RAMA UNIVERSITY

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FACULTY OF ENGINEERING AND TECHNOLOGY

MEC-022

Lecture -01

BASIC ELECTRICAL PROPERTIES OF MOS CIRCUITS

INTRODUCTION OF MOSFET

The rapid strides of the semiconductor industry in recent years are due to its ability to incorporate more and more devices operating at higher and higher speeds in an IC. Metal Oxide Field Effect Transistor (MOSFET) circuits occupy less silicon area and consume less power than their bipolar counterparts (BJT) making them ideal choice for VLSI circuits. The MOSFET was the subject of a patent in 1933, but did not reach commercial maturity until about thirty years later. The delay was principally due to a lack of understanding of the importance of the oxide/semiconductor interface, and to the time taken to develop suitable fabrication procedures, notably for the growth of the thin gate oxide.

• MOSFET's are made from crystalline semiconductor that forms the host structure called the substrate or bulk of the device. Substrate for nMOS is p-type silicon whereas for the pMOS devices it is n-type silicon.

• The thin oxide of the transistor electrically isolates the gate from the semiconductor underneath. The gate oxide is made of oxidized silicon forming non-crystalline, amorphous SiO2. The gate oxide thickness is typically from near 15 Å to 100 Å.

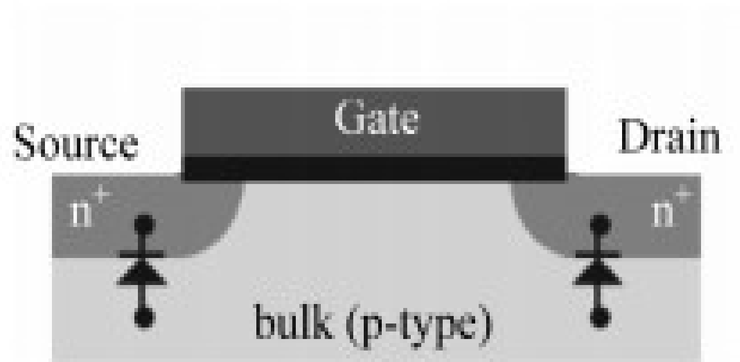
• Drain and source regions are made from crystalline silicon by implanting a dopant with opposite polarity to that of the substrate. In pMOS, boran impurities are doped and in nMOS phosphorous impurities are doped. The gate is fabricated using polysilicon or metal. Since drain and drain dopants are made of opposite polarity to the substrate (bulk) they form pn junction diodes that are reverse biased in normal operation of the device.

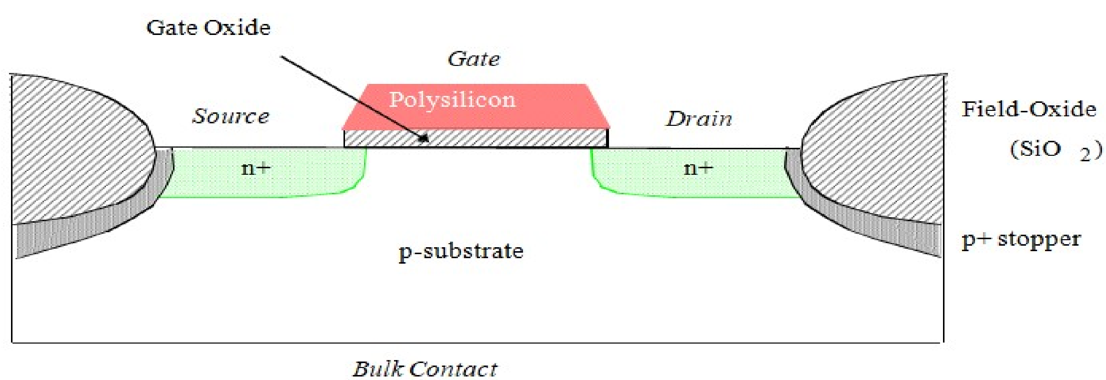
• The gate is the control terminal and the source provides the electrons (nMOS) or holes (pMOS) that are collected by the drain.

• The distance from drain to source is a geometrical parameter called channel length (L) where the conduction takes place. Another geometrical parameter of the device is transistor channel width (W). These two parameters are set by the circuit engineer.

• Other parameters such as oxide thickness, thresho voltage and doping levels depend on the fabrication proce and cannot be changed by the design. They are technolo parameters.

• Complementary Metal Oxide Semiconductor (CMOS) logic circuits have both nMOS and pMOS devices

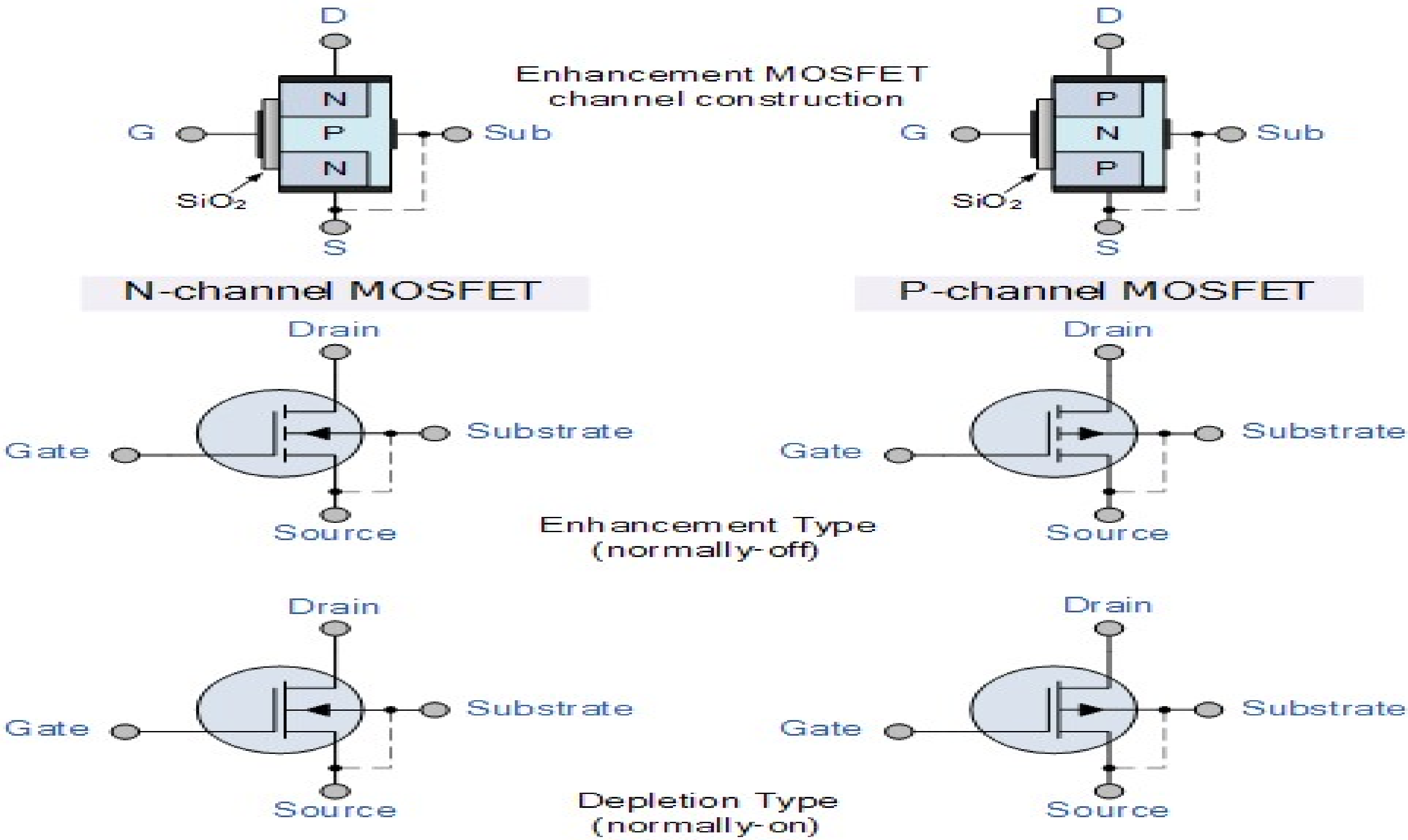




TWO TYPE OF MOSFET

DEPLETION TYPE – the transistor requires the Gate-Source voltage, (V_{GS}) to switch the device "OFF". The depletion mode MOSFET is equivalent to a "Normally Closed" switch.

ENHANCEMENT TYPE – the transistor requires a Gate-Source voltage, (V_{GS}) to switch the device "ON". The enhancement mode MOSFET is equivalent to a "Normally Open" switch.

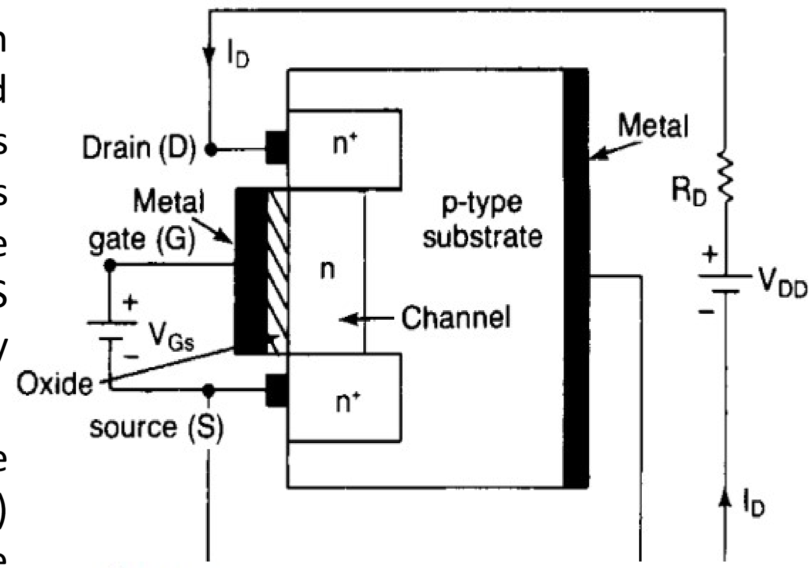


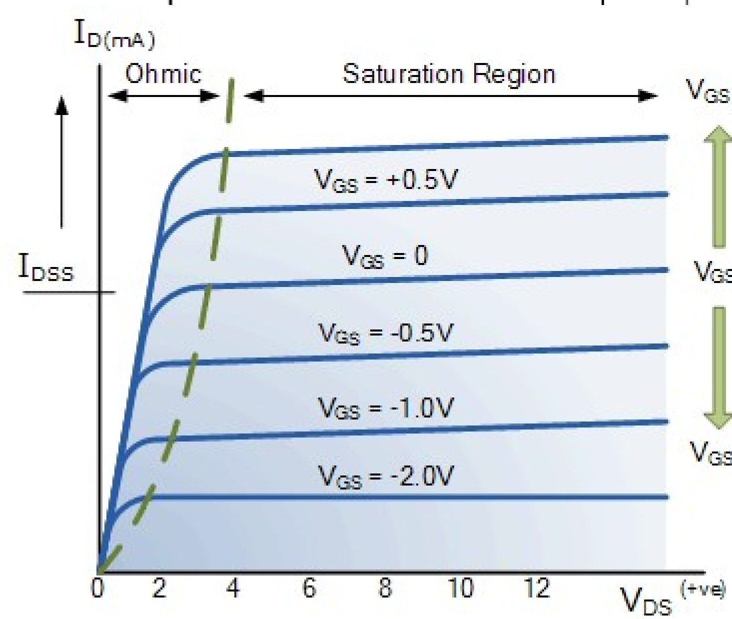
Depletion-mode MOSFET

The **Depletion-mode MOSFET**, which is less common than the enhancement mode types is normally switched "ON" (conducting) without the application of a gate bias voltage. That is the channel conducts when $V_{GS} = 0$ making it a "normally-closed" device. The circuit symbol shown above for a depletion MOS transistor uses a solid channel line to signify a normally closed conductive channel.

For the n-channel depletion MOS transistor, a negative gate-source voltage, $-V_{GS}$ will deplete (hence its name) the conductive channel of its free electrons switching the transistor "OFF". Likewise for a p-channel depletion MOS transistor a positive gate-source voltage, $+V_{GS}$ will deplete the channel of its free holes turning it "OFF".

In other words, for an n-channel depletion mode MOSFET: $+V_{GS}$ means more electrons and more current. While a $-V_{GS}$ means less electrons and less current. The opposite is also true for the p-channel types. Then the depletion mode MOSFET is equivalent to a "normally-closed" switch.






Thank You!