

# Unit 3- MOSFETs

**Dr. Gurleen Kaur Walia**

**Assistant Professor**


**Signal and Image Processing (ED2)**

**School of Electronics & Electrical Engineering (SEEE)**

**Email ID: [gurleen.24800@lpu.co.in](mailto:gurleen.24800@lpu.co.in)**

## Construction & Working of Enhancement-Type MOSFET (Part 1)

MOSFET → Active Device

 can control  
flow of  $e^-$  ⇒ i flow

ex:- BJT, JFET

Passive Device

ex:- Diode, Cap., Trans. etc.

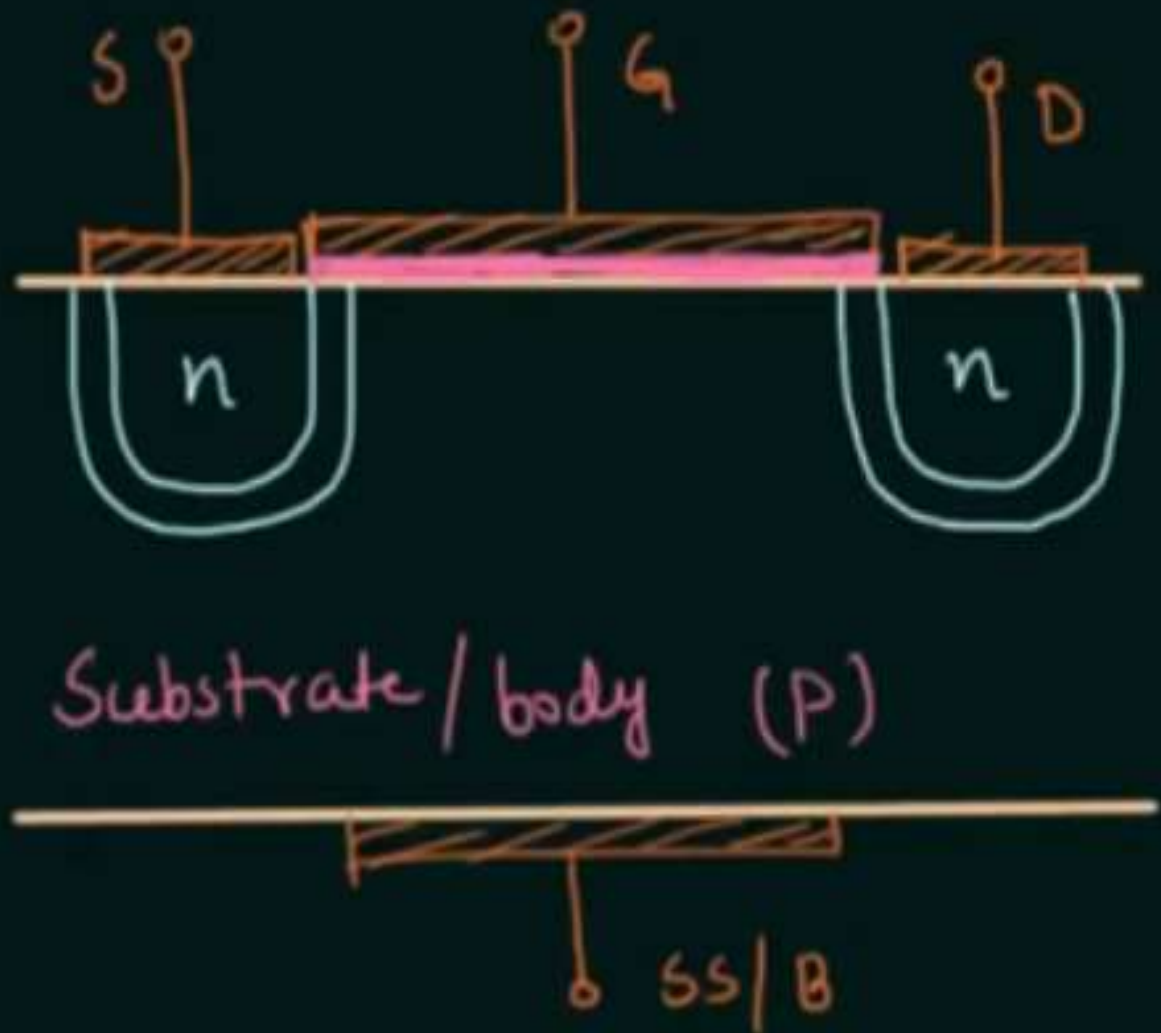
✓ 1) Depletion-type  $\begin{matrix} \nearrow n\text{-ch.} \\ \searrow p\text{-ch.} \end{matrix}$   
Ch. ✓ D & S

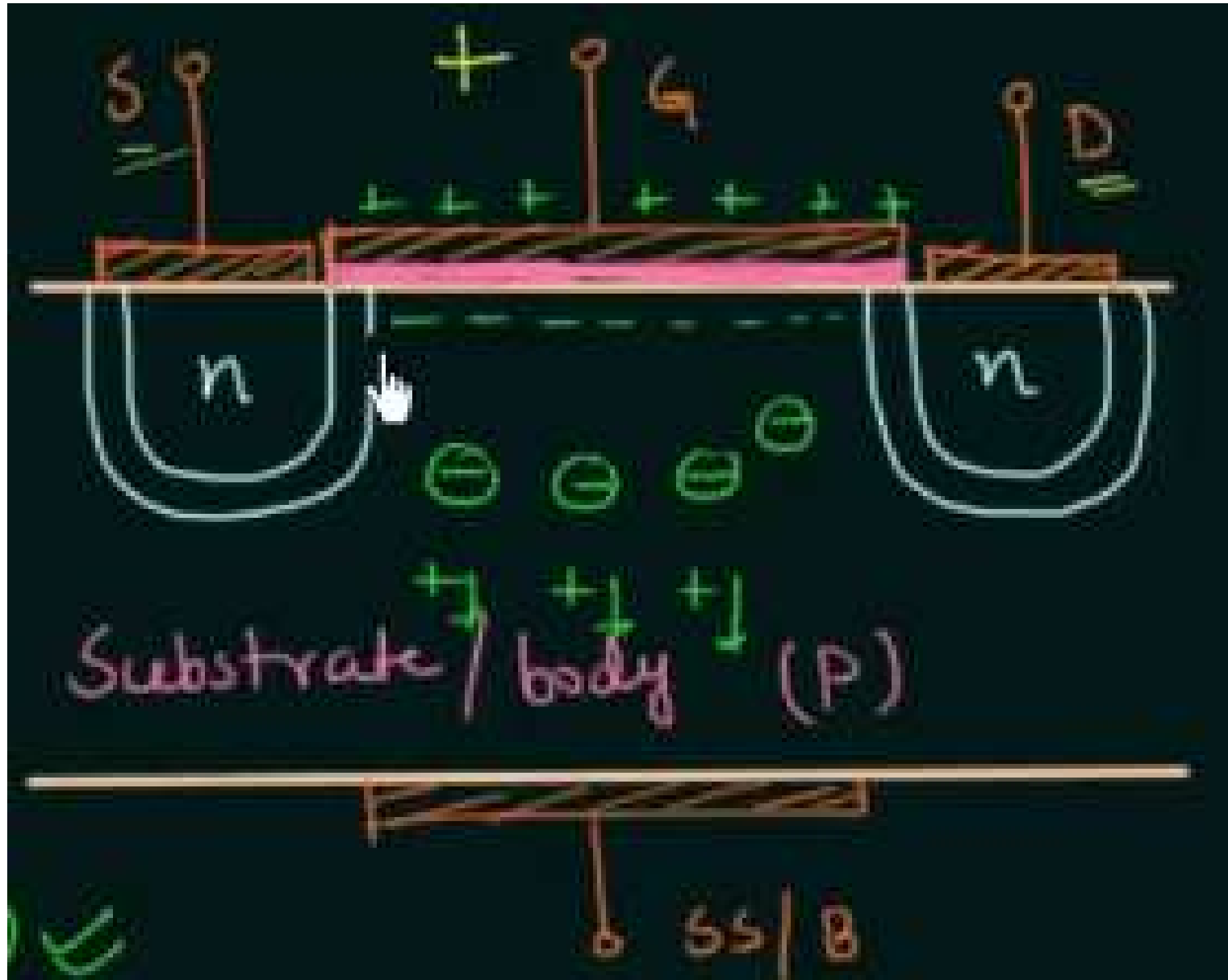
✓ 2) Enhancement-type  $\begin{matrix} \nearrow n\text{-ch.} \\ \searrow p\text{-ch.} \end{matrix}$   
Ch. X D & S

$$\text{SiO}_2 \approx 1000 \text{ \AA}$$

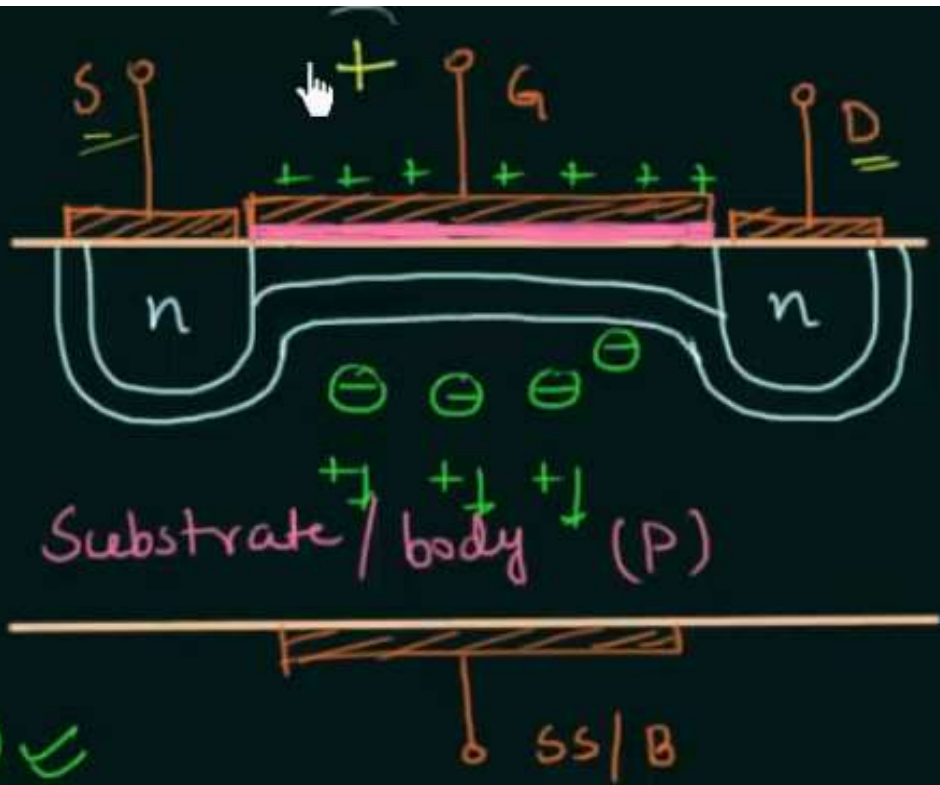
Gate oxide

ns. etc.





$\text{SiO}_2 \approx 1000 \text{Å}^2$   
Gate oxide



s. etc.

$V_{gs} \uparrow$   $\oplus \ominus \checkmark$

$\left\{ \begin{array}{l} \text{maj. c.c.} = \text{holes} \\ \text{min. c.c.} = \text{e}^- \end{array} \right.$

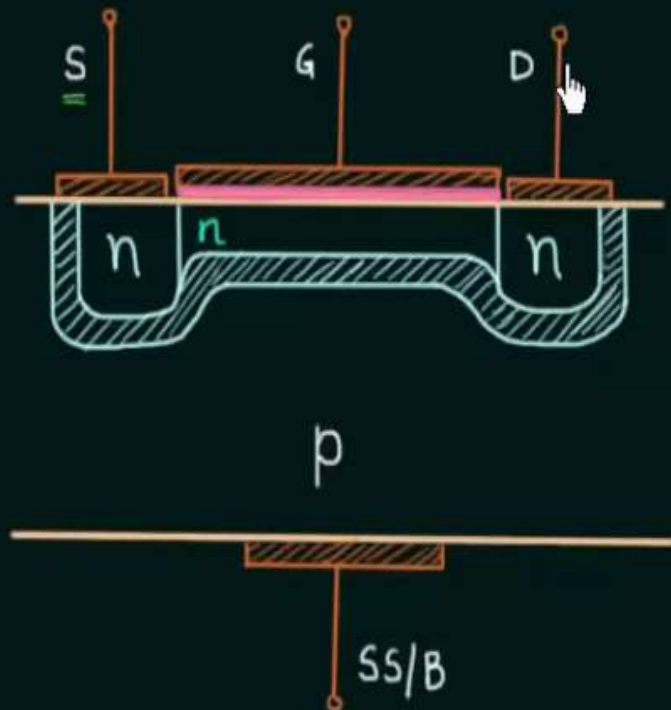
INVERSION

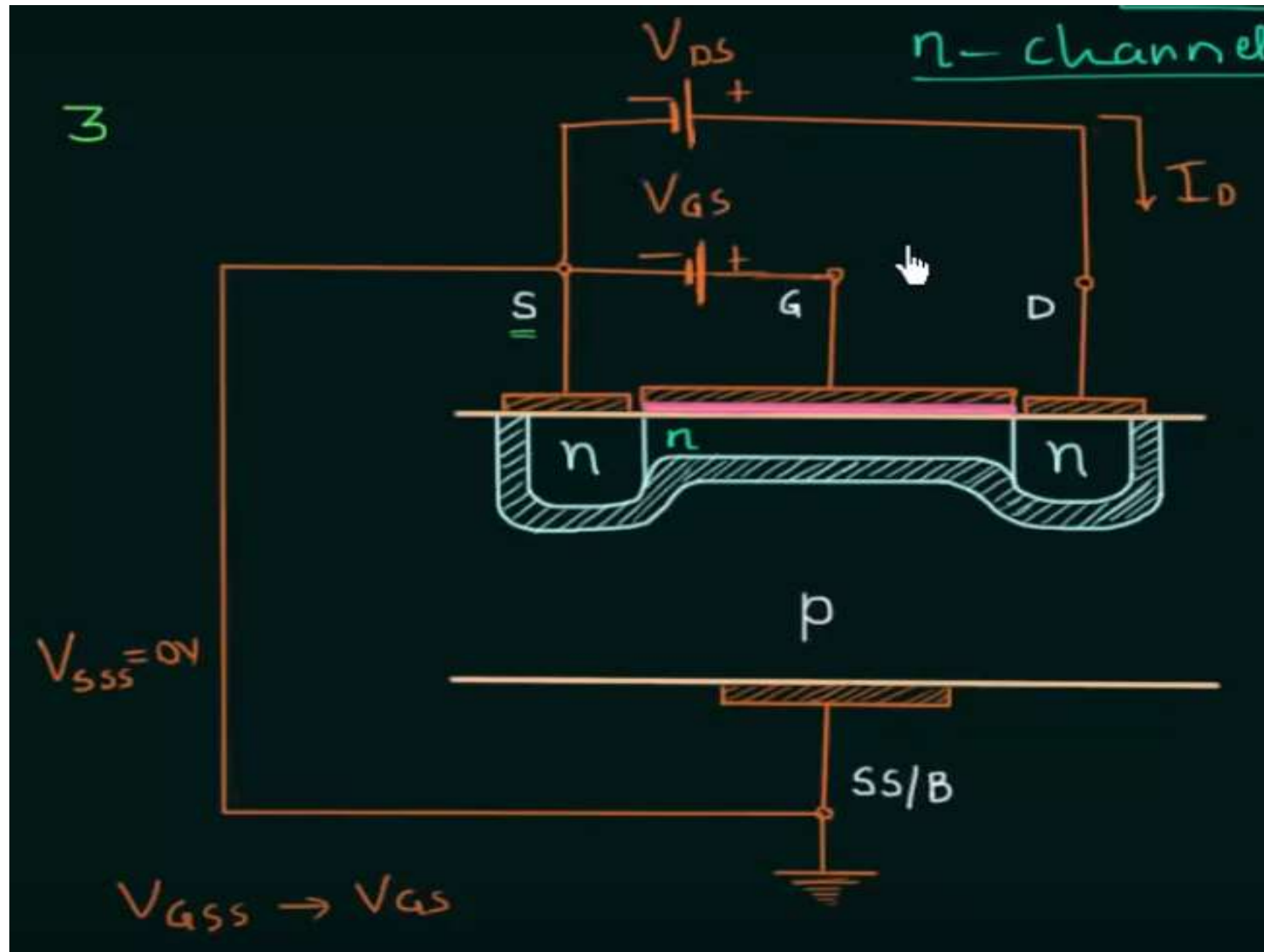
## Construction & Working of Enhancement-Type MOSFET (Part 2)

n-channel

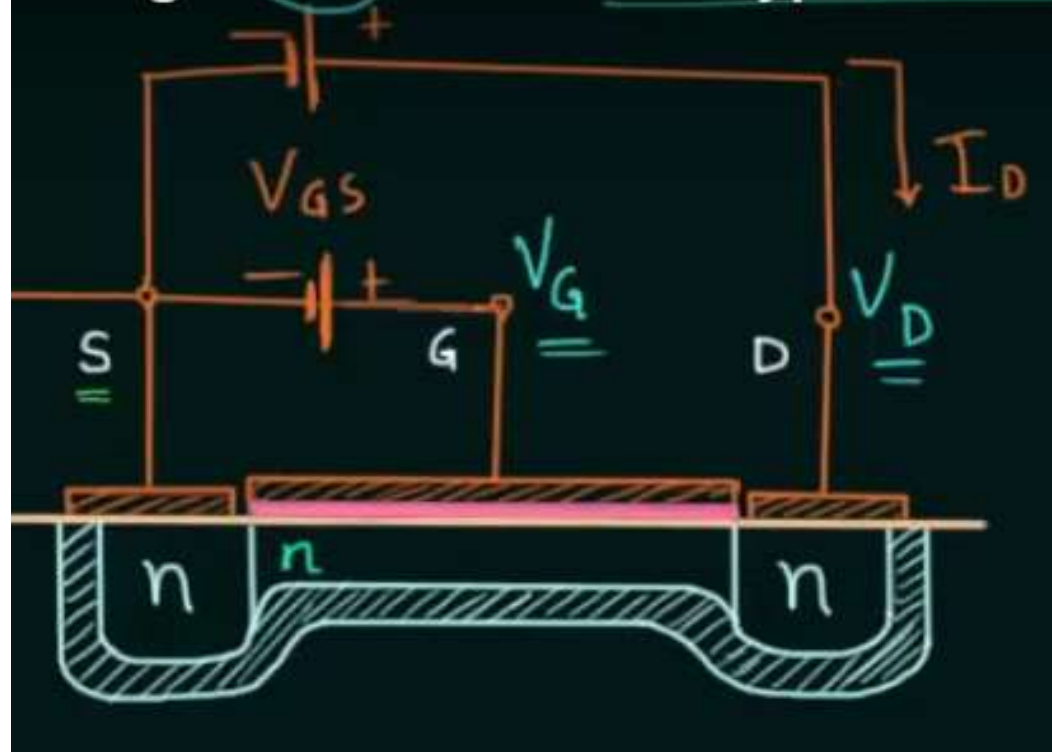
$\uparrow \underline{V_{GS}} \Rightarrow \text{width of ch.} \uparrow$

$V_{GSS}$  or  $V_{GB}$  X  $V_{GS} >$  part.  
Voltage

$$I_D$$
 $V_T$ 
$$V_{GS} > V_T \Rightarrow \text{sig } \uparrow I_D$$




## Working of Enhancement-Type MOSF



$$V_G - V_{GS} + V_{DS} = V_D$$

$$\underbrace{V_{GD}} = V_G - V_D = V_{GS} - V_{DS}$$



$$V_G - V_{GS} + V_{DS} = V_D$$

$$\checkmark \underline{V_{GD}} = V_G - V_D = V_{GS} - V_{DS}$$

$$\boxed{\text{Excess Vol.} = V_{GS} - V_T}$$

$$\checkmark CH1 \rightarrow 1V$$

$$CH1 < CH2 < CH3$$

$$\checkmark CH2 \rightarrow 2V$$

$$\checkmark CH3 \rightarrow 3V$$

$$\text{Case 1: } V_{DS} = 0V$$

$$\boxed{V_{GD} = V_{GS}}$$

↓

uniform d.r.

$$V_T = 1V$$

$$V_{GS} = \underline{2V} = V_{GD}$$

$$V_{GS} = \underline{3V} = V_{GD}$$

$$V_{GS} = 4V = V_{GD}$$

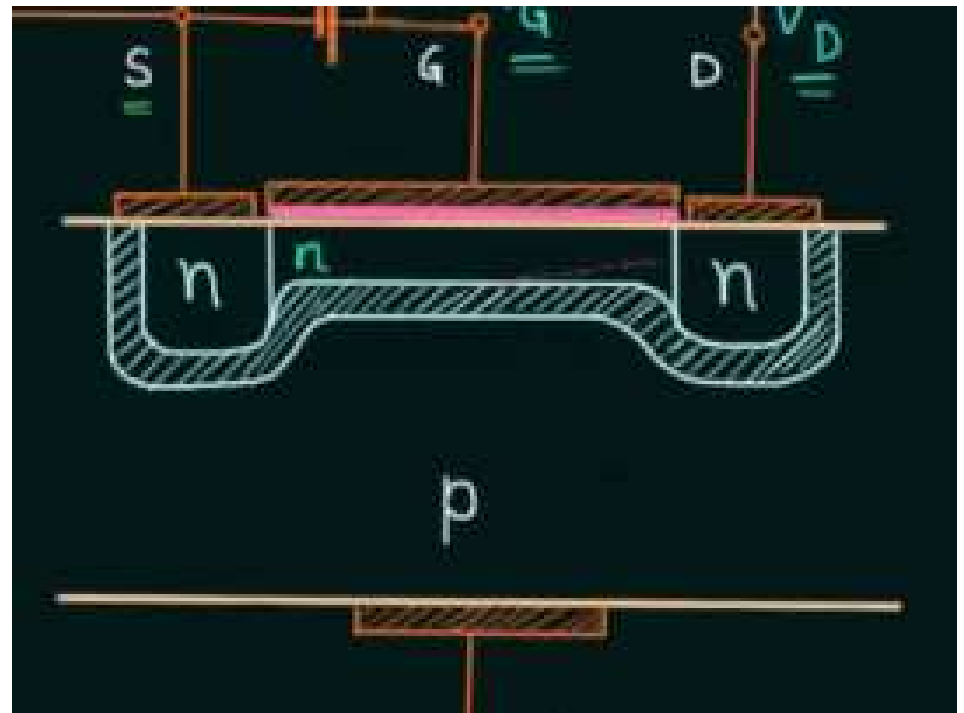
- $I_D = K (V_{GS} - V_{GST})^2$
- $V_{GST}$  – gate-source threshold voltage
- Square-law type relationship
- $K = 0.3 \text{ mA/V}^2$

Case 2:

$$V_{DS} > 0V$$

$$V_{GD} \neq V_{GS}$$

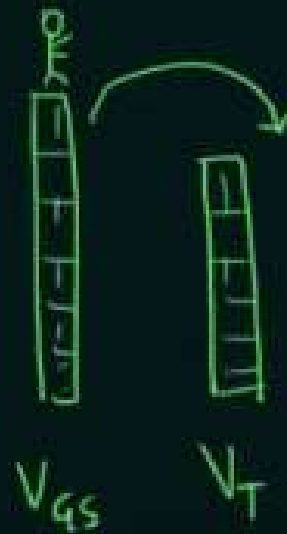
$$D \rightarrow \oplus^{ve}$$



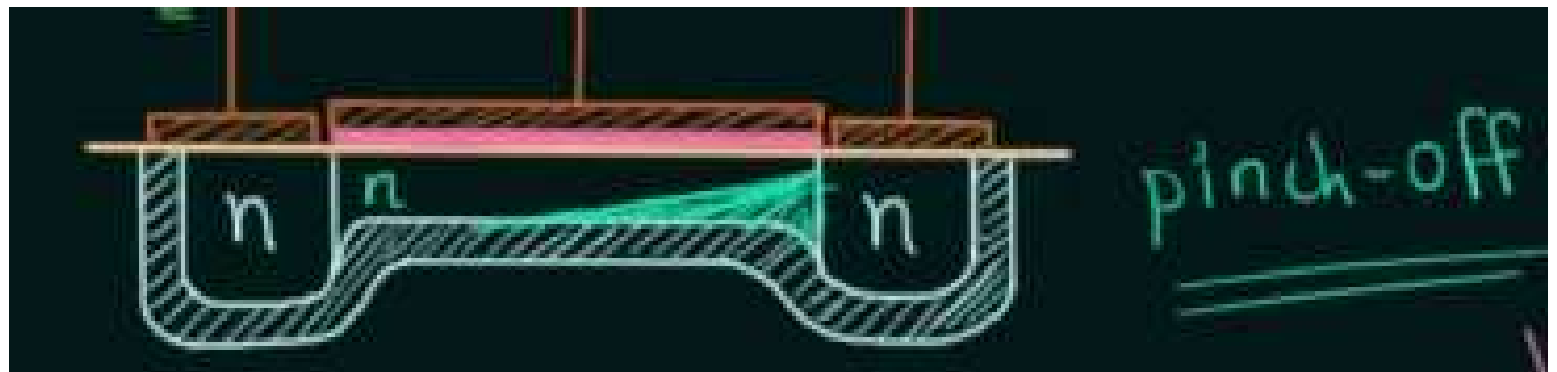
Case 3:

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

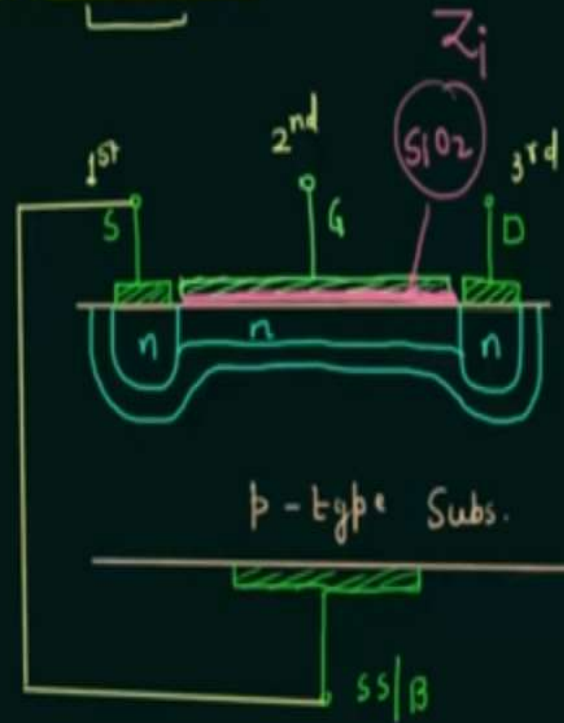
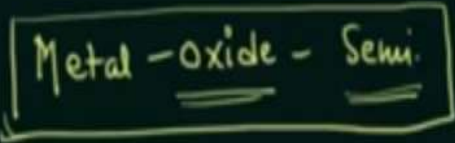
$$V_{GD} = V_T$$



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



## L



### Working of Depletion-Type MOSFET

 $\eta$ -channel

12 n-channel JFET

$$\uparrow V_{DS} \rightarrow I_D \uparrow$$

$$V_{DS} = V_D - V_S$$

$$V_{DS} \uparrow \Rightarrow V_D \uparrow$$

$$I_D \rightarrow \text{const}$$

# Loss

$$V_{GS} = 0V$$

$$I_D \rightarrow I_{DSS} \quad \text{Max.}$$

JFET D-MOSFET

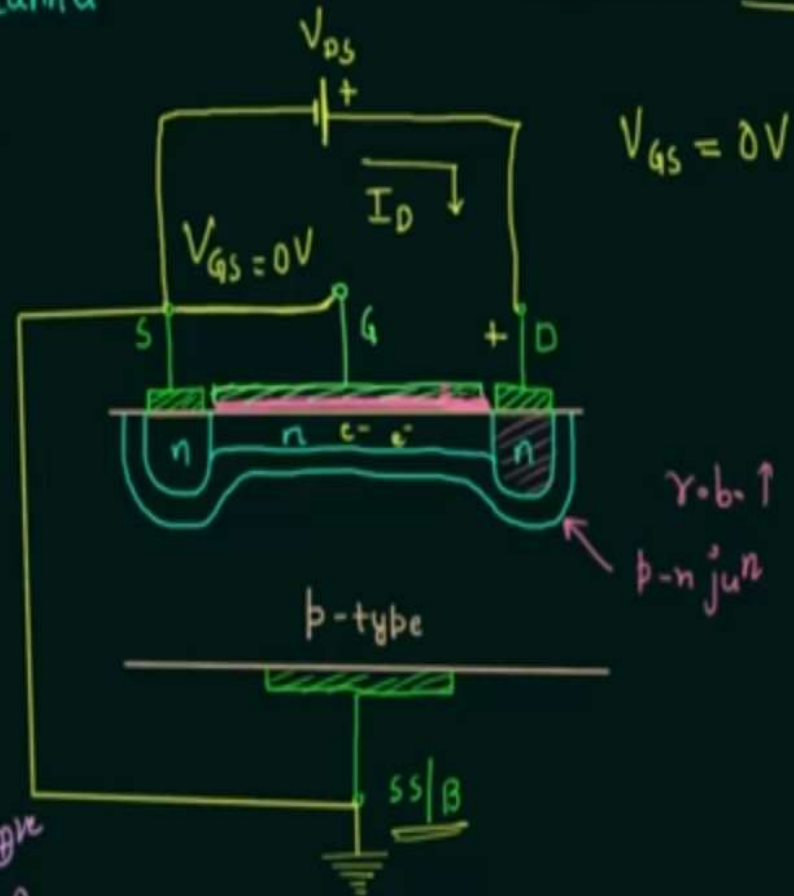
$$I_{\text{loss}} \quad I_{\text{loss}} \times \gamma$$

$$V_{GS} = 0V \quad V_{GS} = 0V$$

$$V_{GS} > 0V_X \quad V_{GS} > 0V_Y$$

$$V_{GS} \leq 0V$$

$$V_{45} \rightarrow \oplus^{ve}$$



$I_D \rightarrow \text{const.}$

$I_{OSS}$

$V_{GS} = 0V$

$V_{DS} = V_{DD}$   $I_{D1}$

C II:  $V_{GS} = -1V$

$V_{DS} = V_{DD}$   $I_{D2}$

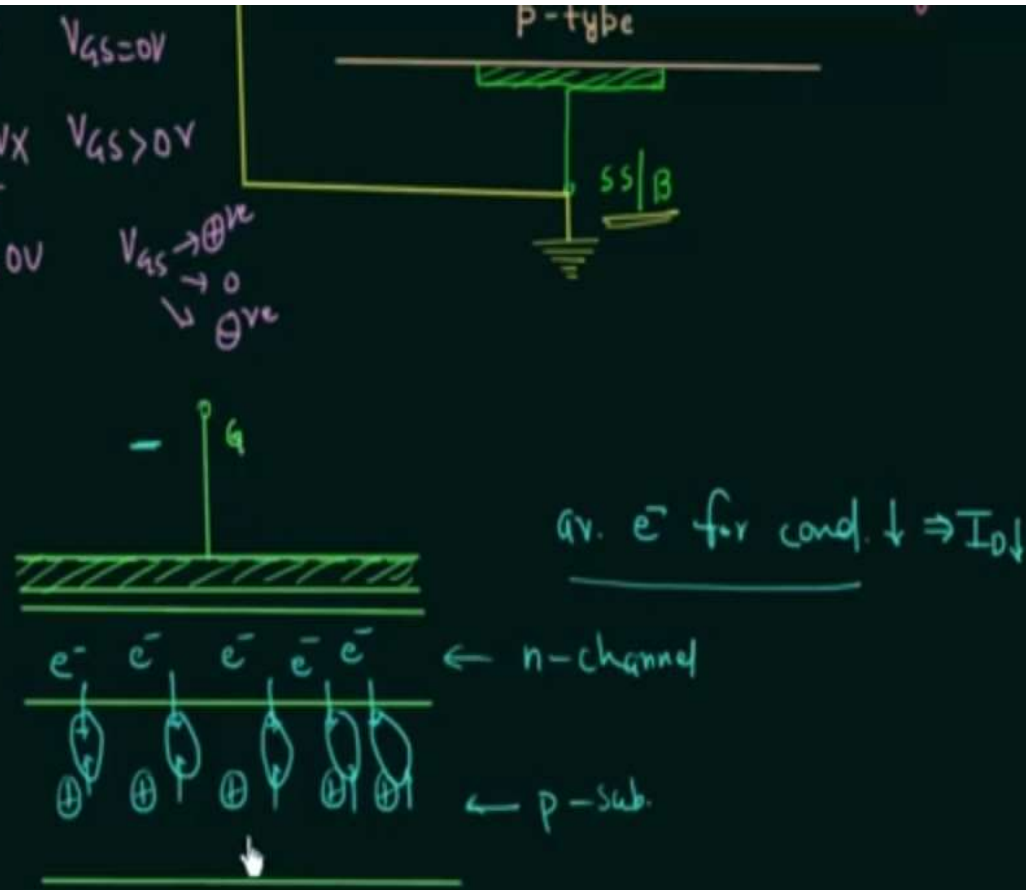
$I_{D1} > I_{D2}$

$V_{GS} = 0V$   $V_{GS} = 0V$

$V_{GS} > 0V$   $V_{GS} > 0V$

$V_{GS} \leq 0V$

$V_{GS} \rightarrow \oplus ve$   
 $\rightarrow 0$   
 $\rightarrow \ominus ve$



av.  $e^-$  for cond.  $\downarrow \Rightarrow I_{D1}$



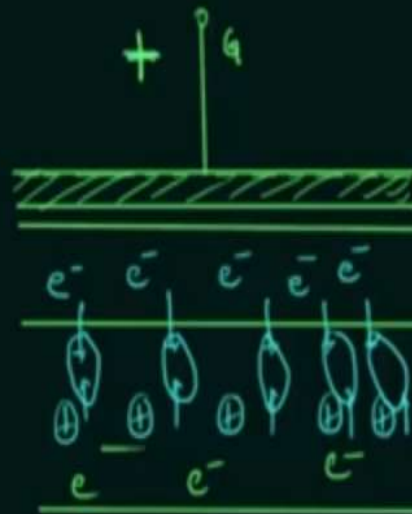
$$\boxed{V_{DS} = V_{DD}} \quad I_{D1}$$

C II:  $V_{GS} = -1V$

$$\underline{\underline{V_{DS} = V_{DD}}}$$

$$I_{D2}$$

$$I_{D1} > I_{D2}$$



av.  $e^-$  for cond.  $\downarrow \Rightarrow I_{D1}$

← n-channel

← p-sub.

C-III:  $V_{GS} = 1V > 0V$

$$I_D \uparrow \underline{\underline{\text{rapidly}}}$$

