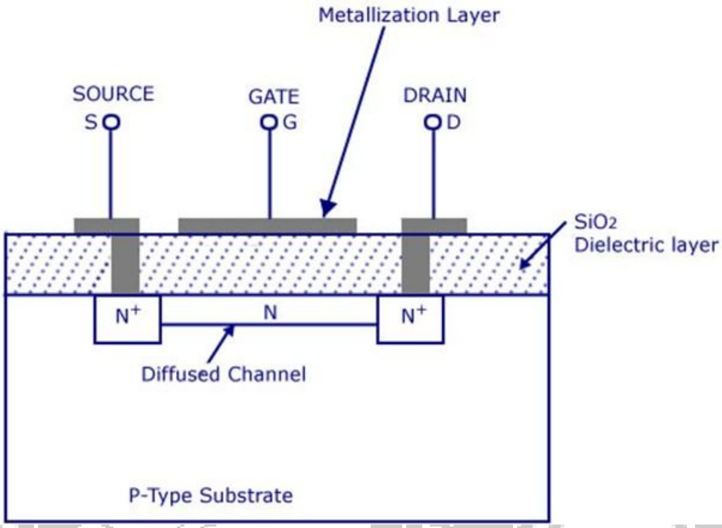
4.5 MOSFET



Construction of a MOSFET.

Figure shows the construction of an N-channel depletion MOSFET. It consists of a highly doped P-type substrate into which two blocks of heavily doped N-type material are diffused forming the source and drain. An N-channel is formed by diffusion between the source and drain. The type of impurity for the channel is the same as for the source and drain. Now a thin layer of SiO_2 dielectric is grown over the entire surface and holes are cut through the SiO_2 (silicon-dioxide) layer to make contact with the N-type blocks (Source and Drain). Metal is deposited through the holes to provide drain and source terminals, and on the surface area between drain and source, a metal plate isdeposited. This layer constitutes the gate. $Si0_2$ layer results in an extremely high input impedance of the order of 10^{10} to 10^{15} Q for this area.

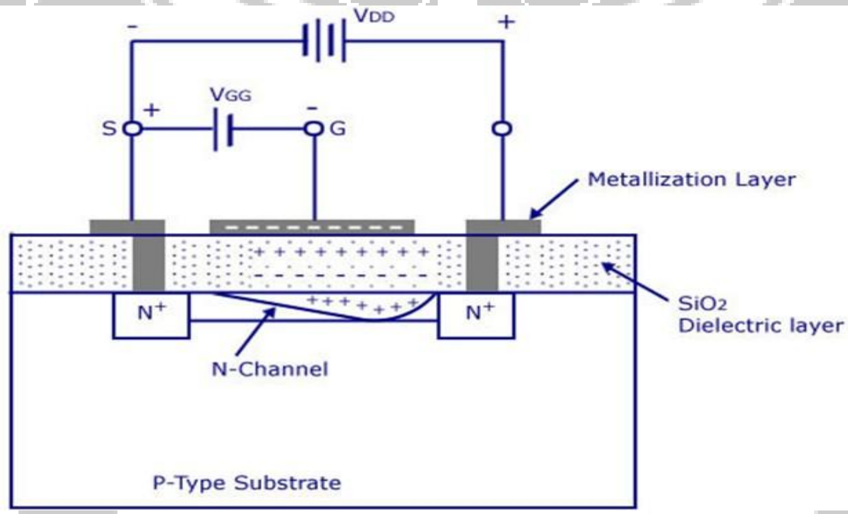
The chip area of a MOSFET is typically 0.003 um^2 or less which is about only 5%of the area required by a BJT. A P-channel DE-MOSFET is constructed like an N-channel DE-MOSFET, starting with an N-type substrate and diffusing P-type drain and

Operation of MOSFET.

DE-MOSFET can be operated with either a positive or a negative gate. When gate is positive with respect to the source it operates in the enhancement—or E-mode and when the gate is negative with respect to the source, as illustrated in figure, it operates in depletion-mode.

When the drain is made positive with respect to source, a drain current will flow, even with zero gate potential and the MOSFET is said to be operating in E-mode. In this mode of operation gate attracts the negative charge carriers from the P-substrate to the N-channel and thus reduces the channel resistance and increases the drain-current. The more positive the gate is made, the more drain current flows.

On the other hand when the gate is made negative with respect to the substrate, the gate repels some of the negative charge carriers out of the N-channel. This creates a depletion region in the channel, as illustrated in figure, and, therefore, increases the channel resistance and reduces the drain current. The more negative the gate, the less the drain current. In this mode of operation the device is referred to as a depletion-mode

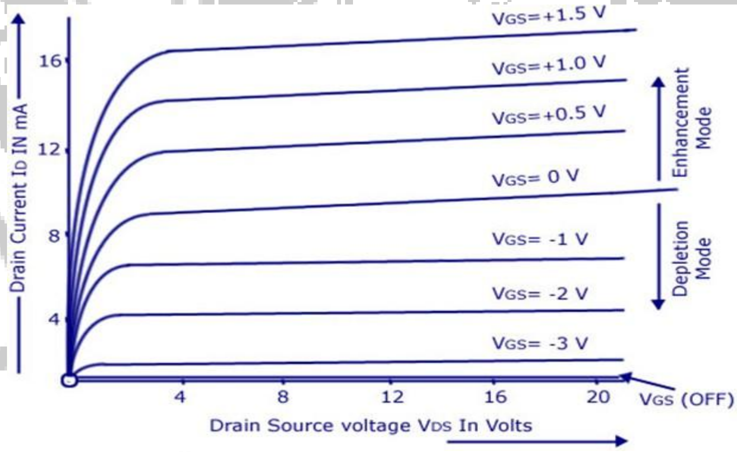


Characteristics of MOSFET

Transfer characteristics

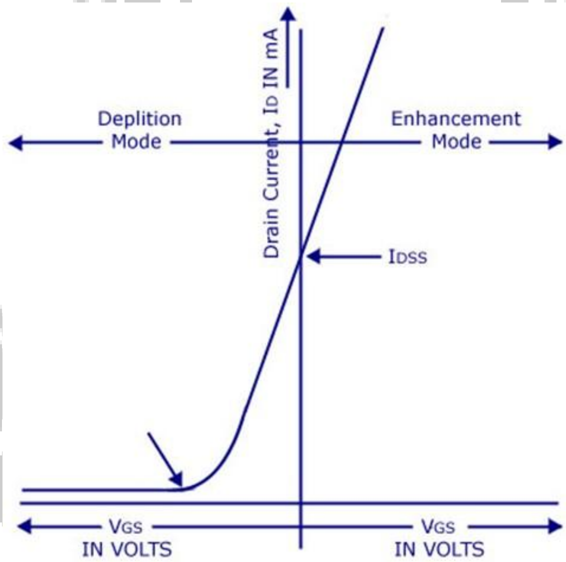
The transfer (or transconductance) characteristic for an N-channel DE-MOSFET is shown in figure. I_{DSS} is the drain current with a shorted gate. Since the curve extends to the right of the origin, I_{DSS} is no longer the maximum possible drain current.

Mathematically, the curve is still part of a parabola and the same square-law relation exists as with a JFET. In fact, the depletion-mode MOSFET has a drain current given by the same transconductance equation as before, equation . Furthermore, it has the same equivalent circuits as a JFET. Because of this, the analysis of a depletion-mode MOSFET circuit is almost identical to that of a JFET circuit. The only difference is the analysis for a positive gate, but even here the same basic formulas are used to determine the drain current I_D, gate- source voltage V_{GS} etc.



Drain characteristics

Typical *drain characteristics,* for various levels of gate-source voltage, of an N- channel MOSFET are shown in figure. The upper curves are for positive V_{GS} and the lower curves are for negative V_{GS}. The bottom drain curve is for V_{GS} = V_{GS}(OFF). For a specified drain-source voltage V_{DS}, V_{GS} (OFF) is the gate-source voltage at which drain current reduces to a certain specified negligibly small value, as shown in figure. This voltage corresponds to the pinch-off voltage V_p of JFET. For V_{GS} between $V_{GS\ (0FF)}$ and zero, the device operates in *depletion-mode* while for V_{GS} exceeding zero the device operates in *enhancement mode.* These drain curves again display an ohmic region, a constant-current source region and a cut-off region. MOSFET has two major applications: a constant current source and a voltage variable resistor.



Symbols for MOSFET