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B.Sc. Part-2 physics (Hons)  
paper-iv, Lecture no-53

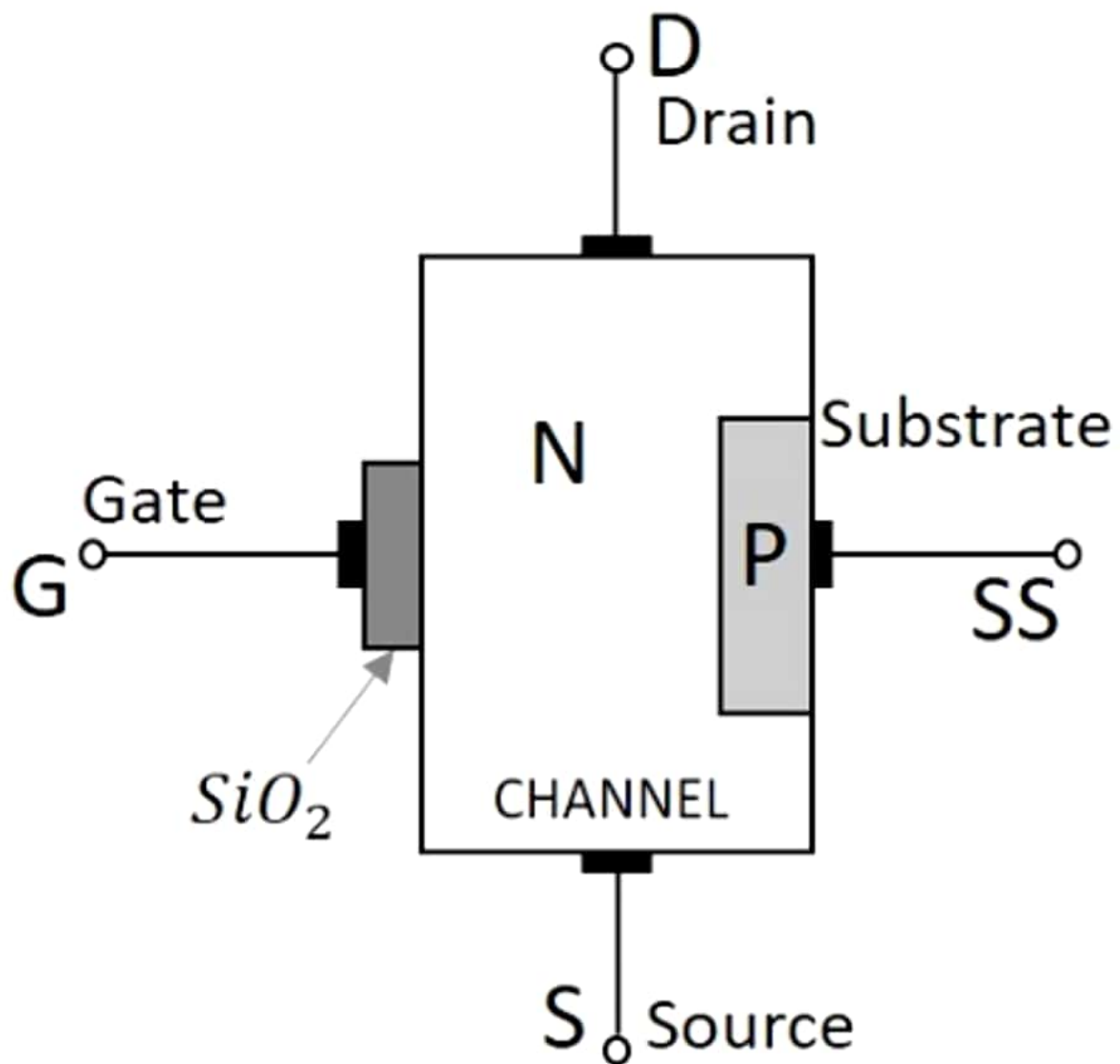
Topic: Metal Oxide Semiconductor  
Field Effect transistor (MOSFET)

MOSFET stands for Metal Oxide Silicon Field Effect Transistor or Metal Oxide Semiconductor Field Effect Transistor. This is also called as IGFET meaning Insulated Gate Field Effect Transistor. The FET is operated in both depletion and enhancement modes of operation. The following figure shows how a practical MOSFET looks like.

# Construction of a MOSFET

The construction of a MOSFET is a bit similar to the FET. An oxide layer is deposited on the substrate to which the gate terminal is connected. This oxide layer acts as an insulator ( $\text{SiO}_2$  insulates from the substrate), and hence the MOSFET has another name as IGFET. In the construction of MOSFET, a lightly doped substrate, is diffused with a heavily doped region. Depending upon the substrate used, they are called as **P-type** and **N-type** MOSFETs.

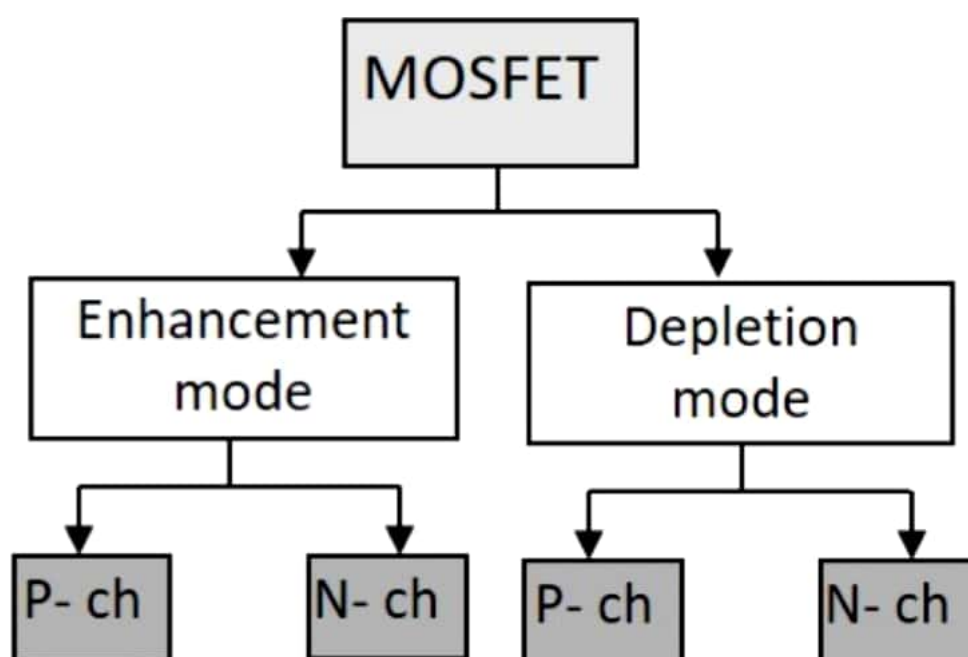
The following figure shows the construction of a MOSFET.



The voltage at gate controls the operation of the MOSFET. In this case, both positive and negative voltages can be applied on the gate as it is insulated from the channel. With negative gate bias voltage, it acts as **depletion MOSFET** while with positive gate bias voltage it acts as an **Enhancement MOSFET**.

## Classification of MOSFETs

Depending upon the type of materials used in the construction, and the type of operation, the MOSFETs are classified as in the following figure.

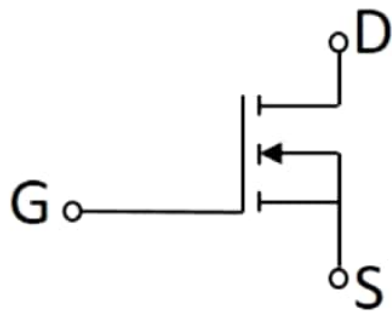


- P- ch = P- channel
- N- ch = N- channel

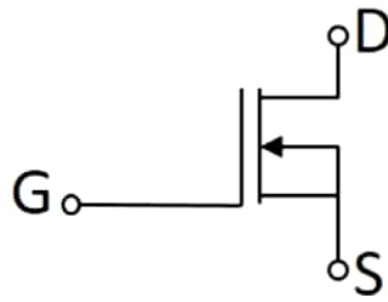
After the classification, let us go through the symbols of MOSFET.

The **N-channel MOSFETs** are simply called as **NMOS**. The symbols for N-channel MOSFET are as given below.

## Symbols of N-Channel MOSFET



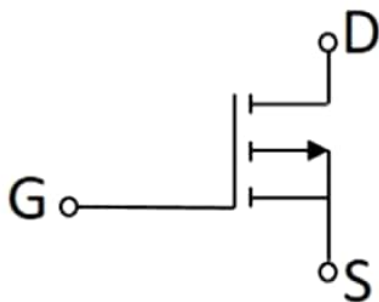
Enhancement Mode



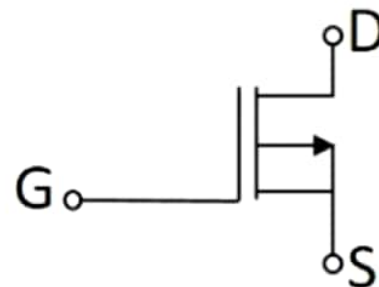
Depletion Mode

The **P-channel MOSFETs** are simply called as **PMOS**. The symbols for P-channel MOSFET are as given below.

## Symbols of P-Channel MOSFET



Enhancement Mode



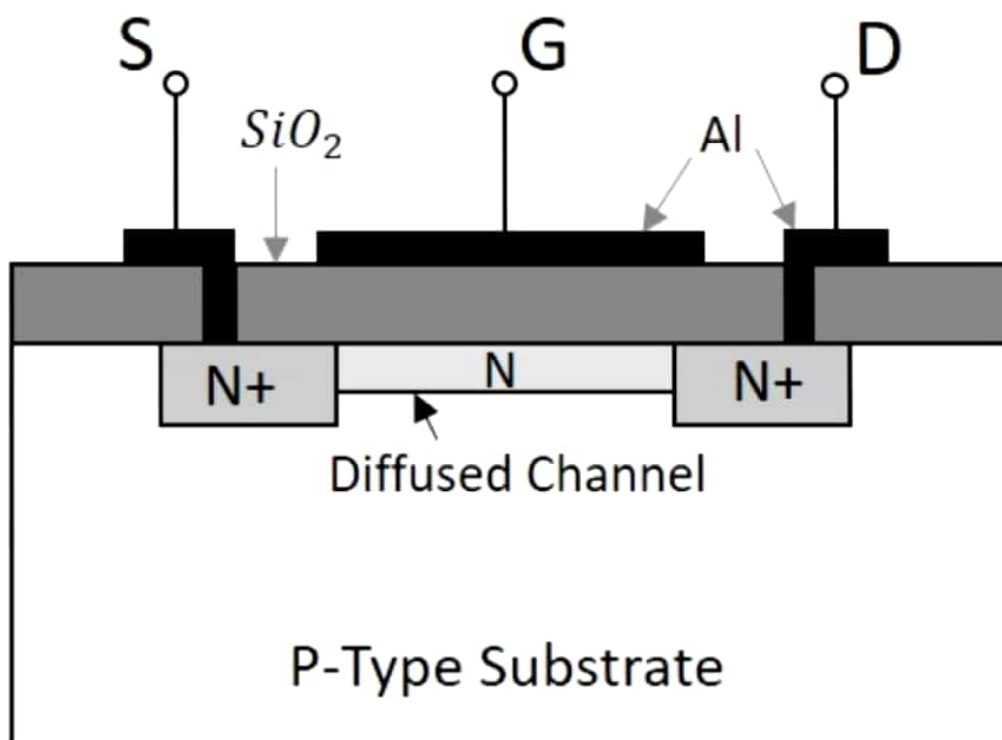
Depletion Mode

Now, let us go through the constructional details of an N-channel MOSFET. Usually an NChannel MOSFET is considered for explanation as this one is mostly used. Also, there is no need to mention that the study of one type explains the other too.



# Construction of N- Channel MOSFET

Let us consider an N-channel MOSFET to understand its working. A lightly doped P-type substrate is taken into which two heavily doped N-type regions are diffused, which act as source and drain. Between these two N+ regions, there occurs diffusion to form an Nchannel, connecting drain and source.



## Structure of N-channel MOSFET

A thin layer of **Silicon dioxide ( $SiO_2$ )** is grown over the entire surface and holes are made to draw ohmic contacts for drain and source terminals. A conducting

layer of **aluminum** is laid over the entire channel, upon this **SiO<sub>2</sub>** layer from source to drain which constitutes the gate. The **SiO<sub>2</sub> substrate** is connected to the common or ground terminals.

Because of its construction, the MOSFET has a very less chip area than BJT, which is 5% of the occupancy when compared to bipolar junction transistor. This device can be operated in modes. They are depletion and enhancement modes.