ENG2210
Electronic Circuits
Chapter 4 MOSFET

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Disclaimer: Most of the slides are skeletons that will be filled/modified in the lecture. Please do not assume that you can know the material just by reading the slides.

Chapter Objectives

- Learn the physical structure of the MOSFET and how it works.
- How to analyze circuits that contains MOSFET.
- How to obtain linear amplification from a nonlinear MOSFET.
- The three basic ways for connecting a MOSFET to construct amplifiers.
- Practical circuits for MOSFET.

MOSFET– Metal Oxide Semiconductor Field Effect Transistor

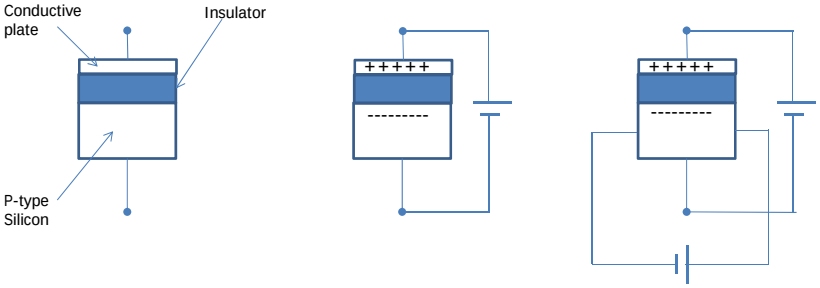
- Transistors (3 terminal devices) diodes are 2 terminal devices – more complicated.
- One terminal usually control the current between the other two terminals.
- Used in digital and analog circuits
- Mainly MOSFET and BJT (vast majority of IC's are MOSFET)
  - Smaller
  - Loss power than BJT – very important –

MOSFET

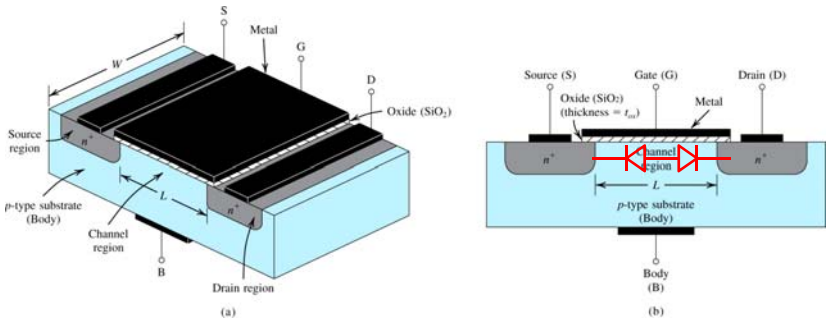
- This is not a course on semiconductor (nor this is a physics course). However, understanding how the device work is very important.

MOSFET

Not a real device, just to explain the idea

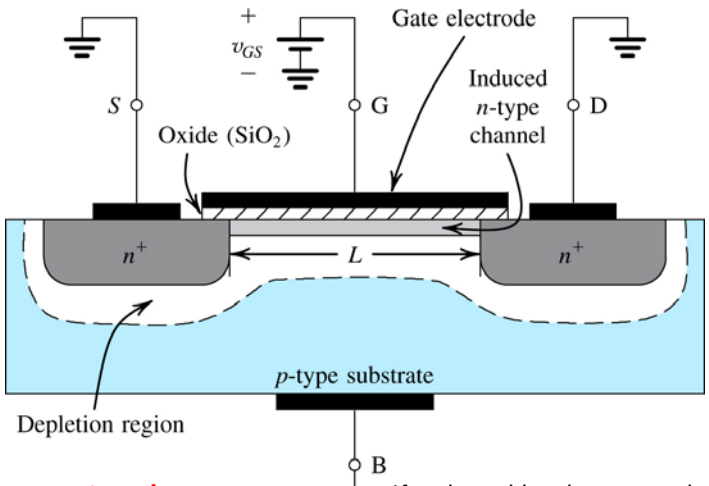


Gate is isolated (SiO2) no current from gate



No current can flow between source and drain

Usually body contact is connected to the source



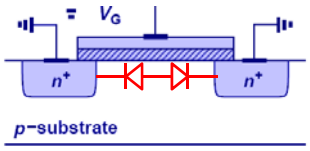
Enhancement mode (normally off) and we have to enhance it to be ON

If v_{gs} is positive, it attracts electrons from the substrate to the part of the substrate next to the SiO2 creating a channel

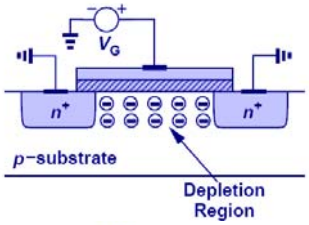
MOSFET Operation

- We start by explaining how things work, then we use mathematics to derive equations.
- Start with n-MOS

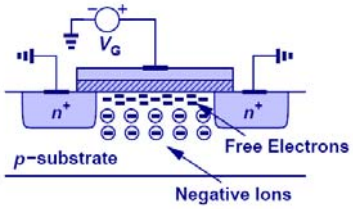
V_G=0, because of the back-to-back diodes, no current flows from source to destination



V_G>0, Holes are repelled by the positive gate voltage and leaving behind negative ions forming a depletion region



As V_G increases (Threshold voltage), Electrons are attracted to the surface forming a channel where current **might** flow



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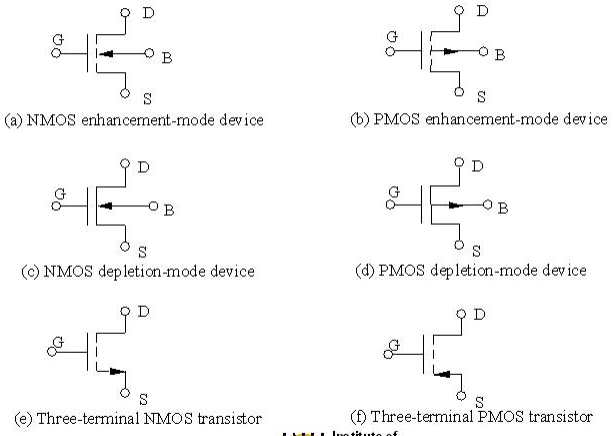
IEEE Standard MOS Transistor Circuit Symbols



Transistors

MES Institute of Microelectronic Systems

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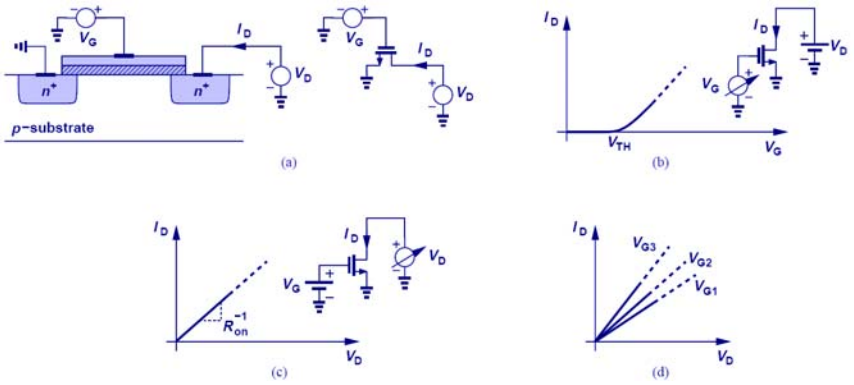
Source: http://people.seas.harvard.edu/~jones/es154/

NMOS Characteristics



- We can vary V_G and keeping V_D constant
- Or vary V_D and keeping V_G constant

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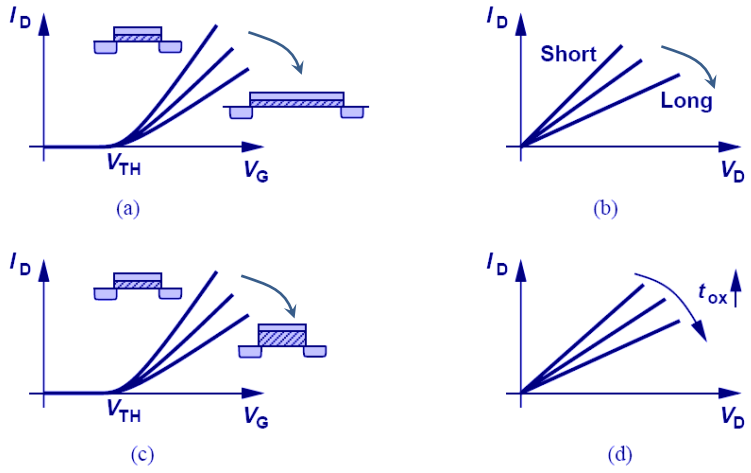
Effect of *L* and t_{ox}



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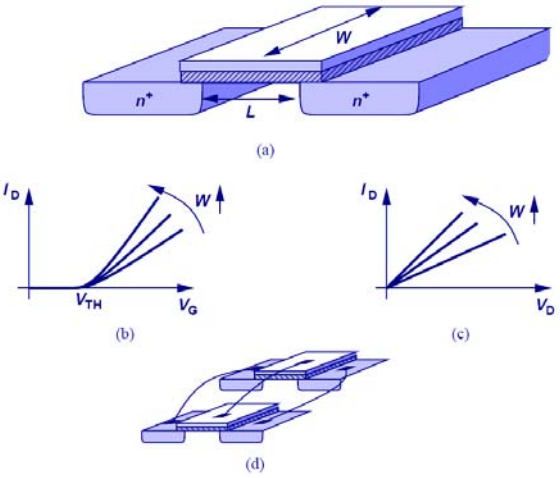
Effect of *W*



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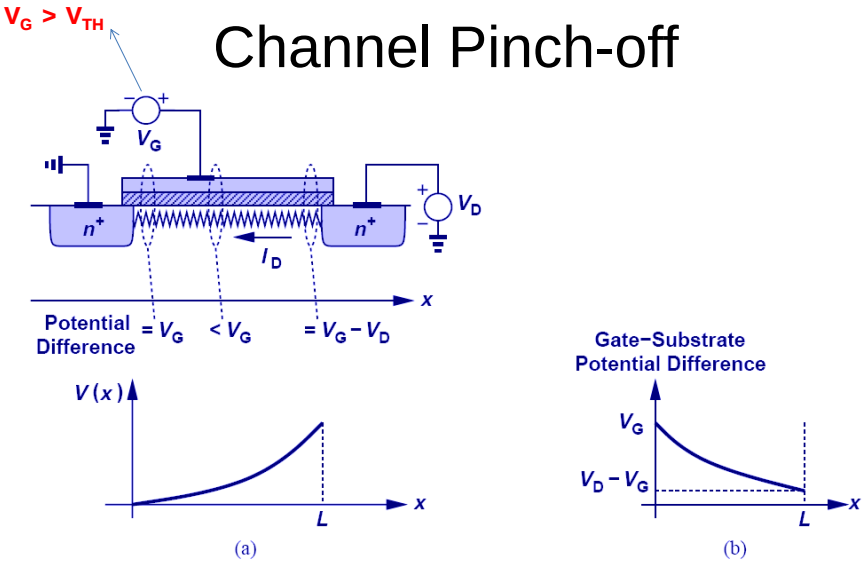
Channel Pinch-off



The channel acts as a resistance, voltage increases from S (*V=0*) to D (*V=V_D*)

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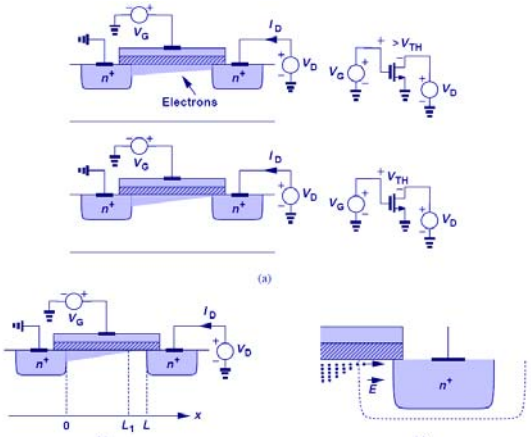
Channel Pinch-Off



- As V_D increases, at some distance x, $V_G - V_D < V_{TH}$ and the channel does not exist anymore.
- Does that mean No current? No, The high electric field in the depletion region carry them through, but V_D does not control the current anymore (constant current source)