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**:

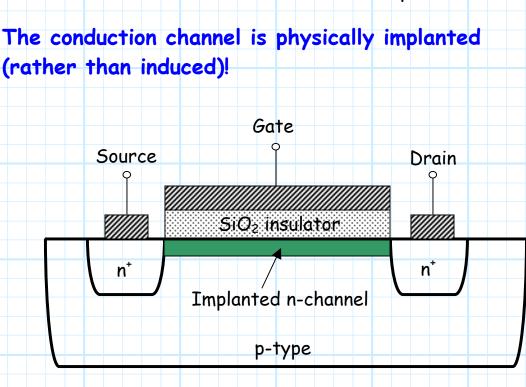
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HO: The Depletion NMOS Transistor

The Depletion MOSFET

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



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-tosource voltage v_{GS} must be greater than the threshold voltage $V_{\vec{r}}$

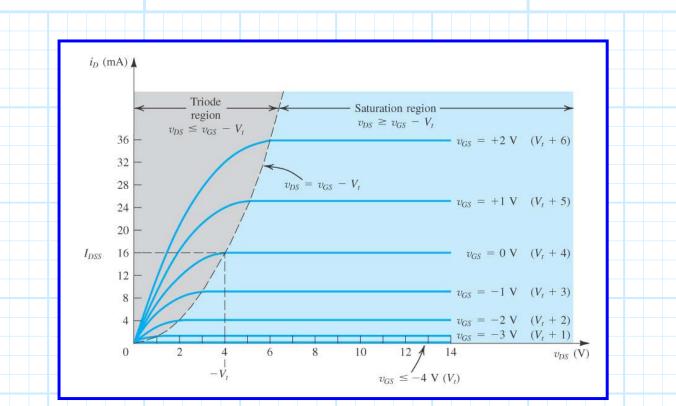
$$V_{GS} > V_t$$

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!

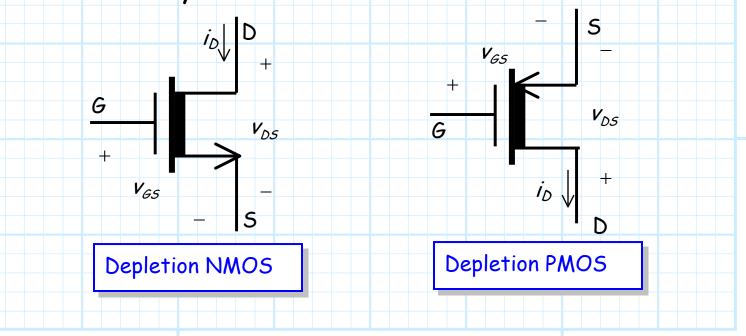
We find then that an enhancement MOSFET and a depletion MOSFET are **precisely** identical in **nearly** every way (e.g., same **modes**, same **equations**, same **terminal** names).



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**.



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