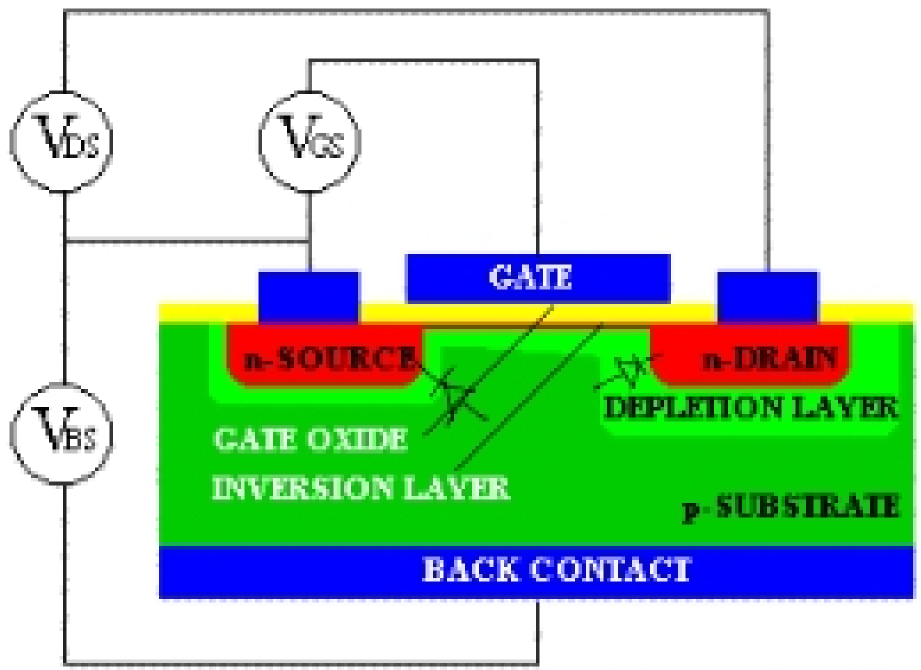
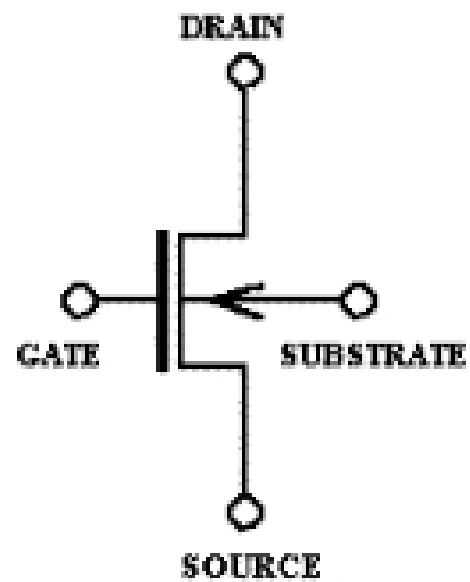
MOSFET as Voltage Controlled Current Source





- The MOS Capacitor electrically connects the 2 reverse biased p-n junctions
- The gate voltage controls the surface potential at the source end controlling the injection of carriers or not (Field Effect)

- **Linear Model**
  - **Predicts correctly the MOSFET behavior for small drain-source voltages**
- **Quadratic Model**
  - **Includes the voltage variation along the channel between S and D**

- Drain Current = (total charge in the inversion layer) / (time of transit carriers between source and drain)

$$I_D = \frac{Q_{inv} W L}{t_r}$$

- **If the velocity of the carriers is constant between source and drain, the transit time equals**

$$t_r = \frac{L}{v} = \frac{L}{\mu E} = \frac{L^2}{\mu V_{DS}}$$

$$v = \mu E = \mu \frac{V_{DS}}{L}$$

$$I_D = \frac{Q_{inv} W L}{\frac{L^2}{\mu V_{DS}}} = \mu Q_{inv} \cdot \left(\frac{W}{L}\right) V_{DS}$$

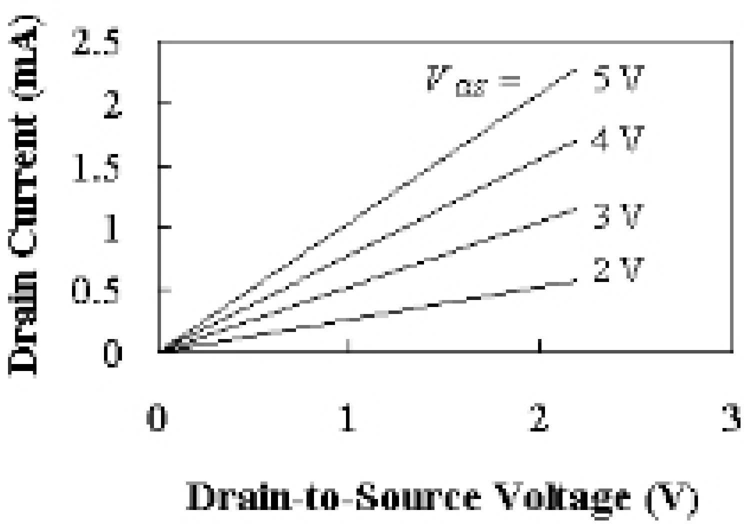
MOSFET Analysis (Linear model)

- **Assuming that the charge density is constant between the source and drain, we can say**

$$Q_{inv} = C_{ox}(V_G - V_t) \leftarrow \text{threshold voltage}$$

$$I_D = \mu \frac{W}{L} C_{ox} (V_{GS} - V_t) V_{DS}$$

- **The linear model is valid only when $V_{DS} << V_{GS} - V_T$. This ensures that the velocity, the electric field and the inversion layer charge density is indeed constant between the source and the drain**



VOLTAGE CONTROLLED RESISTOR