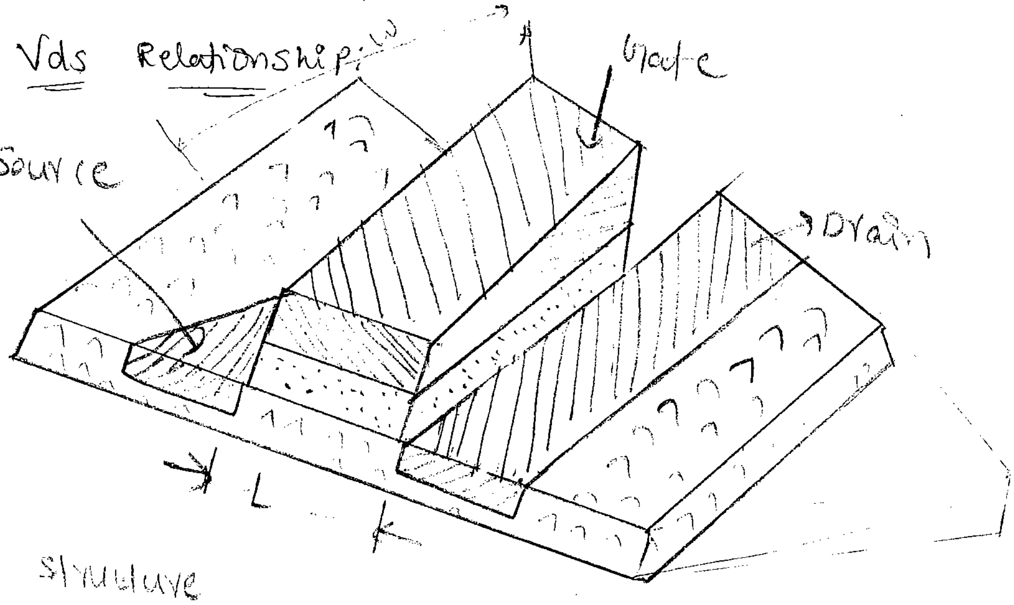
BASIC ELECTRICAL PROPERTIES

(4)

Ids Vs Vds Relationship:



nmos structure

The whole concept of mos Tr involves from the use of a Voltage on the gate to ~~[illegible]~~ induce a charge in the channel b/w source and drain which may then be caused to move from source to drain under the influence of an electric field created by Voltage Vds applied b/w drain and source. Since the charge induced is dependent on gate to source Voltage Vgs then Ids is dependent on both Vgs & Vds.

$$I_{ds} = -I_{sd} = \frac{\text{Charge induced in Channel } (Q_c)}{\text{Transit Time } (\tau)}$$

$$\text{Transit time} \Rightarrow \tau_{sd} = \frac{\text{Length of channel } (L)}{\text{Velocity } (V)}$$

$$\text{Velocity } V = \mu E_{ds}$$

μ = $\bar{e}$ mobility $cm^2/V sec$

E_{ds} = electric field (drain to source)

(B)

$$E_{ds} = \frac{V_{ds}}{L}$$

So, $V = \frac{\mu V_{ds}}{L}$

$$\tau_{sd} = \frac{L^2}{\mu V_{ds}}$$

$\mu_n = 650\ cm^2/V\text{-}sec$

$\mu_p = 240\ cm^2/V\text{-}sec$

Non - Saturation region :-

Charge induced in channel due to gate voltage is due to the voltage difference b/w gate and channel, Vgs.

+ Voltage along channel varies linearly with distance from source due to IR drop in channel & assuming that device is in non-saturation region. then drain side voltage $\frac{V_{ds}}{2}$.

Effective gate voltage $(V_g) = V_{gs} - V_t$.

$V_t \rightarrow$ voltage needed to invert charge under the gate & established channel.

$$Q = C_g V.$$

Potential difference $V = \underbrace{V_{gs} - V_t}_{\text{source}} - \underbrace{\frac{V_{ds}}{2}}_{\text{drain}}$

$$C_g = \frac{\epsilon_0 \epsilon_r A}{D}$$

(c)

$$Q_c = \frac{\epsilon_0 \epsilon_r A}{D}\left(V_{gs} - V_t - \frac{V_{ds}}{2}\right)$$

$$I_{ds} = \frac{Q_c}{\tau}$$

$$= \frac{\frac{\epsilon_0 \epsilon_r A}{D}\left(V_{gs} - V_t - \frac{V_{ds}}{2}\right)}{\frac{L^2}{\mu V_{ds}}}$$

$$= \frac{\epsilon_0 \epsilon_r W L}{D} \times \frac{\mu V_{ds}}{L^2}\left(V_{gs} - V_t - \frac{V_{ds}}{2}\right)$$

$(A = WL)$

$$= \frac{\epsilon_0 \epsilon_r W}{D} \times \frac{\mu V_{ds}}{L}\left((V_{gs} - V_t) - \frac{V_{ds}}{2}\right)$$

$$I_{ds} = \frac{\epsilon_0 \epsilon_r W}{D L} \cdot \mu\left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2}\right)$$

when $V_{ds} < V_{gs} - V_t$

let $k = \frac{\epsilon_0 \epsilon_r \mu}{D}$

$$I_{ds} = \frac{kW}{L}\left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2}\right)$$

Let $\beta = \frac{kW}{L}$

$$\therefore I_{ds} = \beta\left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2}\right)$$

$$k = \frac{\epsilon_0 \epsilon_r \mu}{D} \times \frac{A}{A}$$

sub $k = \frac{C_g \mu}{WL}$ in I_{ds}

$$I_{ds} = \frac{C_g \mu}{WL} \cdot \frac{W}{L}\left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2}\right)$$

$$= \frac{C_g \mu}{L^2}\left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2}\right)$$

gate capacitance / unit area C_o

(D)

$$C_o = \frac{C_g}{WL}$$

$$C_g = C_o . WL$$

$$\therefore I_{ds} = \frac{C_o \mu W}{L} \left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2} \right)$$

Saturation region :-

$$V_{ds} = V_{gs} - V_t$$

$$I_{ds} = \beta \left((V_{gs} - V_t) V_{ds} - \frac{V_{ds}^2}{2} \right)$$

$$= \beta \left(V_{ds} . V_{ds} - \frac{V_{ds}^2}{2} \right)$$

$$= \beta \left(\frac{V_{ds}^2}{2} \right)$$

$$= \frac{\beta}{2} (V_{gs} - V_t)^2$$

(or) $$I_{ds} = \frac{C_g \mu}{2L^2} \left(\frac{V_{ds}^2}{2} \right)$$

or $$I_{ds} = \frac{C_o \mu W}{2L} (V_{gs} - V_t)^2$$

For both enhancement mode & depletion mode.