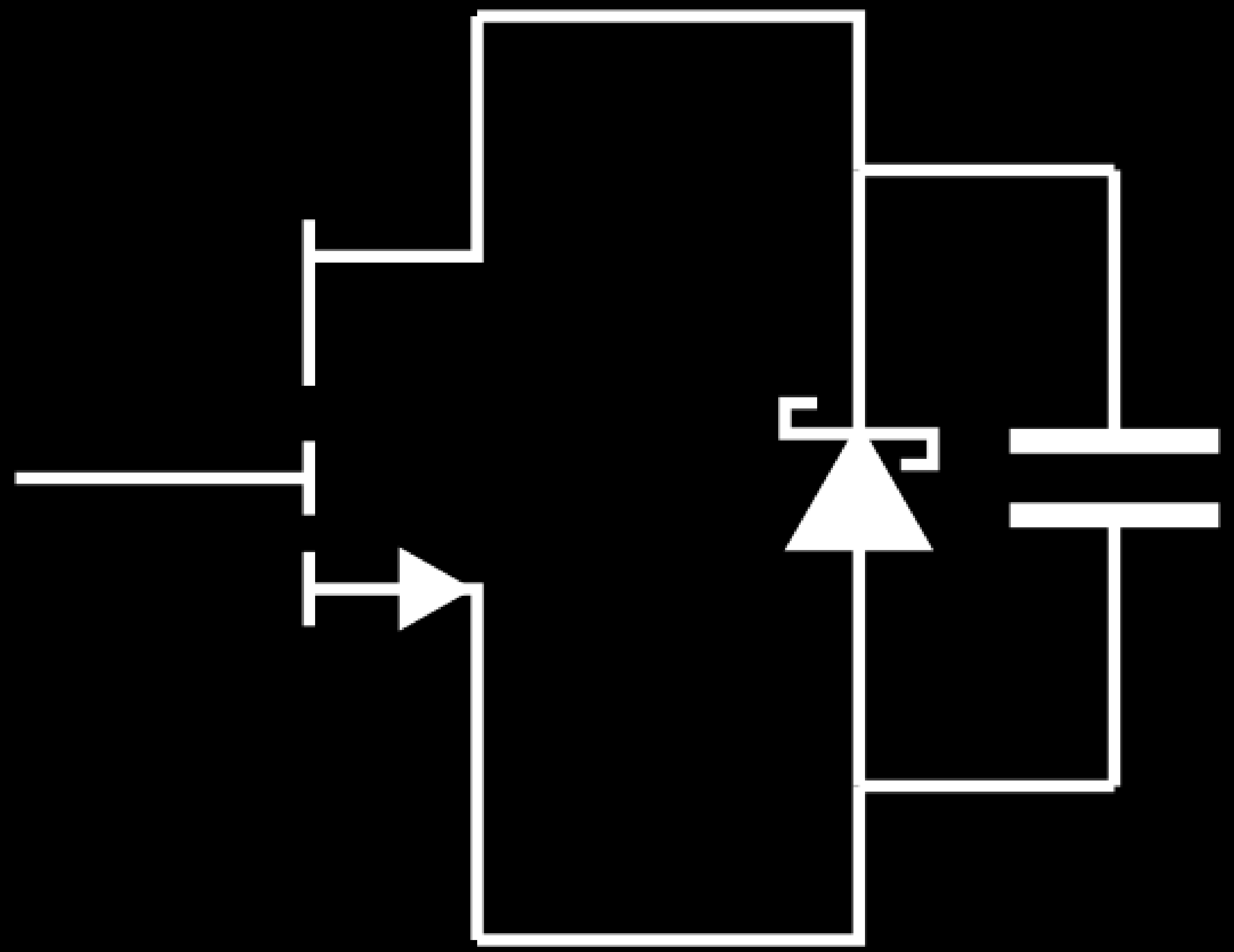






$$V_{sd(on)} = -V_{gs} + V_{gd}$$

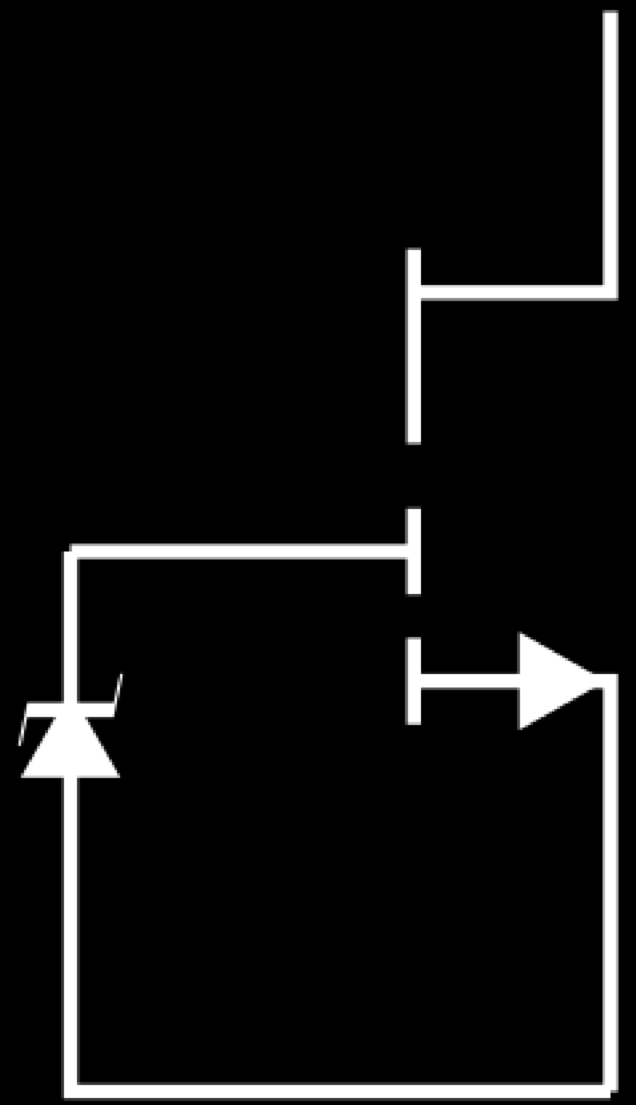
# Switching Speed

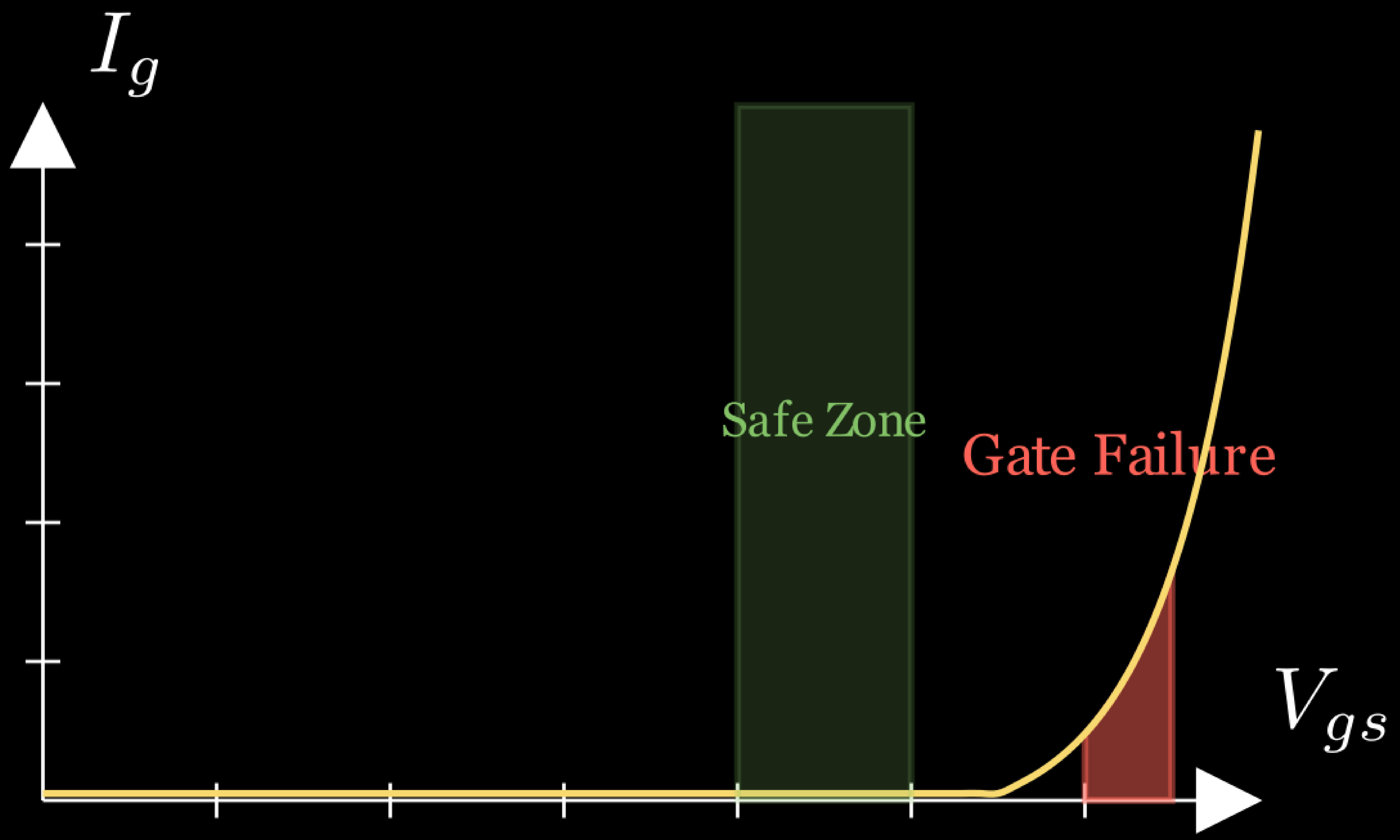


Total $C_{oss} = C_{oss(\mathrm{GaN})} + C_{\mathrm{diode}}$

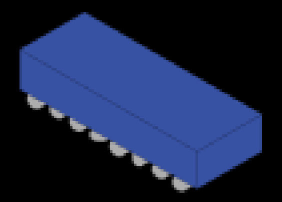
Switching Loss Increases

# Device Protection

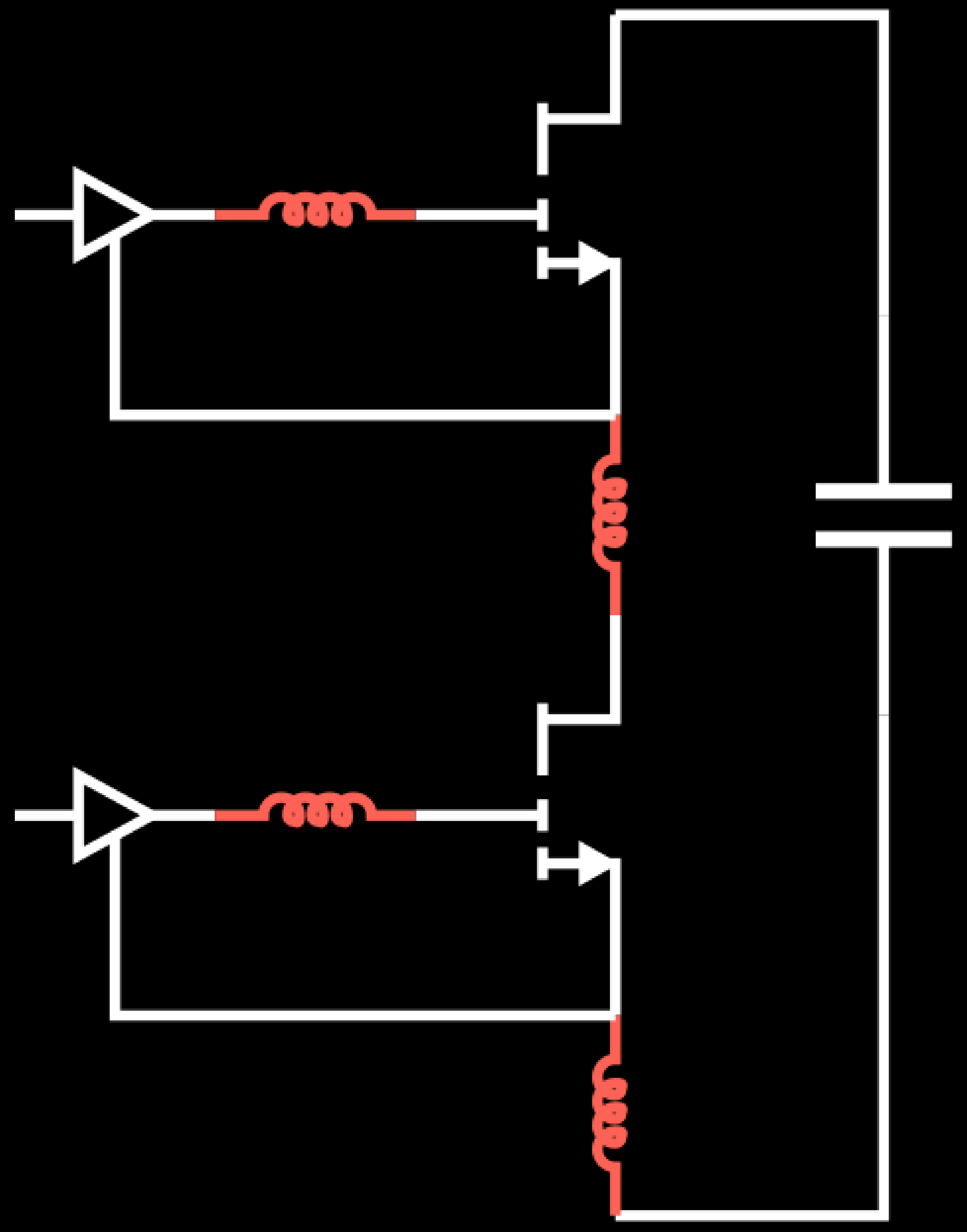


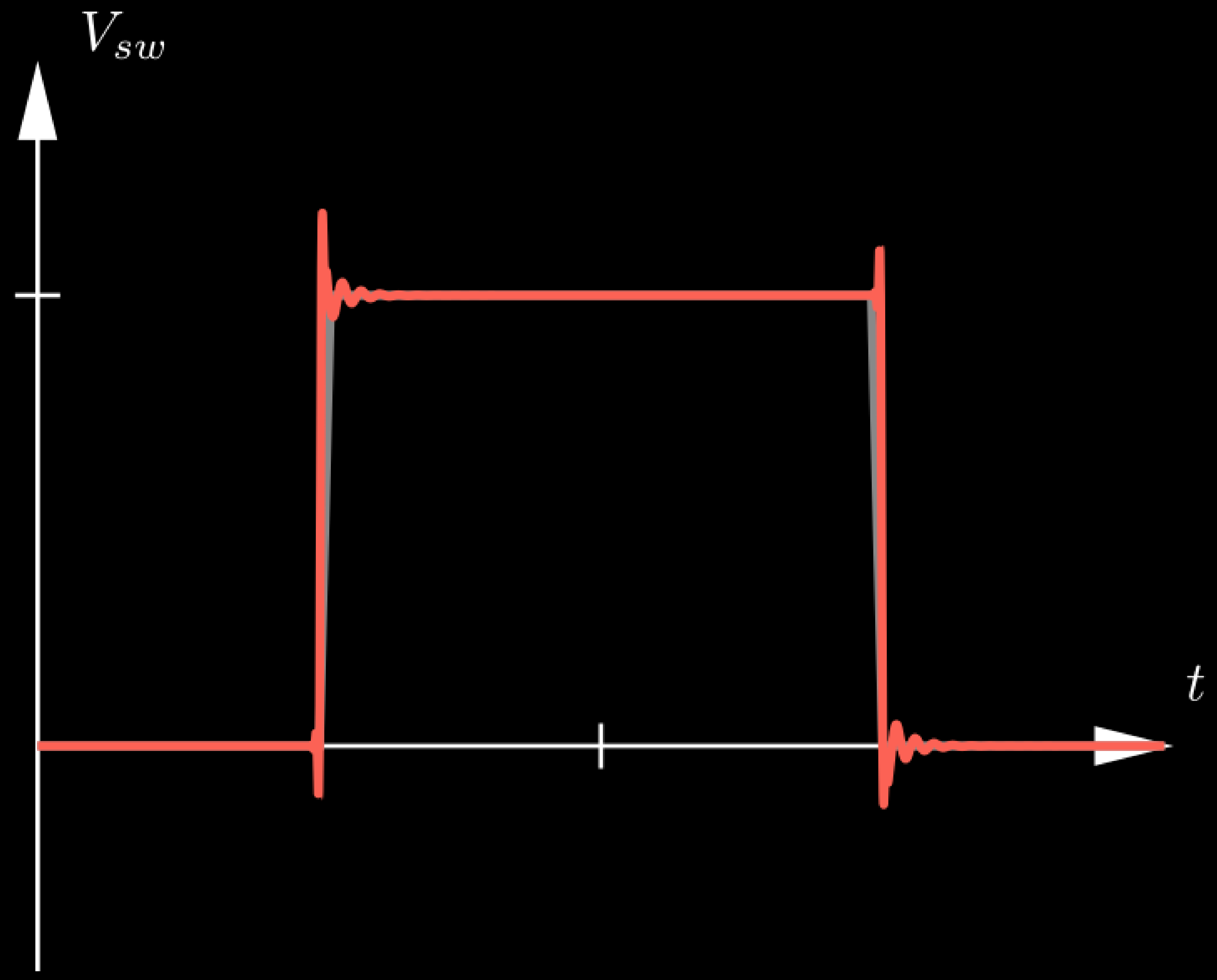


# PCB Layout



LGA





- Select deadtime carefully
- Use dedicated GaN drivers
- Minimize power and gate loop areas (Layout)
- Design thermal system