

## 4.11 The Depletion-Type MOSFET

**Reading Assignment:** *pp. 346-351*

An alternative to the enhancement MOSFET (both NMOS and PMOS) is the **depletion** MOSFET.

Enhancement and depletion MOSFETs are the **same** in every way **except**:

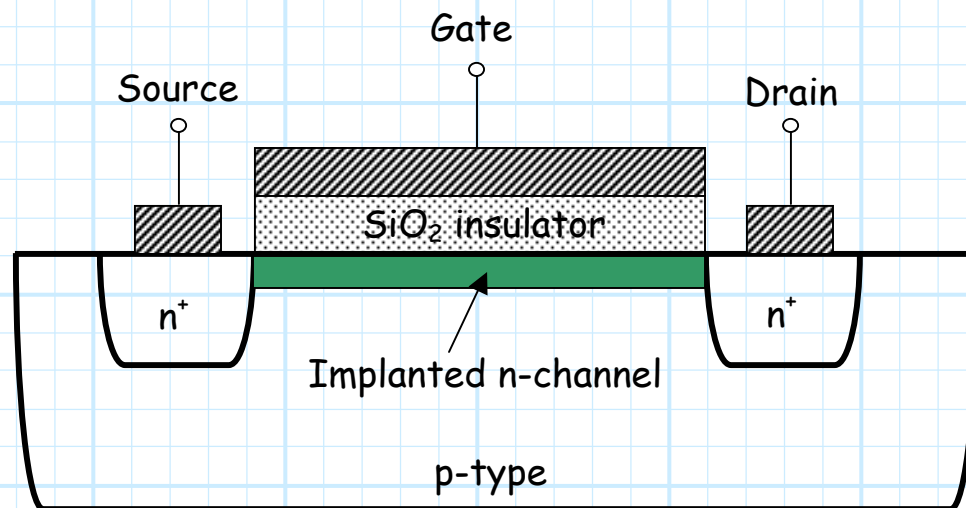
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**HO: The Depletion NMOS Transistor**

# The Depletion MOSFET

The physical construction of a **depletion MOSFET** is identical to the **enhancement MOSFET**, with one exception:

**The conduction channel is physically implanted (rather than induced)**



Thus, for a **depletion NMOS** transistor, the channel conducts **even if  $v_{GS}=0$ !**

\* If the value of  $v_{GS}$  is **positive**, the channel is **further enhanced**. That is, more free electrons are attracted to the channel, and its **conductivity increases**.

\* If the value of  $v_{GS}$  is **negative**, free electrons are **repelled** from the channel! The conductivity of the channel is thus **decreased**. We call this phenomenon **channel depletion**.

- \* If the value of  $v_{GS}$  becomes sufficiently negative, **all** of the free electrons in the channel will be **repelled**—the channel is said to be **completely depleted**!
- \* A channel that is completely depleted **cannot conduct**. In other words, the depletion MOSFET is in **cutoff**!
- \* Thus, the **negative** value of  $v_{GS}$  at which the channel is completely depleted is the **threshold voltage**  $V_t$  for a **depletion NMOS device**.

In other words, to have a **conducting** channel, the gate-to-source voltage  $v_{GS}$  must be greater than the threshold voltage  $V_t$ :

$$v_{GS} > V_t$$

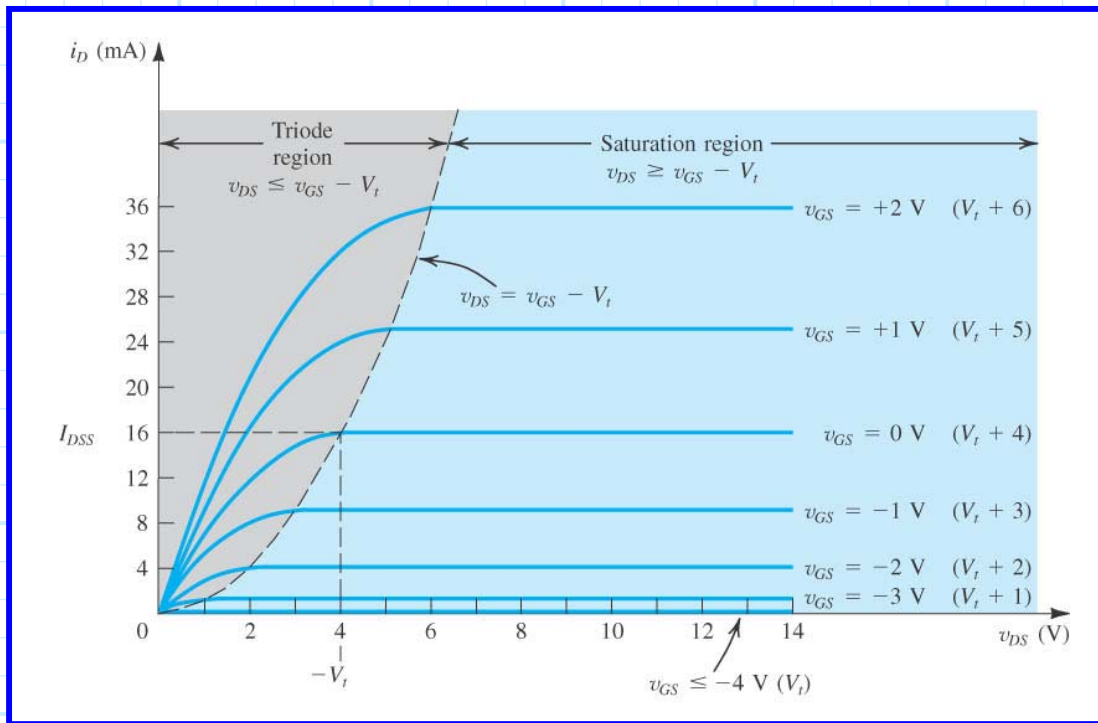
**Just like the enhancement NMOS device!**

Moreover, this means that to have a **conducting** channel, the **excess gate voltage** must be positive:

$$v_{GS} - V_t > 0$$

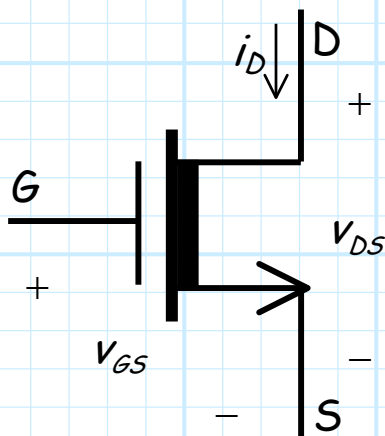
**Just like the enhancement NMOS device!**

We find then that an enhancement MOSFET and a depletion MOSFET are **precisely** identical in **nearly** every way (e.g., same **modes**, same **equations**, same **terminal names**).

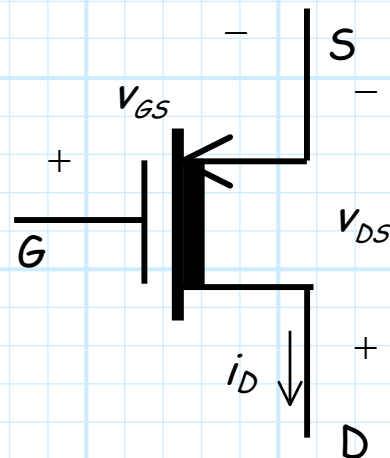


There are just **two** differences to remember:

1. The **threshold voltage** for a depletion **NMOS** device is **negative** (i.e.,  $V_t < 0$ ). While the threshold voltage for a depletion **PMOS** device is **positive** (i.e.,  $V_t > 0$ ).
2. The **depletion MOSFET** has a slightly different **circuit symbol**.



Depletion NMOS



Depletion PMOS