3.2 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.

Symbol of MOSFET

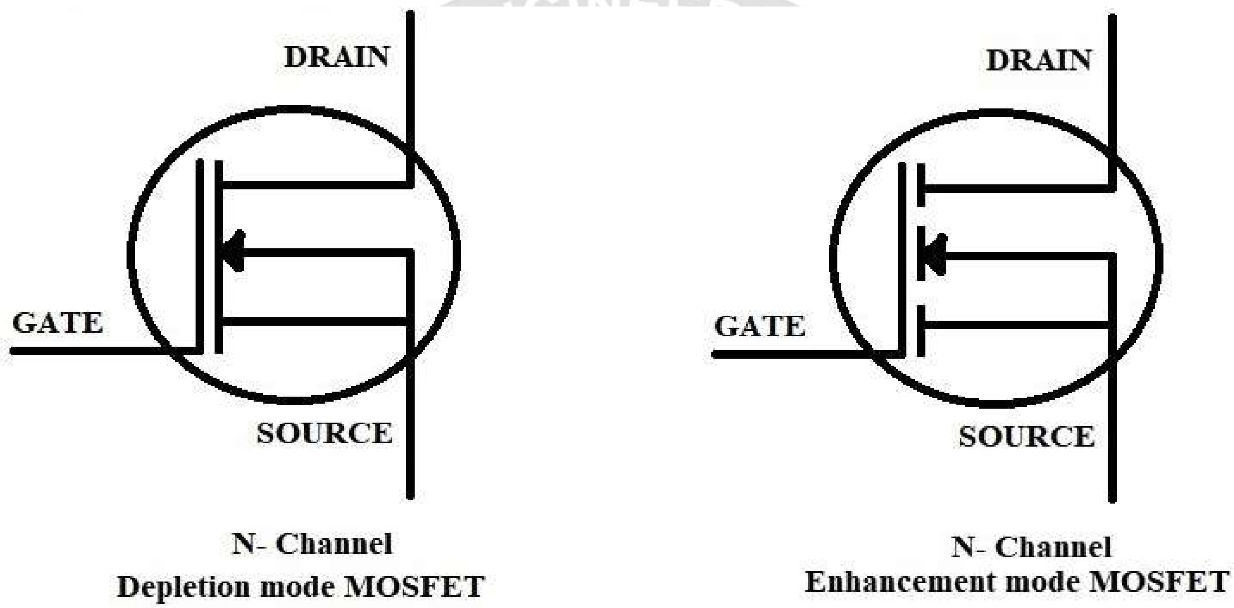

Fig:3.2.1 Symbol of N-Channel Depletion MOSFET and Enhancement MOSFET

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

Construction of N- Channel MOSFET

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.

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_2 layer from source to drain which constitutes the gate. The SiO_2 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.

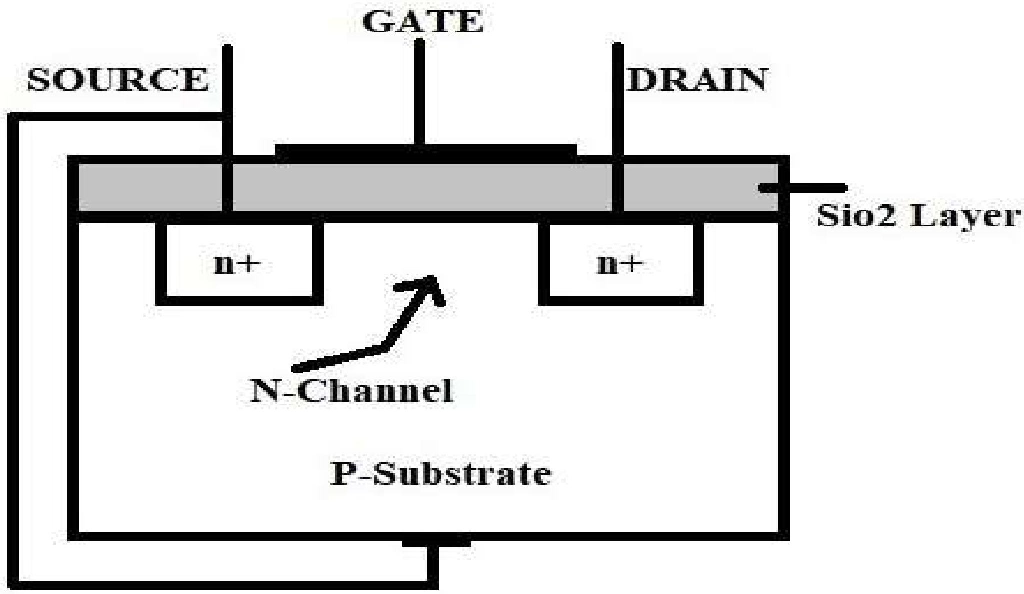

Fig:3.2.2 Construction of N-Channel MOSFET

Working of N-Channel MOSFET Enhancement Mode

The same MOSFET can be worked in enhancement mode, if we can change the polarities of the voltage VGG. So, let us consider the MOSFET with gate source voltage VGG being positive.

When no voltage is applied between gate and source, some current flows due to the voltage between drain and source. Let some positive voltage is applied at VGG. Then the minority carriers i.e. holes, get repelled and the majority carriers i.e. electrons gets attracted towards the SiO2 layer.

With some amount of positive potential at VGG a certain amount of drain current ID flows through source to drain. When this positive potential is further increased, the current ID increases due to the flow of electrons from source and these are pushed further due to the voltage applied at VGG. Hence the more positive the applied VGG, the more the value of drain current ID will be. The current flow gets enhanced due to the increase in electron flow better than in depletion mode. Hence this mode is termed as Enhanced Mode MOSFET.

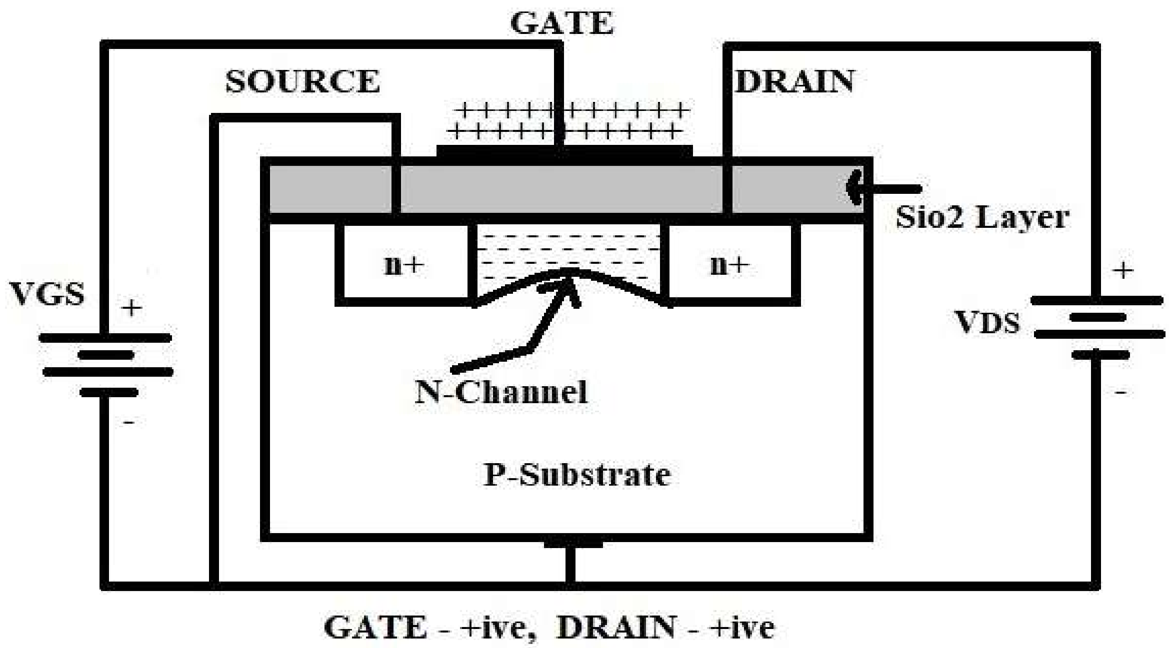

Fig:3.2.3 Working of N - Channel Enhancement mode MOSFET

Working of N - Channel depletion mode MOSFET

There is no PN junction present between gate and channel in this, unlike a FET. The diffused channel N between two N+ regions, the insulating dielectric SiO2 and the aluminum metal layer of the gate together form a parallel plate capacitor.

If the NMOS has to be worked in depletion mode, the gate terminal should be at negative potential while drain is at positive potential, as shown in the following figure.

When no voltage is applied between gate and source, some current flows due to the voltage between drain and source. Let some negative voltage is applied at VGG. Then the minority carriers i.e. holes, get attracted and settle near SiO2 layer. But the majority carriers, i.e., electrons get repelled.

With some amount of negative potential at VGG a certain amount of drain current ID flows through source to drain. When this negative potential is further increased, the electrons get depleted and the current ID decreases.

Hence the more negative the applied VGG, the lesser the value of drain current ID will be the channel nearer to drain gets more depleted than at source like in FET and the current flow decreases due to this effect. Hence it is called as depletion mode MOSFET.

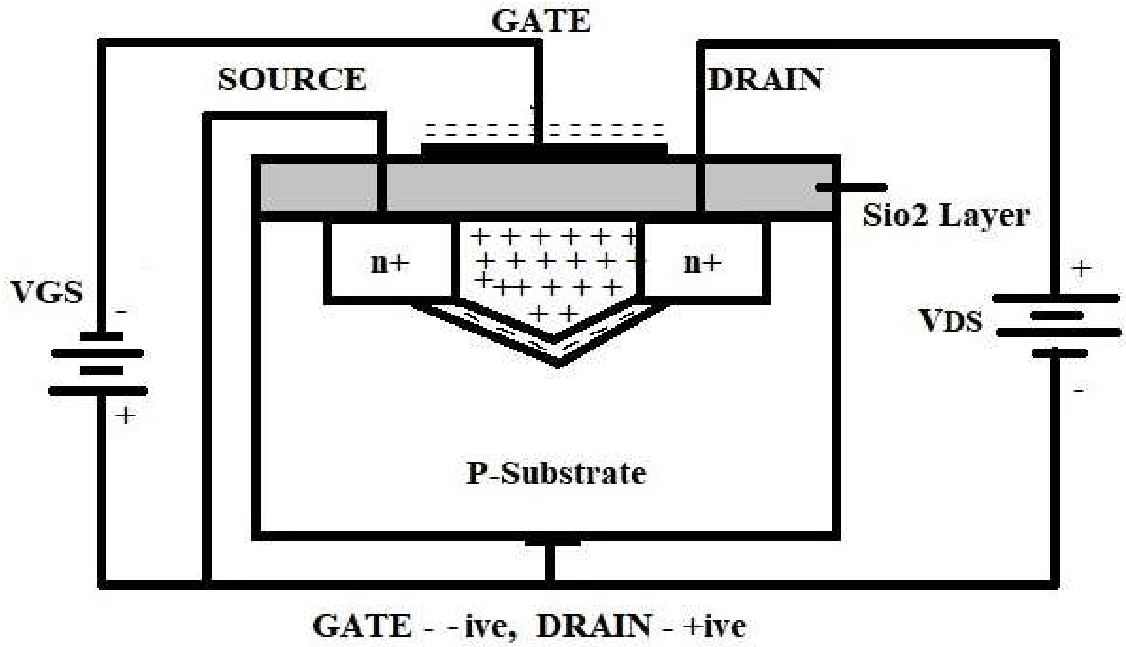

Fig:3.2.4 Working of N - Channel Depletion mode MOSFET

Drain Characteristics

The drain characteristics of a MOSFET are drawn between the drain current ID and the drain source voltage VDS. The characteristic curve is as shown below for different values of inputs.

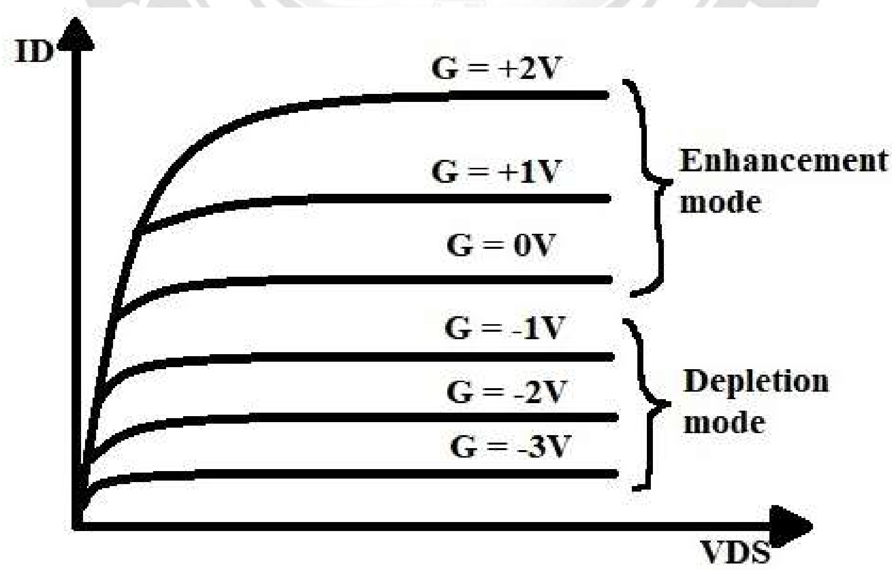

Fig:3.2.5 Drain Characteristics of N - Channel Depletion mode and Enhancement mode MOSFET

Actually when VDS is increased, the drain current ID should increase, but due to the applied VGS, the drain current is controlled at certain level. Hence the gate current controls the output drain current.

Transfer Characteristics

Transfer characteristics define the change in the value of VDS with the change in ID and VGS in both depletion and enhancement modes. The below transfer characteristic curve is drawn for drain current versus gate to source voltage.

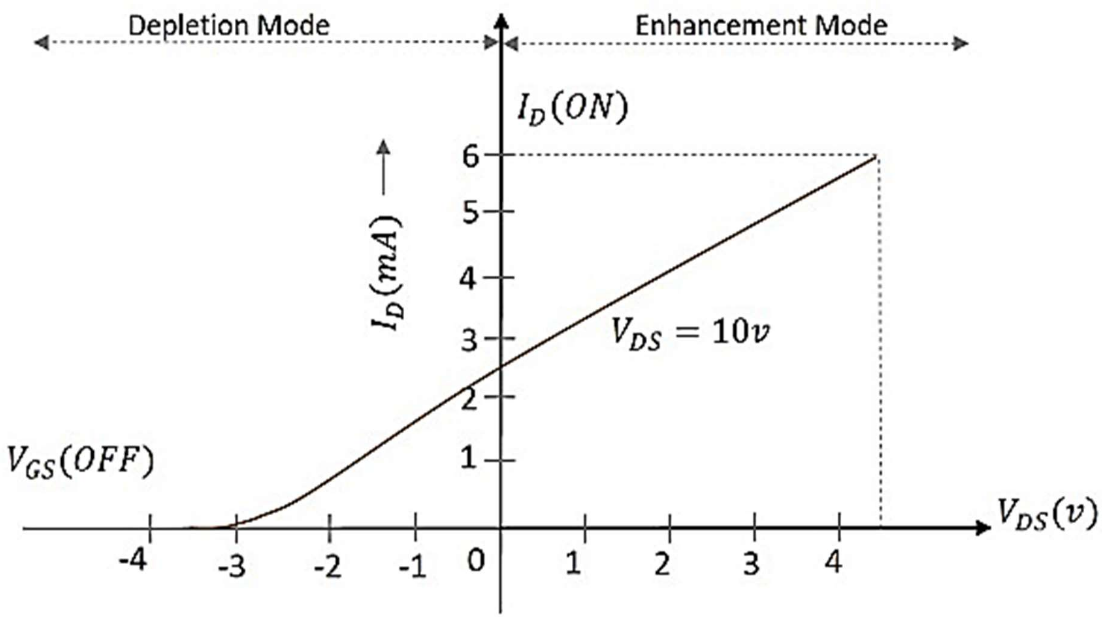

Fig:3.2.6 Transfer Characteristics of N - Channel Depletion mode and Enhancement mode MOSFET

Applications

- Amplifiers made of MOSFET are extremely employed in extensive frequency applications
- The regulation for DC motors are provided by these devices
- As because these have enhanced switching speeds, it acts as perfect for the construction of chopper amplifiers
- Functions as a passive component for various electronic elements.