

## 2.4 MOSFET (Metal Oxide Semiconductor Field Effect Transistor)

- Like JFET, it has a source, Drain and Gate.
- It is also called IGFET (Insulated Gate FET) because gate terminal is insulated from channel. Therefore it has extremely high input resistance.

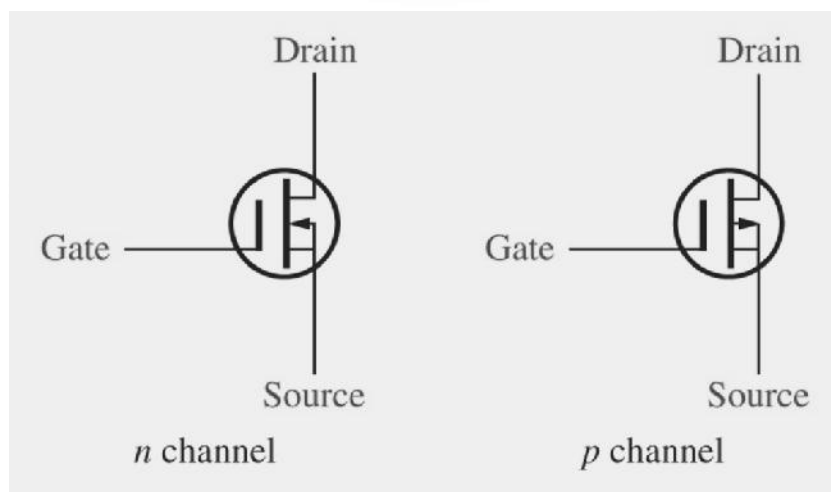
### Types of MOSFET

- Depletion mode MOSFET  
N-channel  
P-channel
- Enhancement mode MOSFET  
N-channel  
P-channel

The enhancement-type MOSFET is usually referred to as an E-MOSFET, and the depletion type, a D-MOSFET. The drain current in a MOSFET is controlled by the gate-source voltage  $V_{GS}$ .

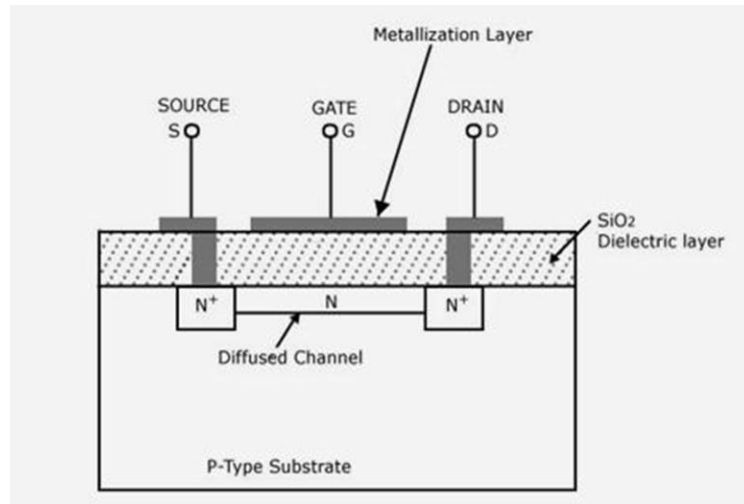
### Depletion mode-MOSFET [D-MOSFET]

In depletion mode of operation the bias voltage on the gate reduce the number of charge carriers in the channel and therefore reduce the drain current  $I_D$ . It operates in both depletion mode and enhancement mode.



**Figure 2.4.1 D-MOSFET symbol for n-channel and p-channel**

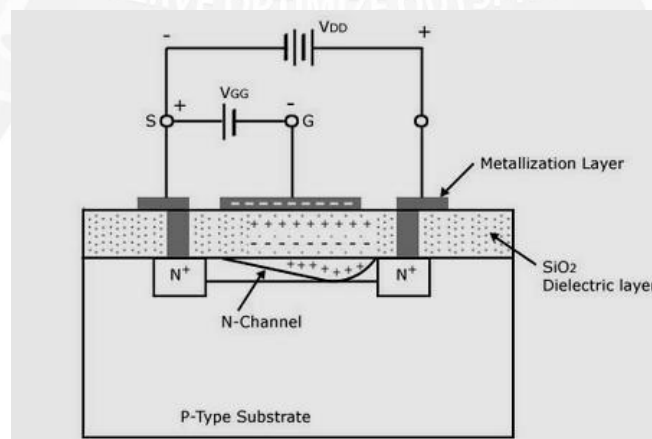
[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 90]



**Figure 2.4.2 D-MOSFET n-channel and p-channel**

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 90]

- It consists of lightly diffused. Doped p-type substrate in which two highly doped n-regions are
- The source and drain terminals are connected through metallic contacts to n-doped regions linked by an n-channel. The gate is also connected to a metal contact surface but remains insulated from the n-channel by a very thin silicon dioxide ( $\text{SiO}_2$ ) layer.  $\text{SiO}_2$  is a particular type of insulator referred to as a dielectric that sets up opposing (as revealed by the prefix di-) electric fields within the dielectric when exposed to an externally applied field.
- Then the thin layer of metal aluminum is formed over the  $\text{SiO}_2$  layer. This metal covers the entire channel region and it forms the gate (G).



**Figure 2.4.3 n-channel D-MOSFET under applied bias**

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 91]

**Case (i) “when and is increased from zero”**

Here N-base (Drain) is connected to positive supply. It act as a reverse bias. Due to this, depletion region gets increases.

Free electron from n-channel are attracted towards positive potential of drain terminal.

This establishes current through channel flows from drain to source and denoted as  $I_{DSS}$ .

**Pinch of voltage**

The pinch off voltage is the voltage at which the junction is depleted of charge carriers.

**Case (ii) “when and is increased from zero”**

- The negative charge on gate repels conduction electrons from the channel and attract holes from the p-type substrate.
- Due to this electron-hole recombination occurs and reduce the number of free electrons in the channel available for conduction, reducing Drain current ( $I_D$ ).
- When negative voltage of is increased the pinch of voltage decreased. When is further increased the channel is fully depleted and no current flows through it.
- The negative voltage depletion MOSFET.

**Characteristics curve**

- Drain characteristics
- Transfer characteristics

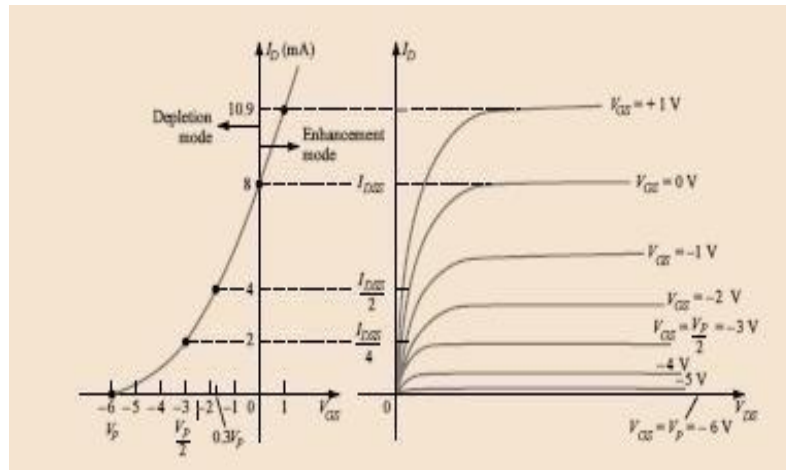
D-MOSFET's are biased to operate in two modes:

Depletion or Enhancement mode.

**ENHANCEMENT- MODE MOSFET [E-MOSFET]**

- In this mode bias on the gate increases the number of charge carriers in the channel and increases the drain current ( $I_D$ ).

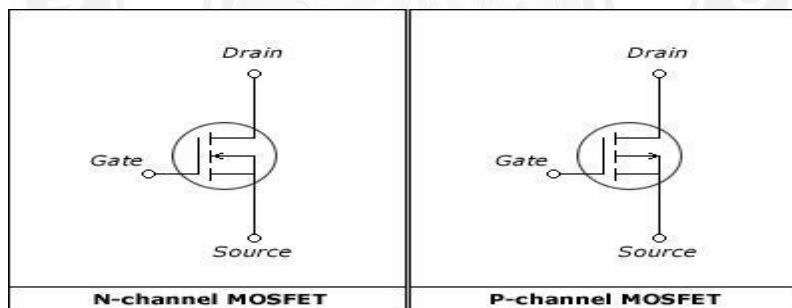
- It operates only in the enhancement mode and has no depletion mode of operation. It has no physical channel



**Figure 2.4.4 Drain and transfer characteristics**

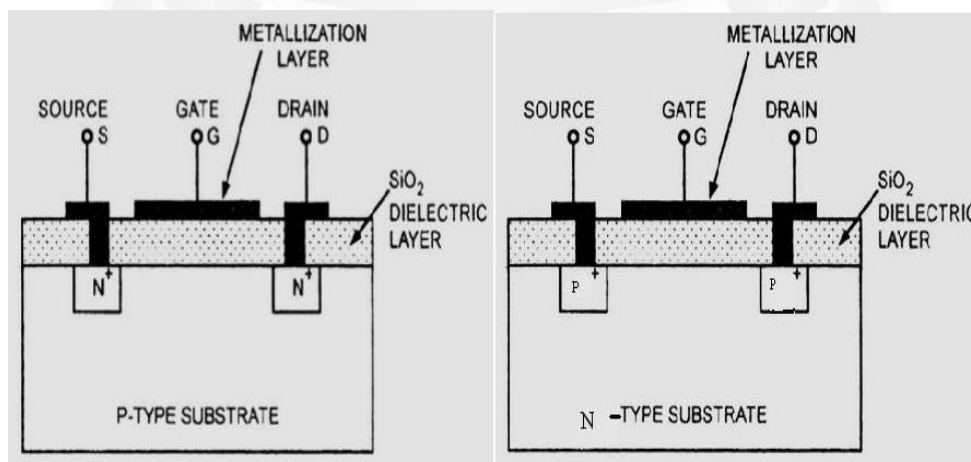
[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 91]

### Symbol of E-MOSFET



**Figure 2.4.5 symbol of n-channel and p-channel E-MOSFET**

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 98]



**Figure 2.4.6 Construction of n-channel and p-channel E-MOSFET**

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 98]

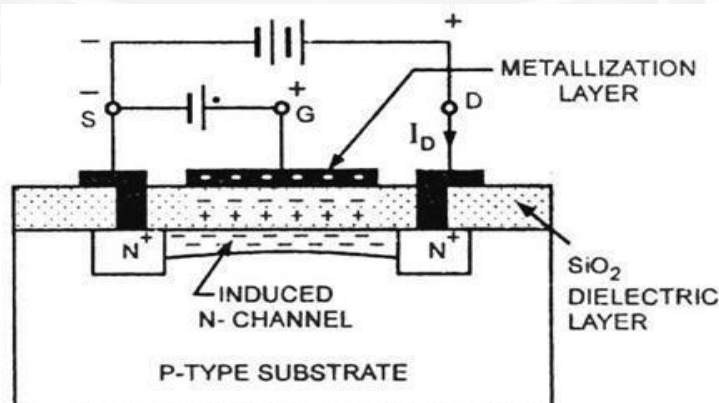
In the basic construction of the n-channel enhancement-type MOSFET, a slab of p-type material is formed from a silicon base and is again referred to as the substrate. As with the depletion-type MOSFET, the substrate is sometimes internally connected to the source terminal, while in other cases a fourth lead is made available for external control of its potential level.

The  $\text{SiO}_2$  layer is still present to isolate the gate metallic platform from the region between the drain and source, but now it is simply separated from a section of the p-type material.

In summary, therefore, the construction of an enhancement-type MOSFET is quite similar to that of the depletion-type MOSFET, except for the absence of a channel between the drain and source terminals.

### Operation

- If  $V_{GS}$  is set at 0 V and a voltage applied between the drain and source of the device, the absence of an n-channel (with its generous number of free carriers) will result in a current of effectively zero amperes—quite different from the depletion-type MOSFET and JFET where  $I_D - I_{DSS}$ .
- It is not sufficient to saturation level as occurred for the JFET and depletion-type MOSFET.
- The conductivity of the channel is enhanced by the positive bias voltage on the gate, the device is known as enhancement MOSFET. E-MOSFET's are normally called as -OFF - MOSFET

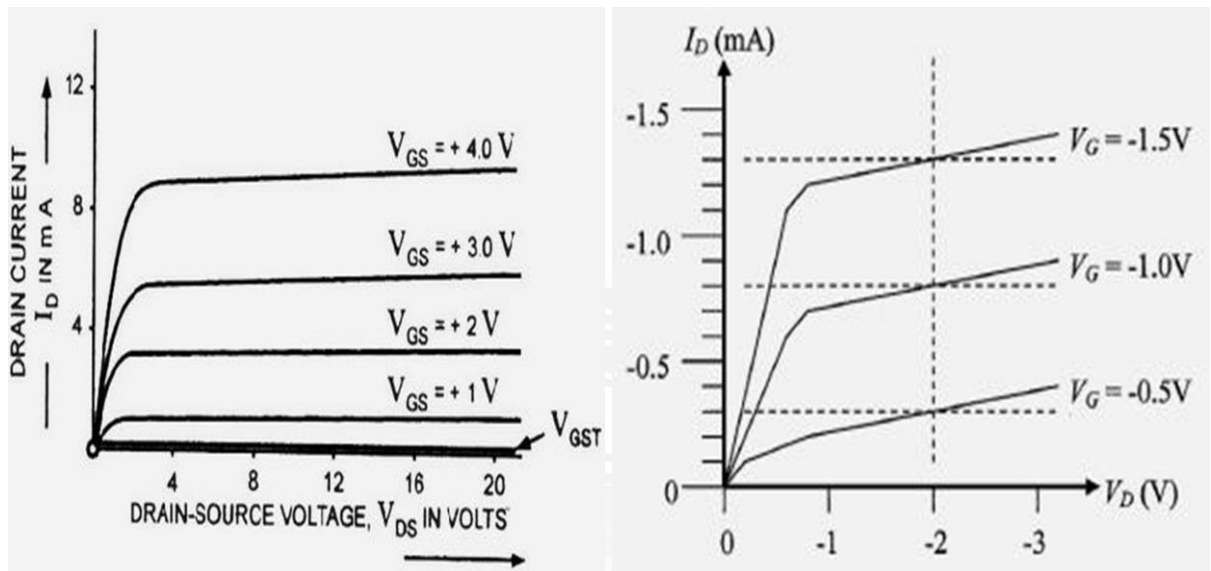


**Figure 2.4.7 N-channel E-MOSFET under applied bias**

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 99]

## Characteristics of E-MOSFET

### Drain characteristics curve



a) N-channel

b) P-channel

**Figure 2.4.8 Drain characteristics curve a) n-channel b) p-channel**

[Source: "Electronic devices and circuits" by "Balbir Kumar, Shail.B.Jain, and Page: 101]