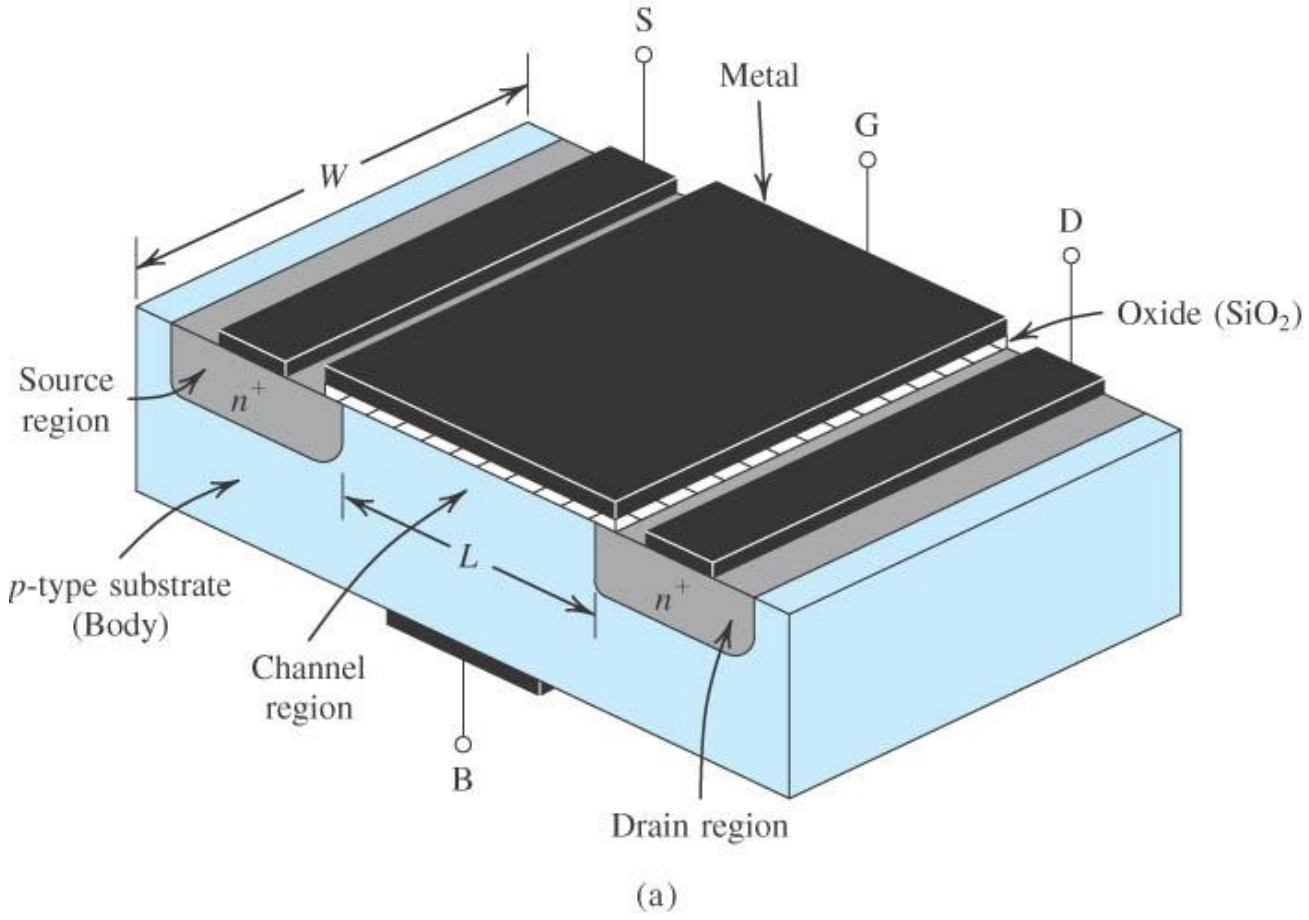
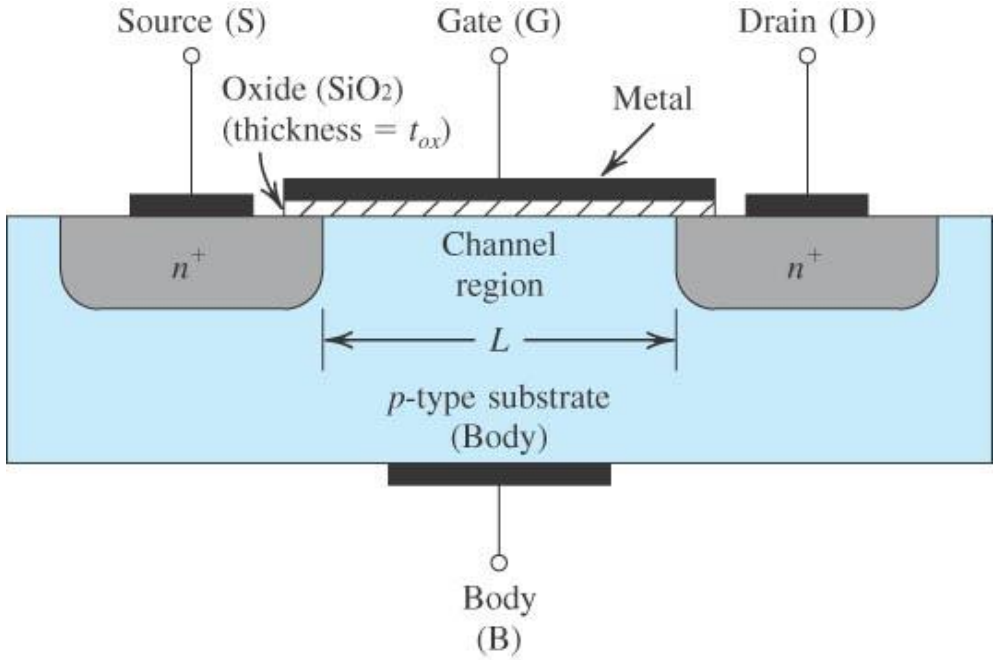
Elettronica Digitale
A.A. 2020-2021

Lezione 24/03/2021

Transistore MOSFET

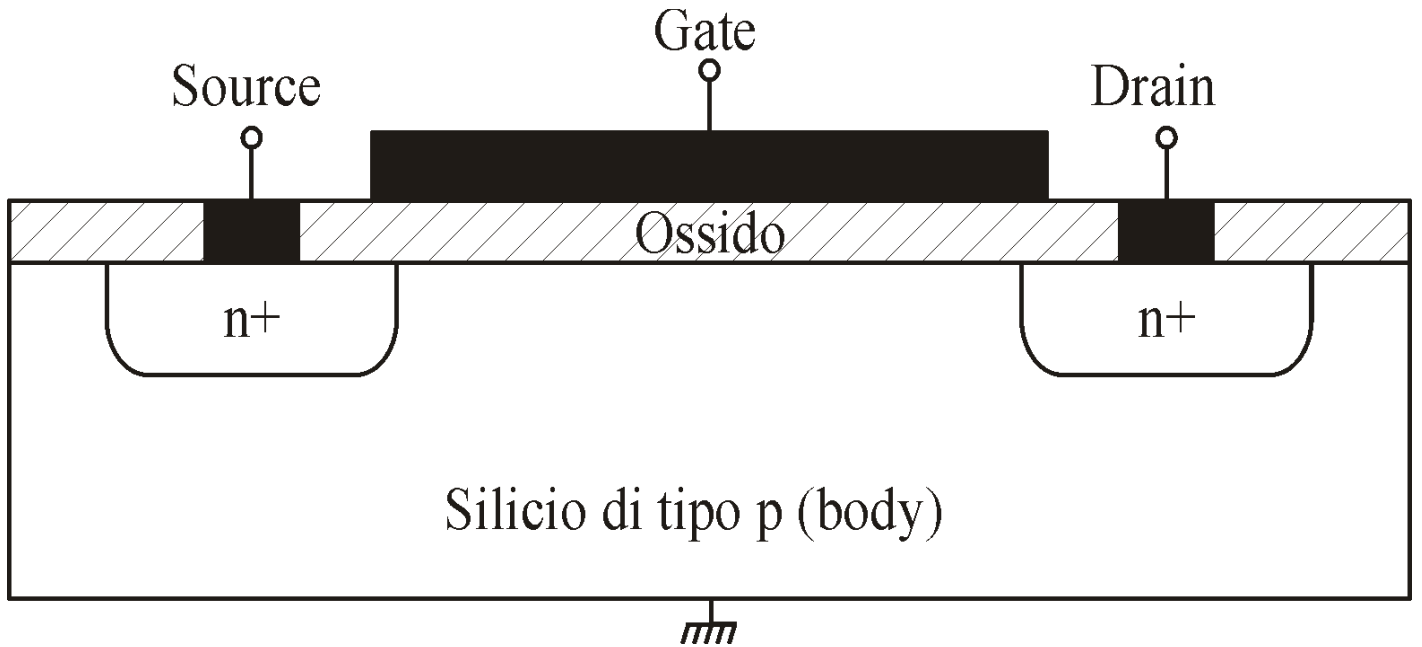


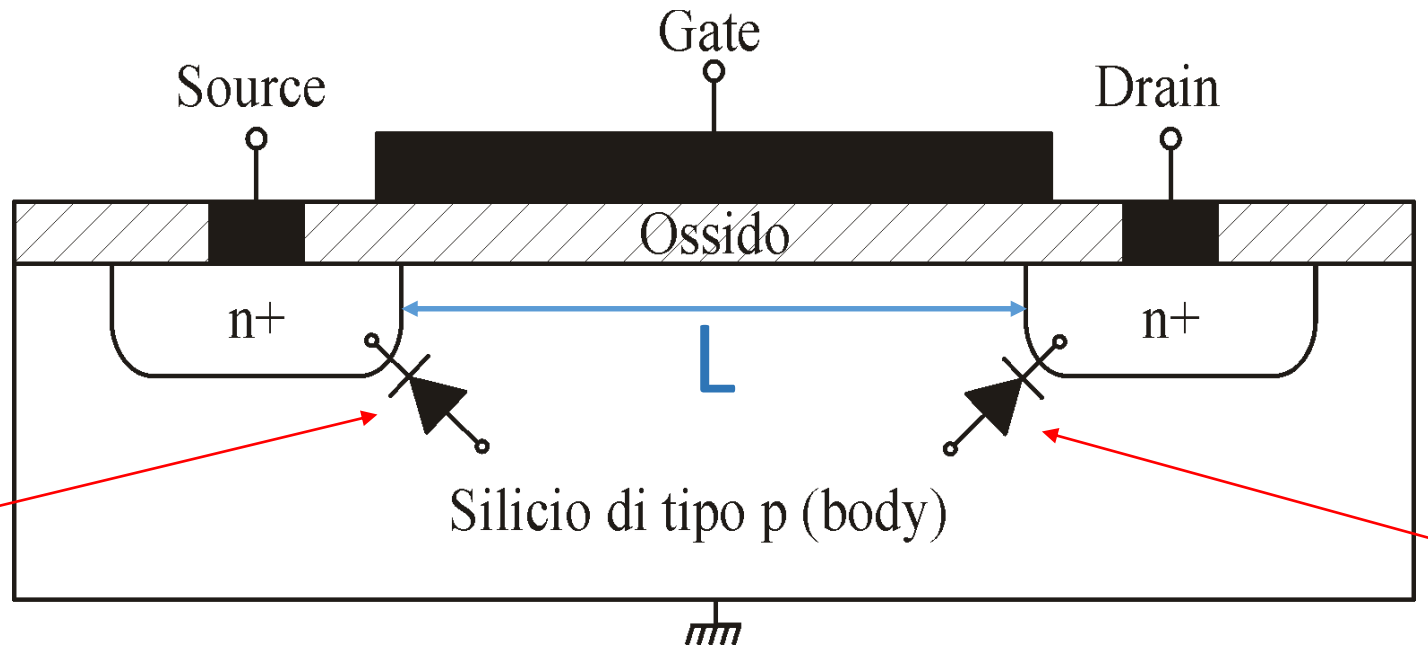
(a)



(b)

Transistore MOSFET



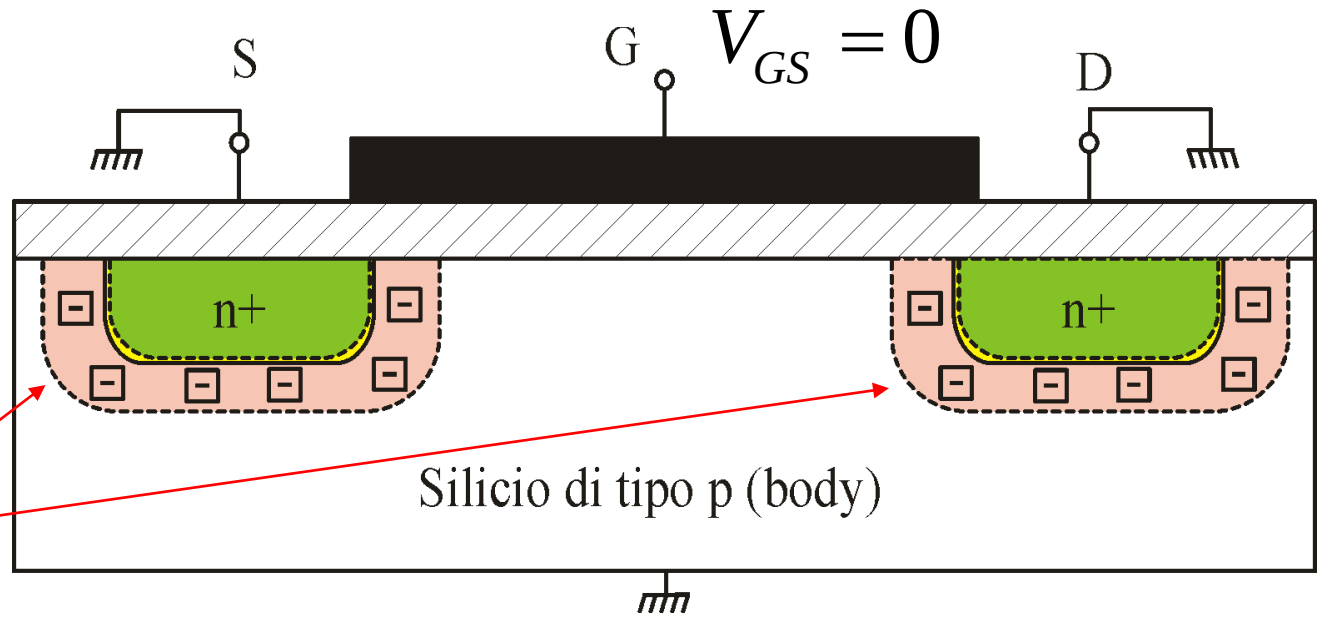


Giunzione "SB" polarizzata inversamente

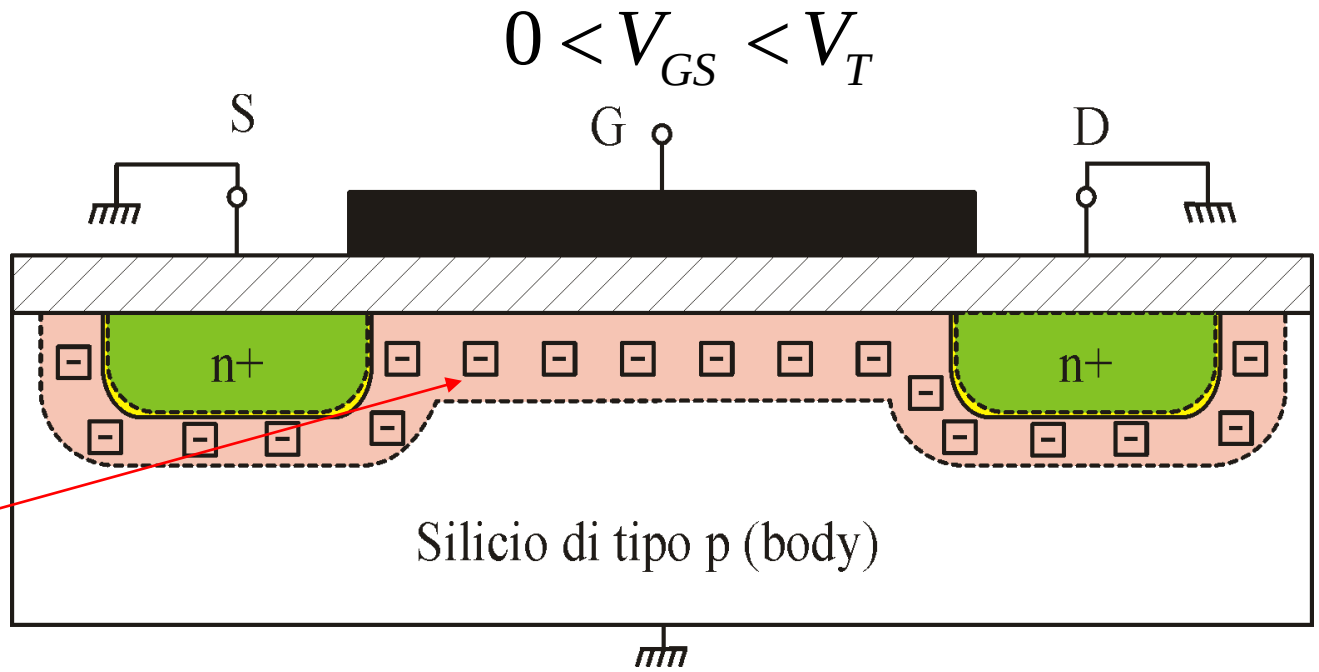
Giunzione "DB" Polarizzata inversamente

Transistore MOSFET

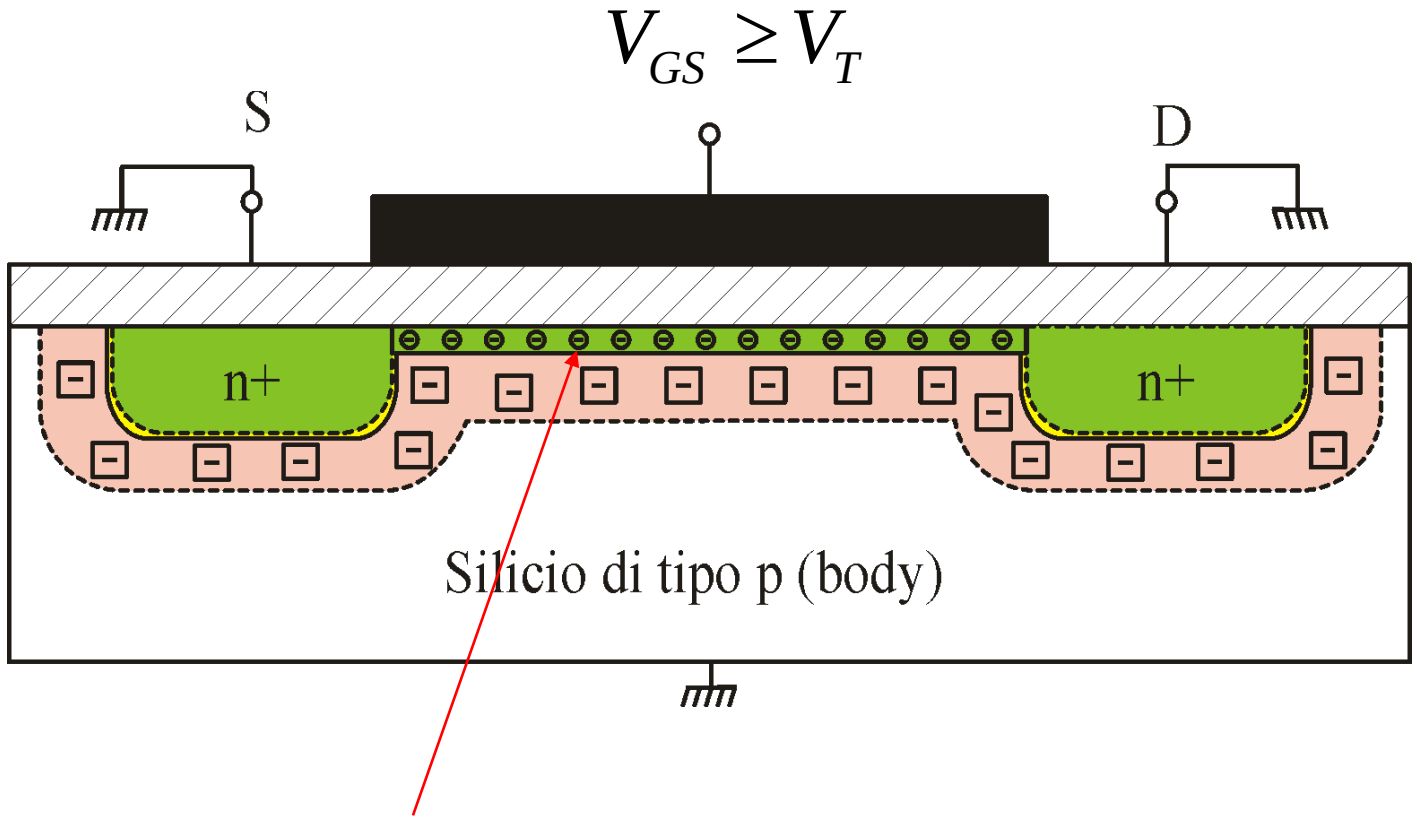
Regione di svuotamento giunzione n+/p



Sotto il gate si forma una regione di svuotamento con cariche fisse



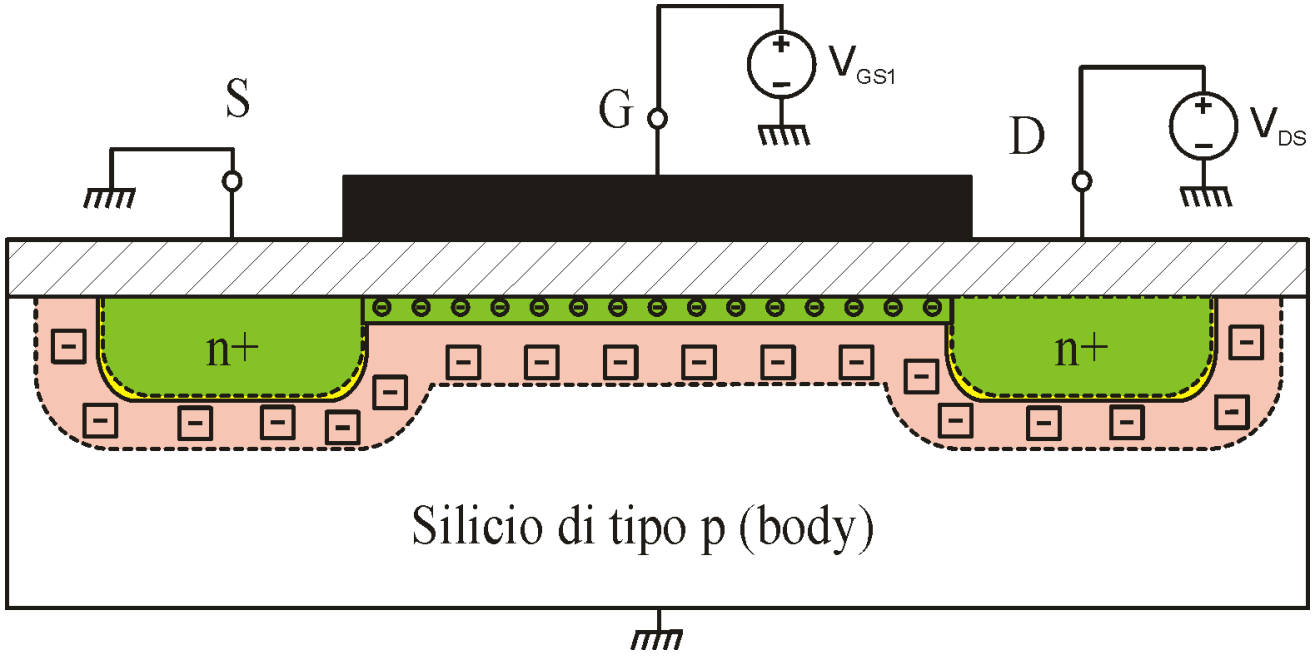
Transistore MOSFET



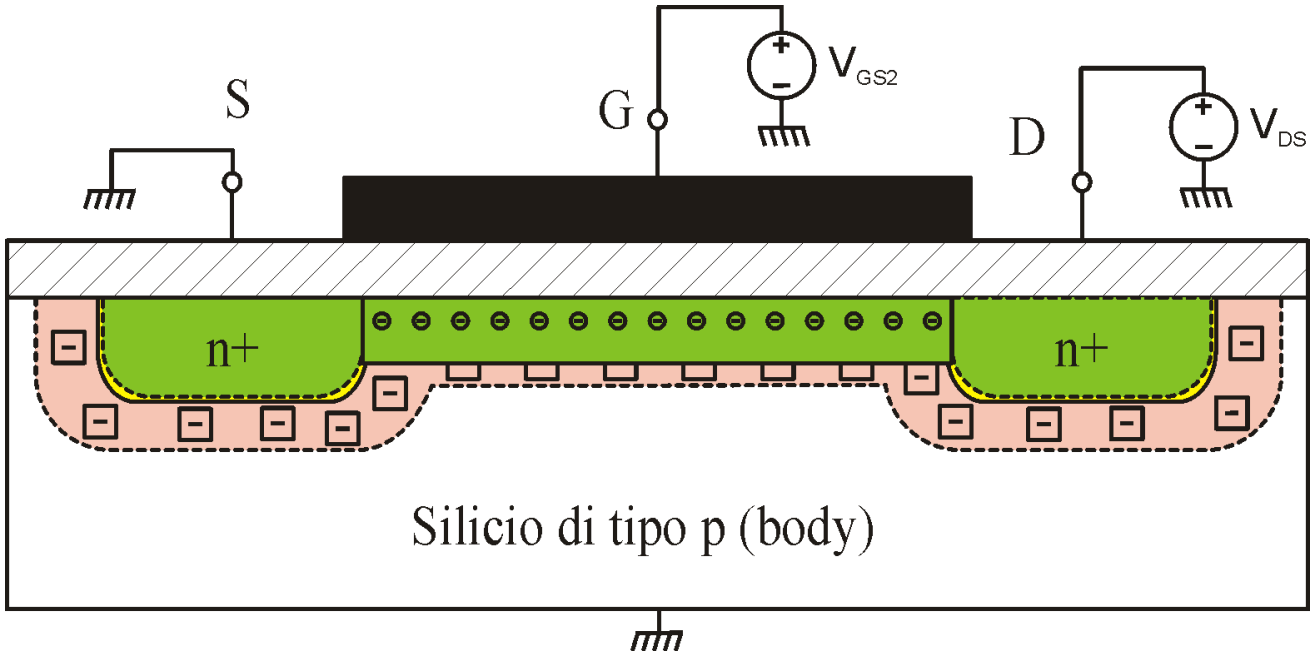
A seguito del fenomeno dell'inversione, sotto l'ossido di gate si forma un canale di cariche mobili (elettroni) che mette in comunicazione il source con il drain. Se si applica una differenza di potenziale tra source e drain, si può avere nel canale lo scorrimento di una corrente sostenuta dalle cariche mobili (elettroni).

Transistore MOSFET

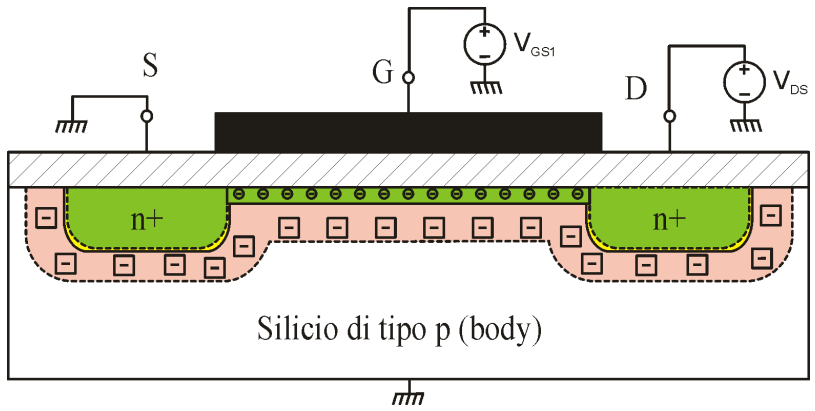
$$V_{GS1} > V_T$$

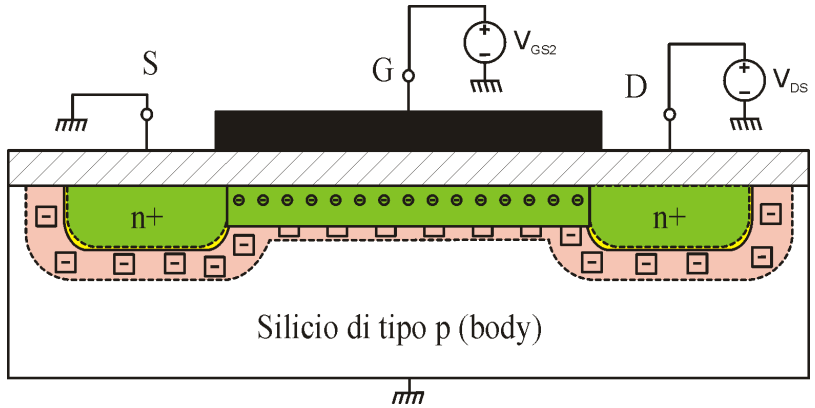


$$V_{GS2} > V_{GS1} > V_T$$

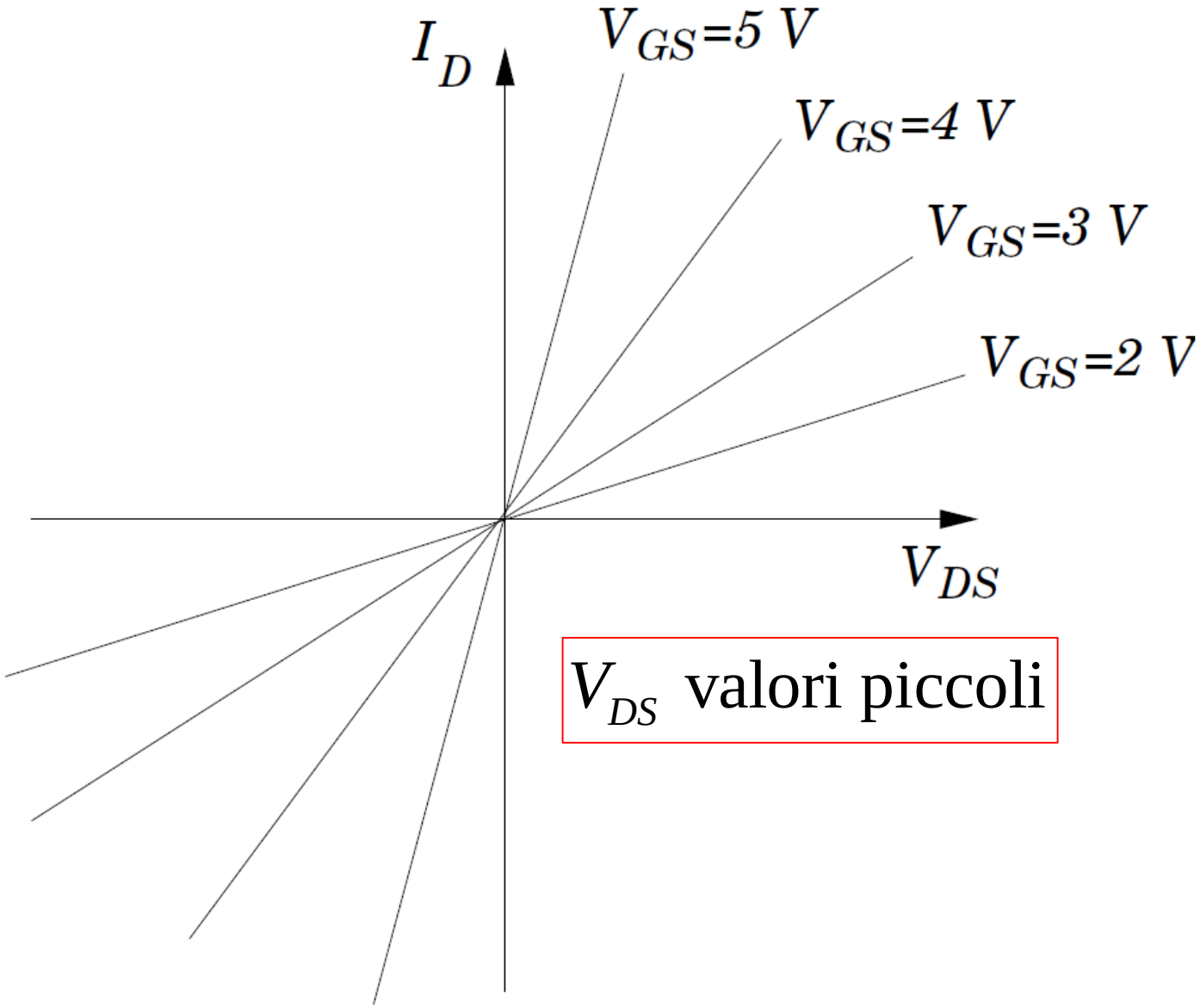


Transistore MOSFET





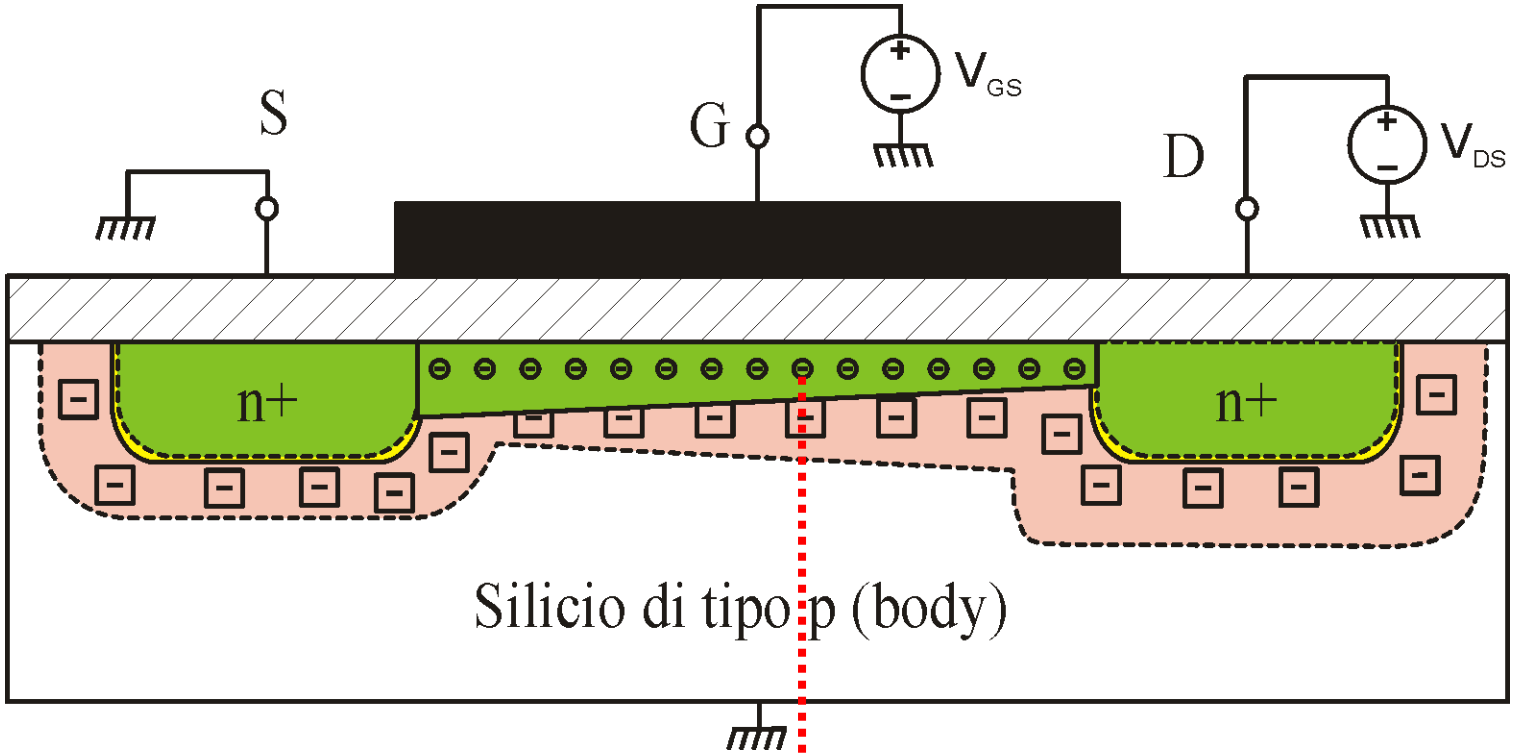
$$V_{GS2} > V_{GS1} > V_T$$



V_{DS} valori piccoli

Transistore MOSFET

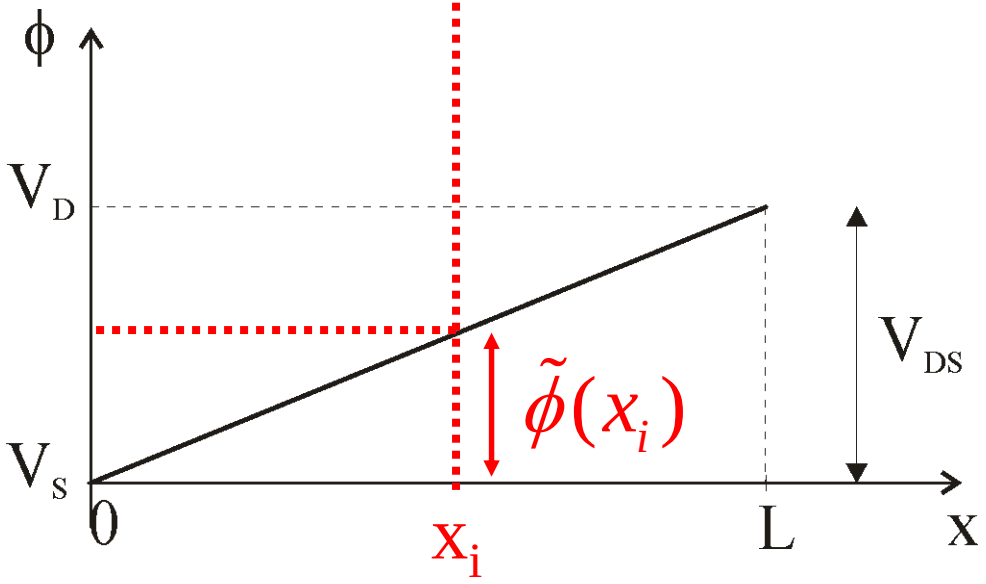
$$V_{GS} > V_T$$



$$V_{GX_i} = V_{GS} + V_{SX_i} = V_{GS} - \tilde{\phi}(x_i)$$

$$x_i = 0 \Rightarrow V_{GX_i} = V_{GS}$$

$$x_i = L \Rightarrow V_{GX_i} = V_{GS} - V_{DS} = V_{GD}$$



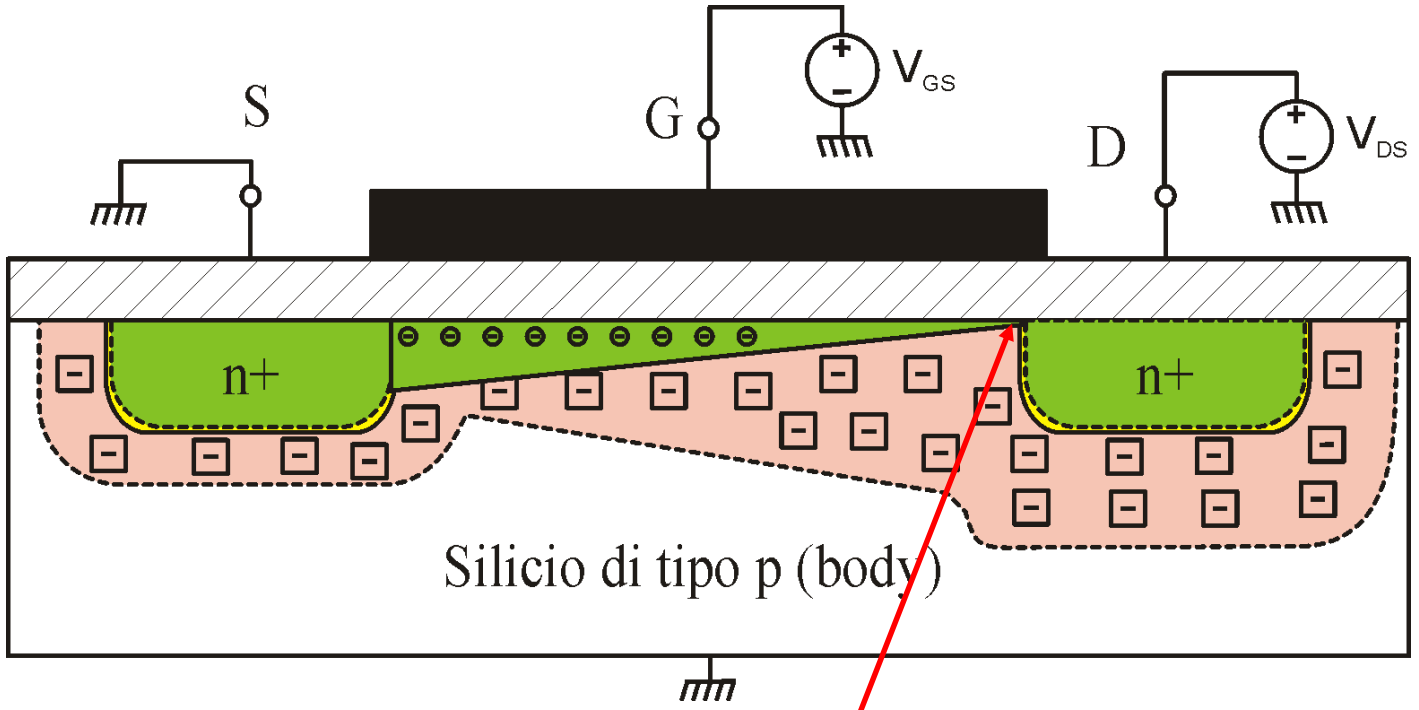
Transistore MOSFET

$$V_{GS} > V_T$$

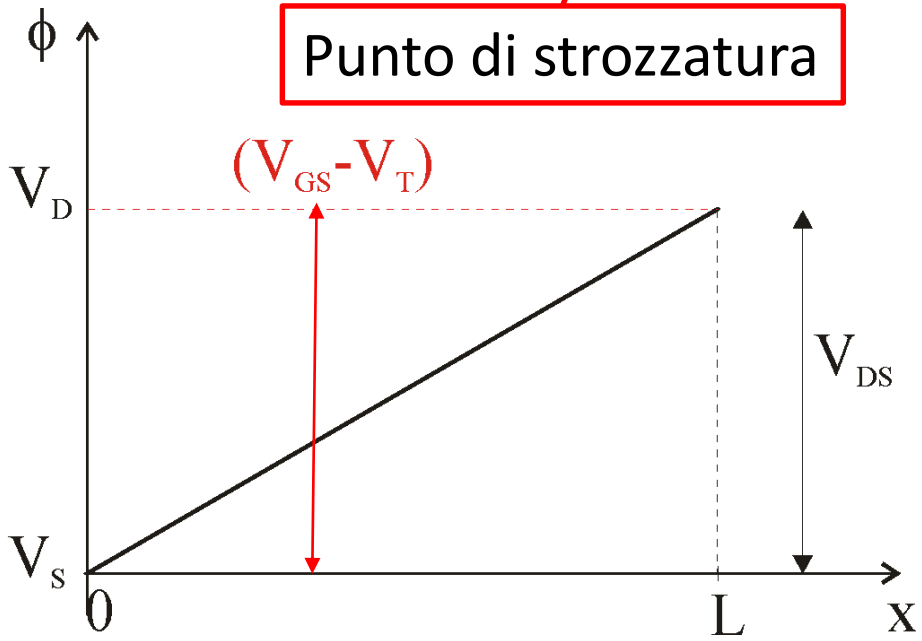
Se $V_{DS} = V_{GS} - V_T$

$x_i = L$ $\Rightarrow$ $V_{GX_i} = V_{GS} - V_{DS} = V_T$

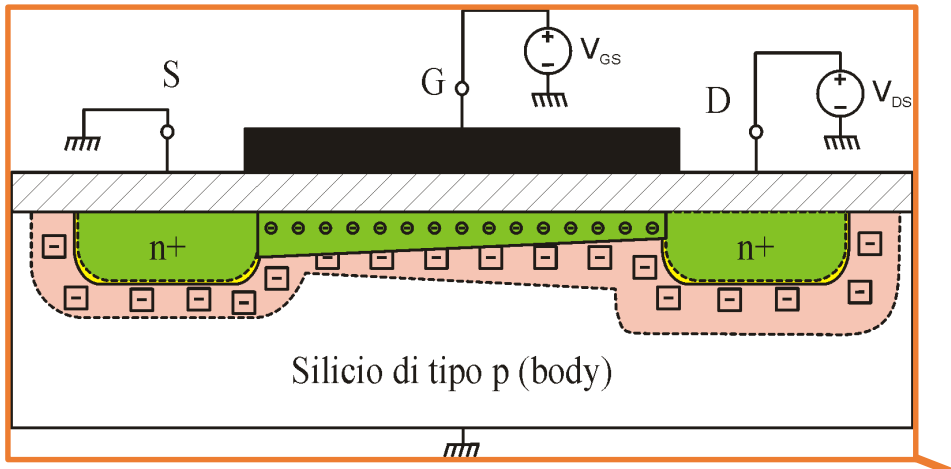
Strozzatura del canale (pinch-off)

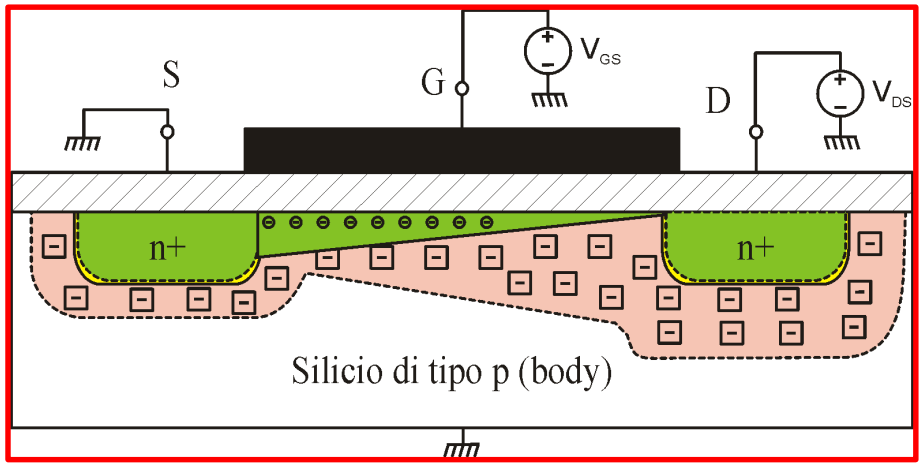


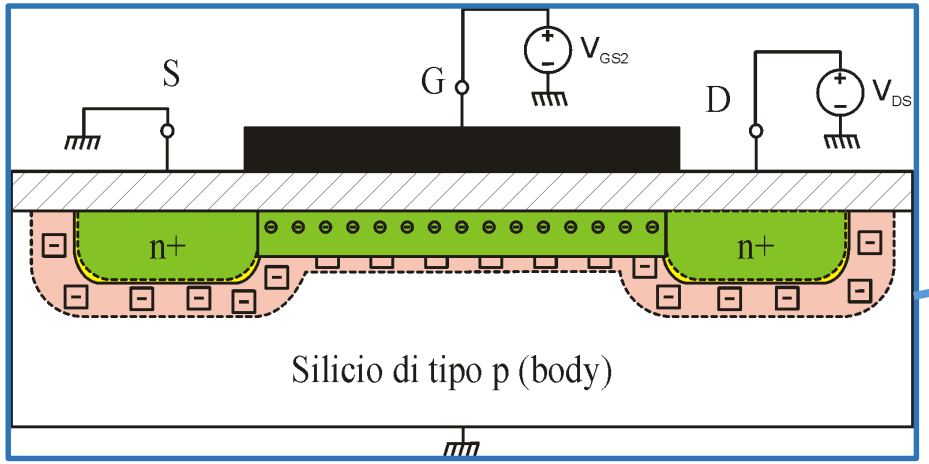
Punto di strozzatura

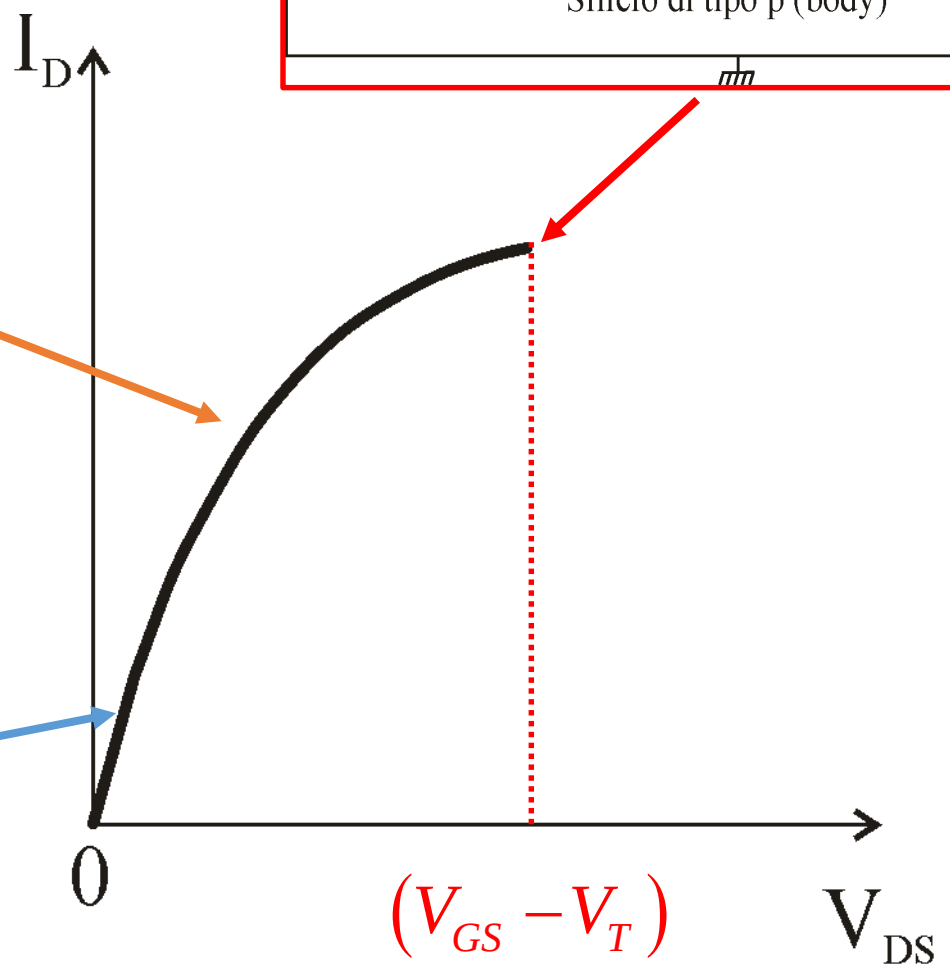


Transistore MOSFET









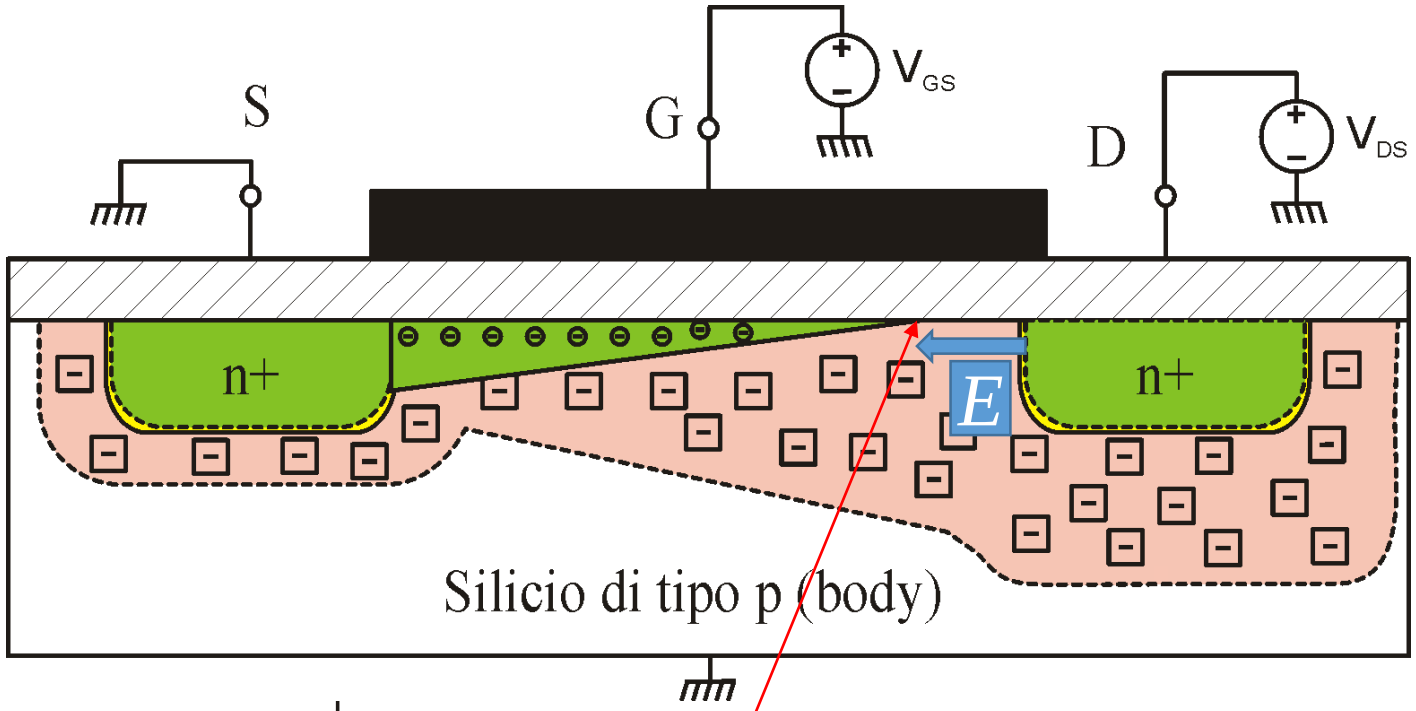
Transistore MOSFET

$$V_{GS} > V_T$$

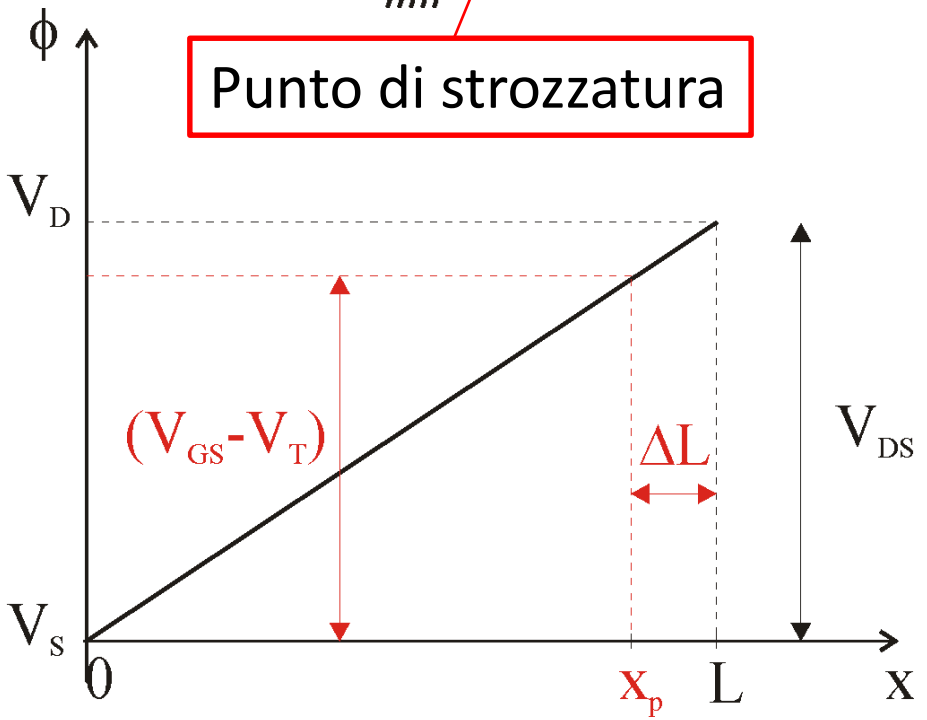
Se $V_{DS} > (V_{GS} - V_T)$

Il punto di strozzatura del canale si sposta verso il source alla coordinata x_p

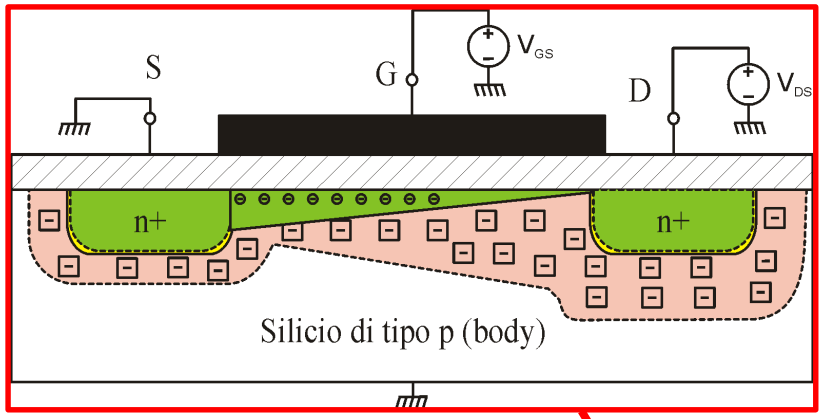
$$V_{GXp} = V_{GS} - \tilde{\phi}(x_p) = V_{GS} - (V_{GS} - V_T)$$
$$= V_T$$

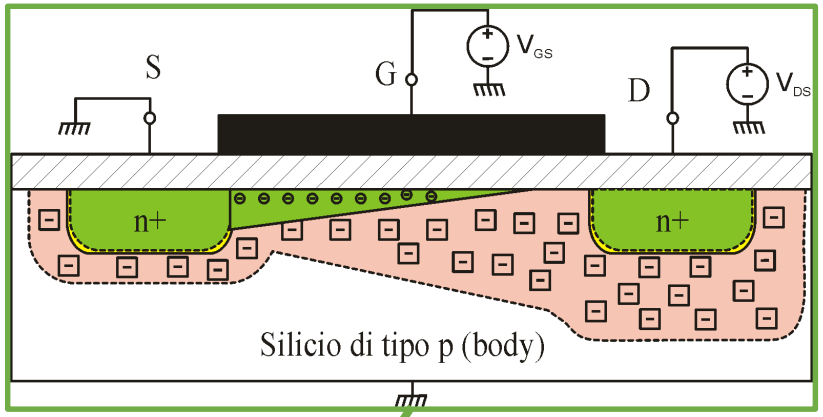


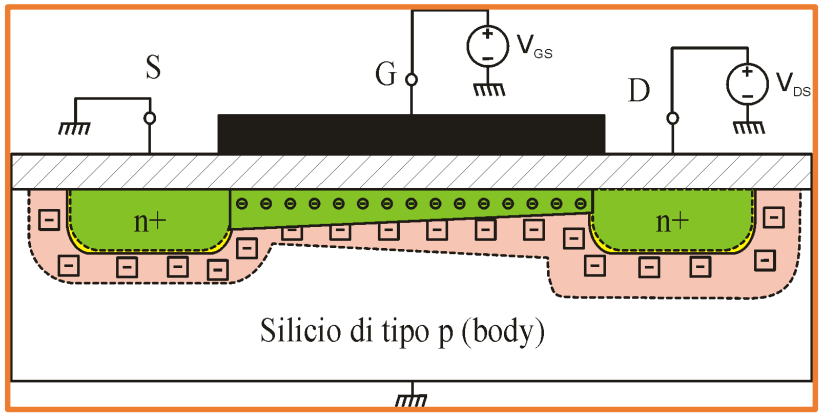
Punto di strozzatura

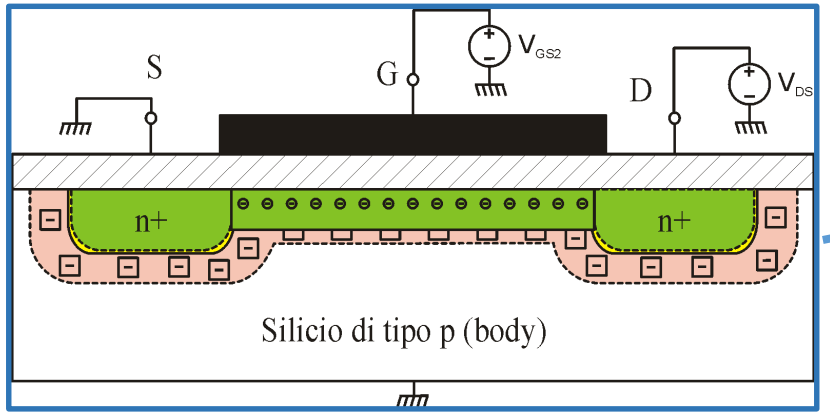


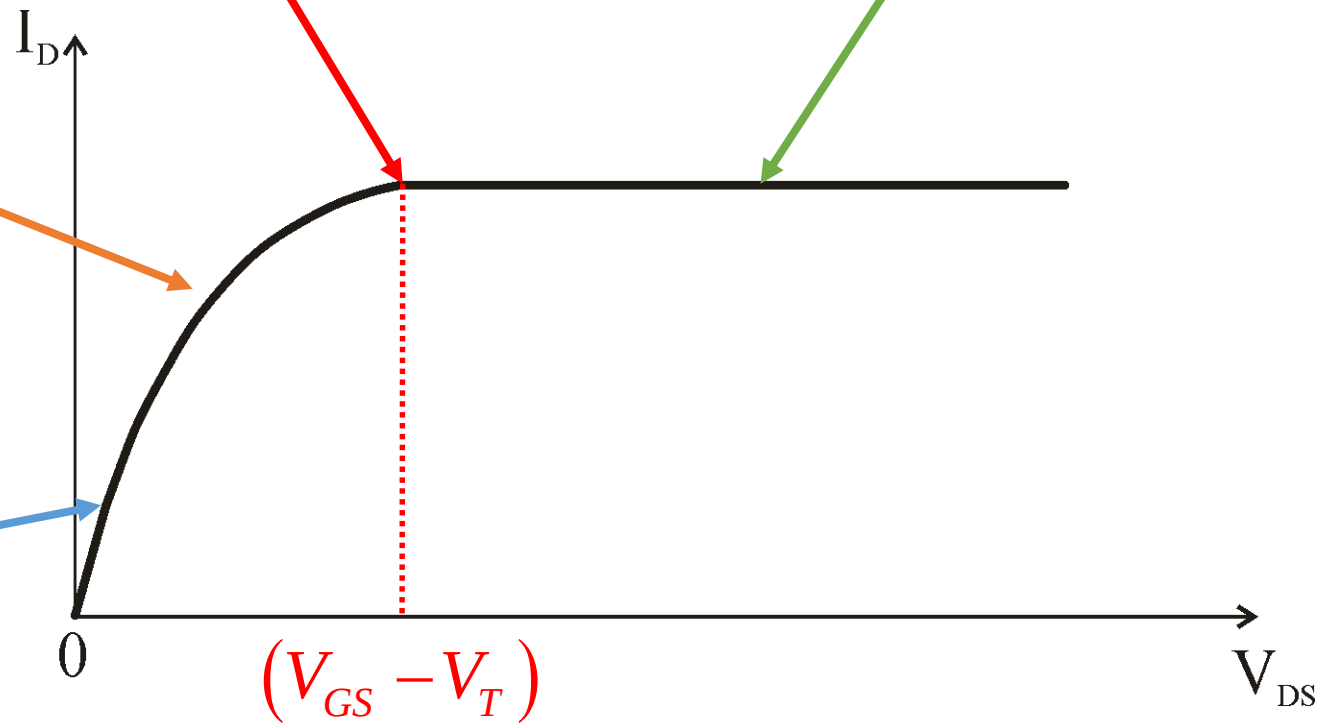
Transistore MOSFET











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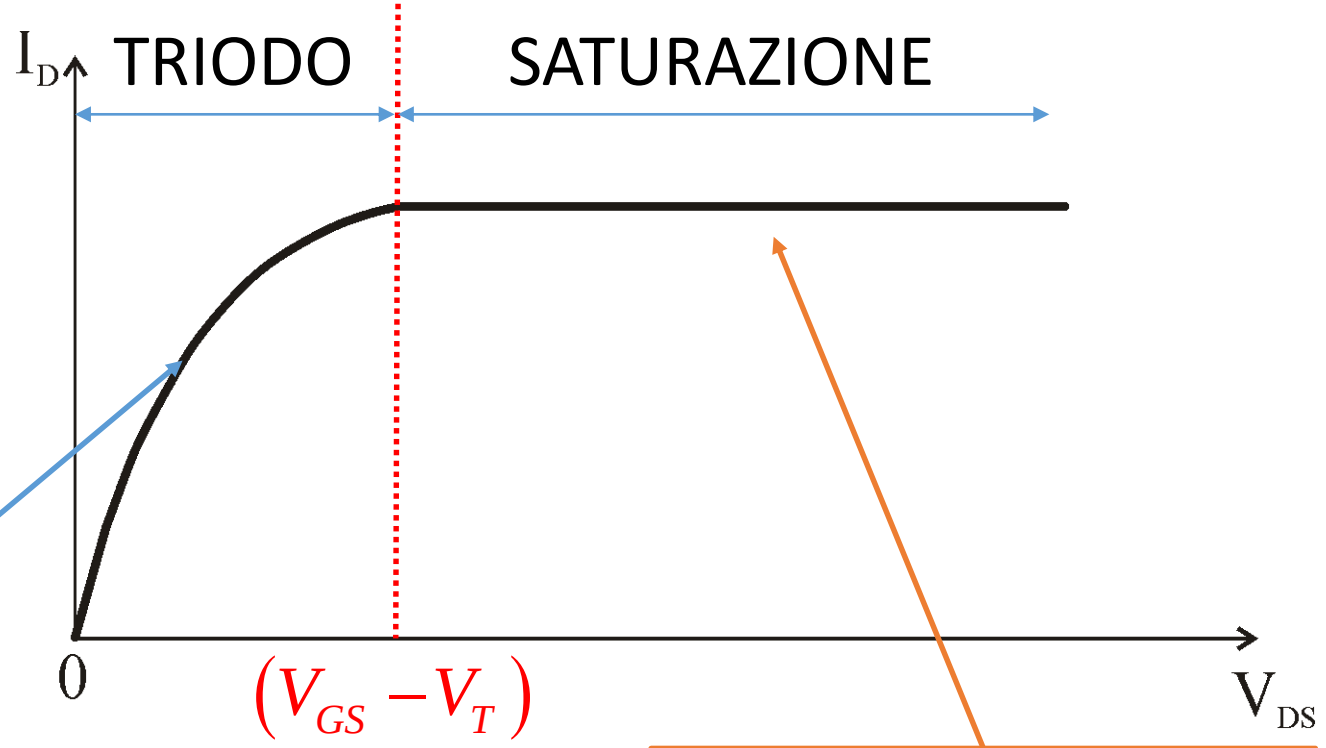


ZONA TRIODO

ZONA SATURAZIONE

$$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}}$$

$$I_D = \mu_n C_{ox} \frac{W}{L}\left[(V_{GS}-V_T)V_{DS} - \frac{V_{DS}^2}{2}\right]$$

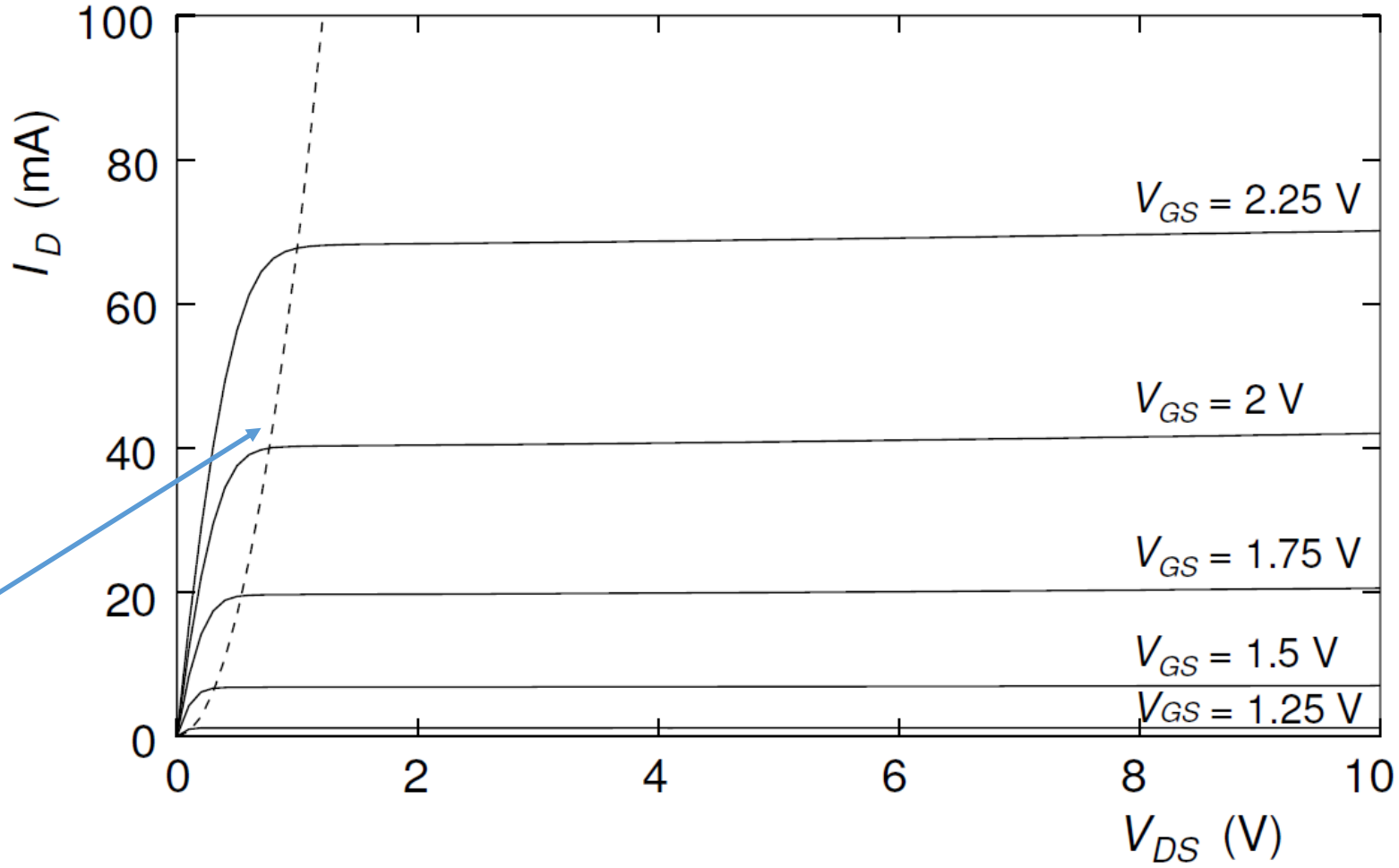
$$I_D = \mu_n C_{ox} \frac{W}{L}\frac{(V_{GS}-V_T)^2}{2} = k\frac{W}{L}(V_{GS}-V_T)^2$$

Transistore MOSFET

Inizio della saturazione

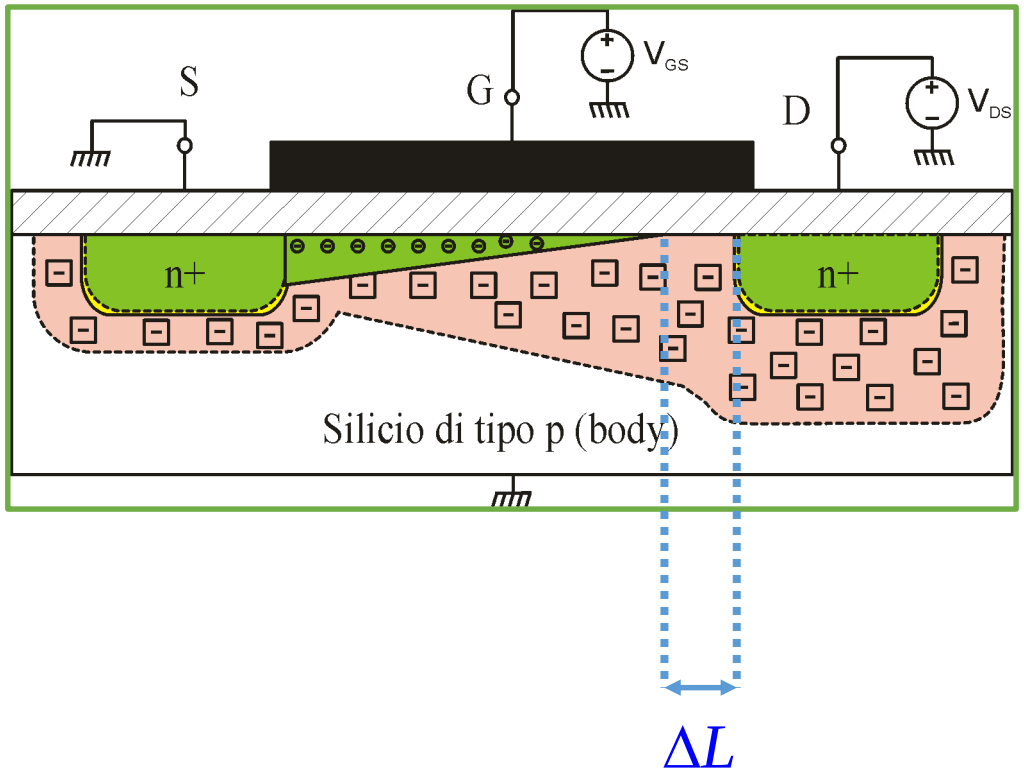
$$\begin{cases} I_D = k\dfrac{W}{L}\left(V_{GS} - V_T\right)^2 \\ V_{DS} = \left(V_{GS} - V_T\right) \end{cases}$$

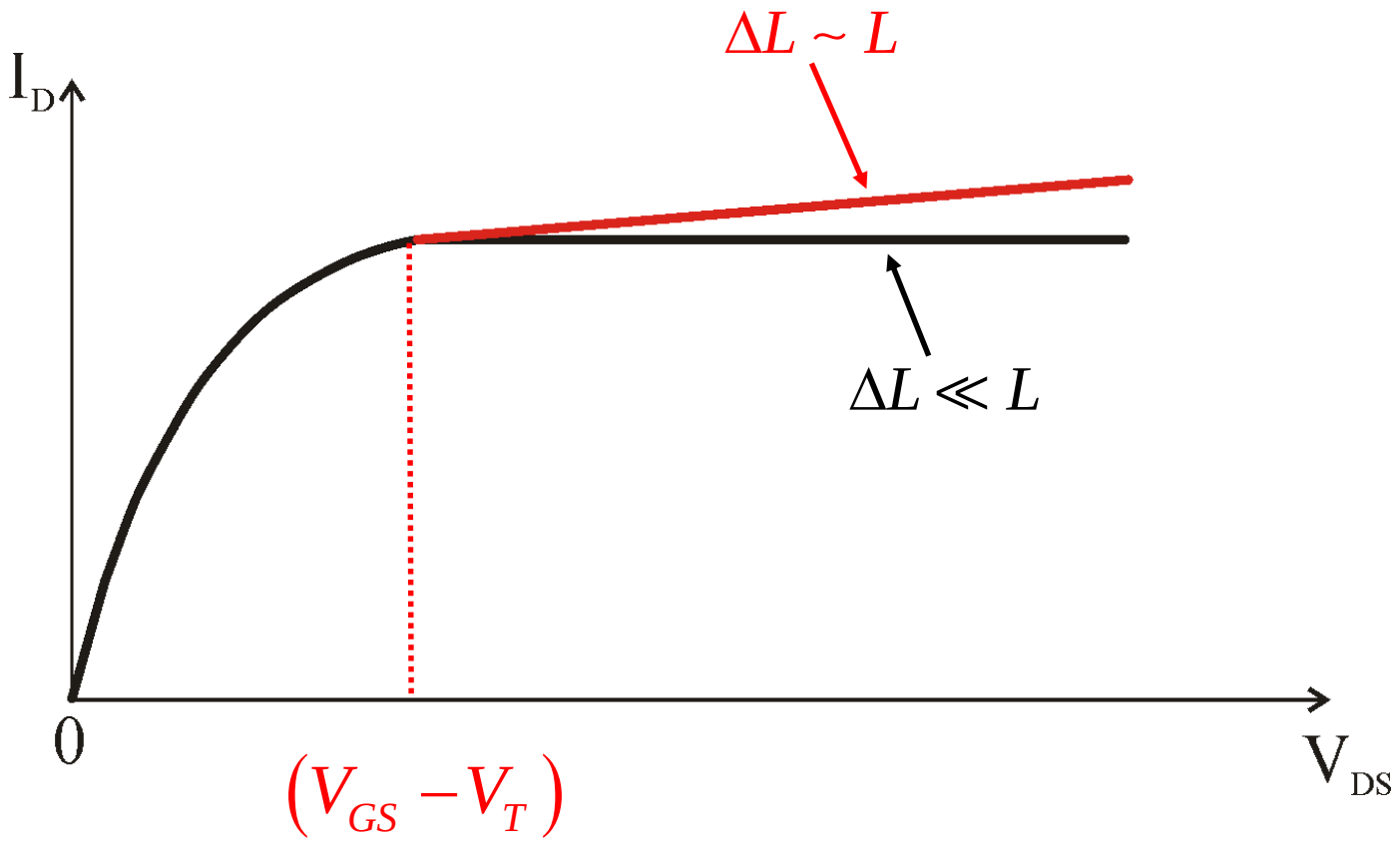
$$I_D = k\frac{W}{L}V_{DS}^2$$



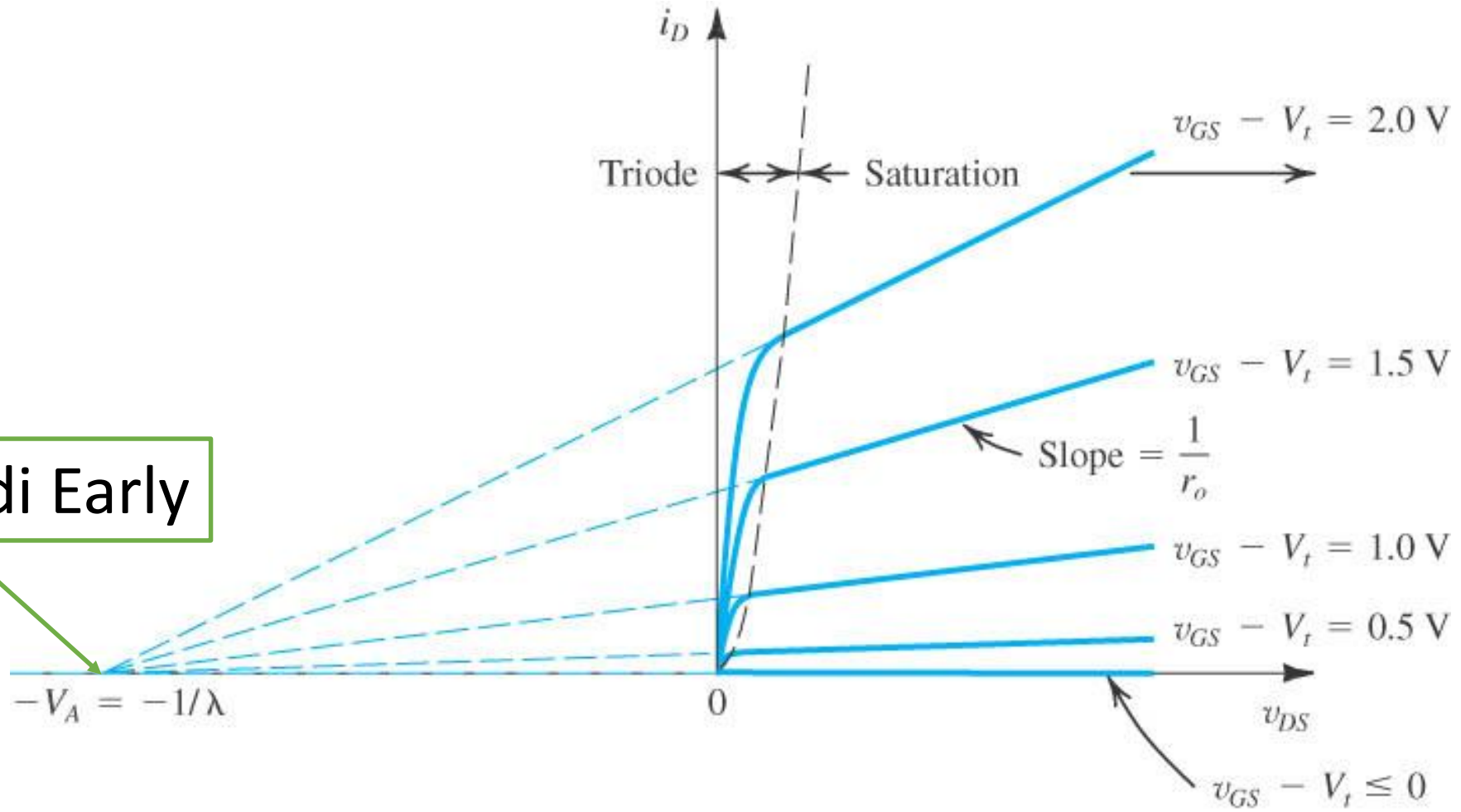
Equazione di una parabola nel piano I_D-V_{DS}

Transistore MOSFET – Effetto della modulazione di canale





Transistore MOSFET – Effetto della modulazione di canale



Tensione di Early

ZONA SATURAZIONE $I_D = k\frac{W}{L}\left(V_{GS} - V_T\right)^2\left(1 + \lambda V_{DS}\right)$