Fundumantal of Electronic I

Second Class

Chapter01: Semiconductor Diodes

Lec01_p2

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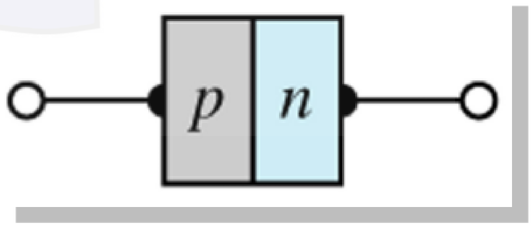
p-n Junctions

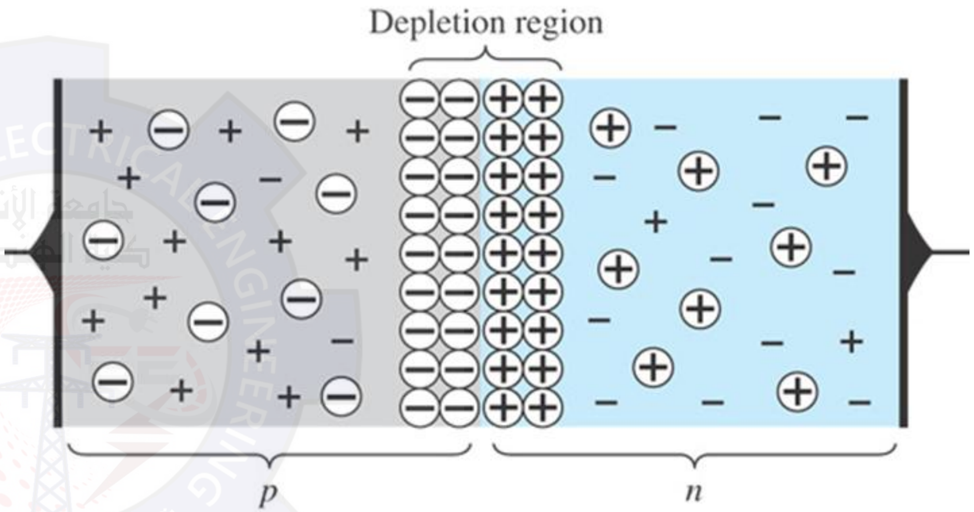
One end of a silicon or germanium crystal can be doped as a *p*-type material and the other end as an *n*-type material.

The result is a *p-n* junction.



p-n Junctions

At the *p-n* junction, the excess conduction-band electrons on the *n*-type side are attracted to the valence-band holes on the *p*-type side.



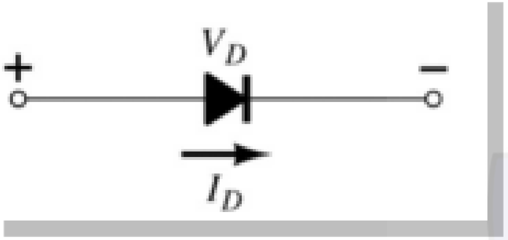
The electrons in the *n*-type material migrate across the junction to the *p*-type material (electron flow).

The electron migration results in a negative charge on the p-type side of the junction and a positive charge on the n-type side of the junction.

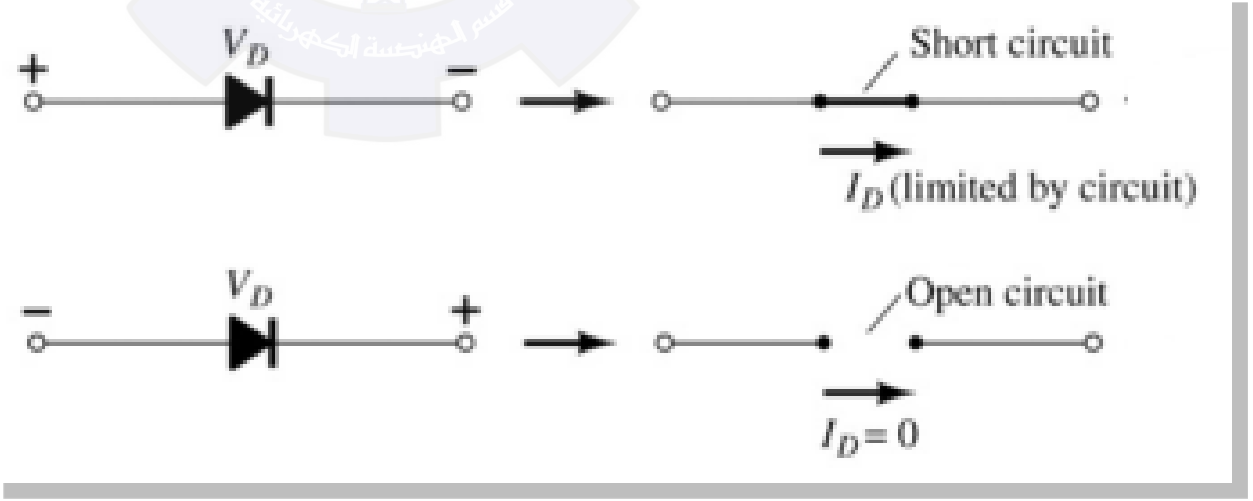
The result is the formation of a depletion region around the junction.

Diodes

The diode is a 2-terminal device.

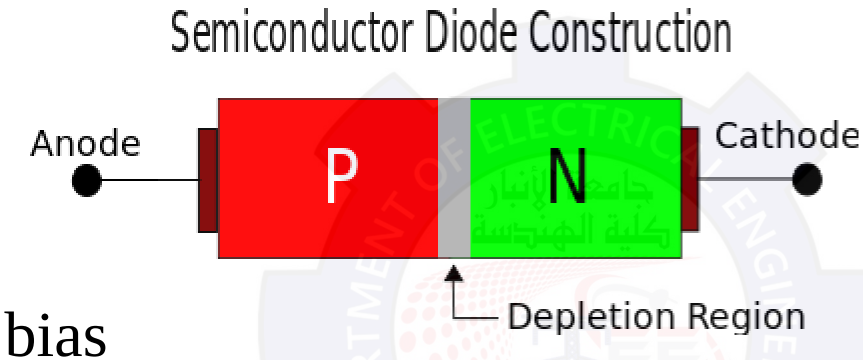


A diode ideally conducts in only one direction.

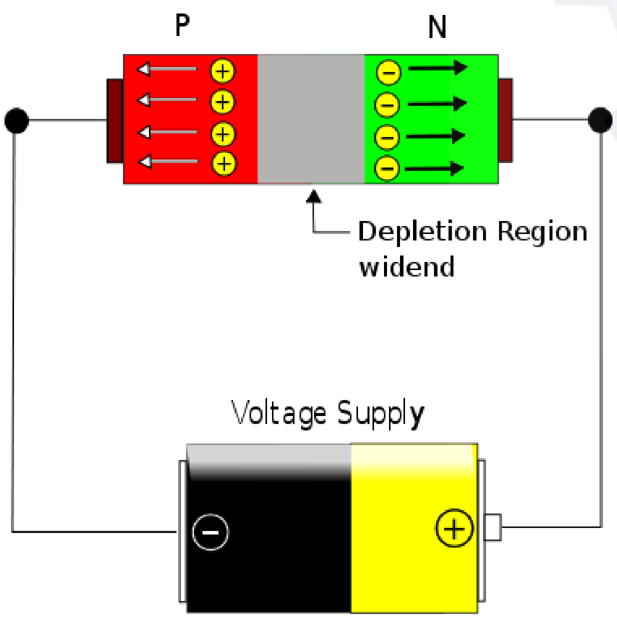


Diode Operating Conditions

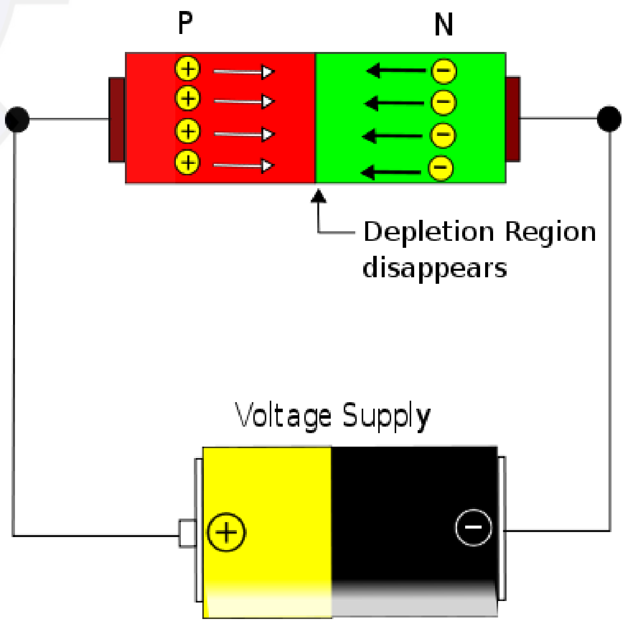
- **No bias**
- **Forward bias**
- **Reverse bias**



Reverse bias

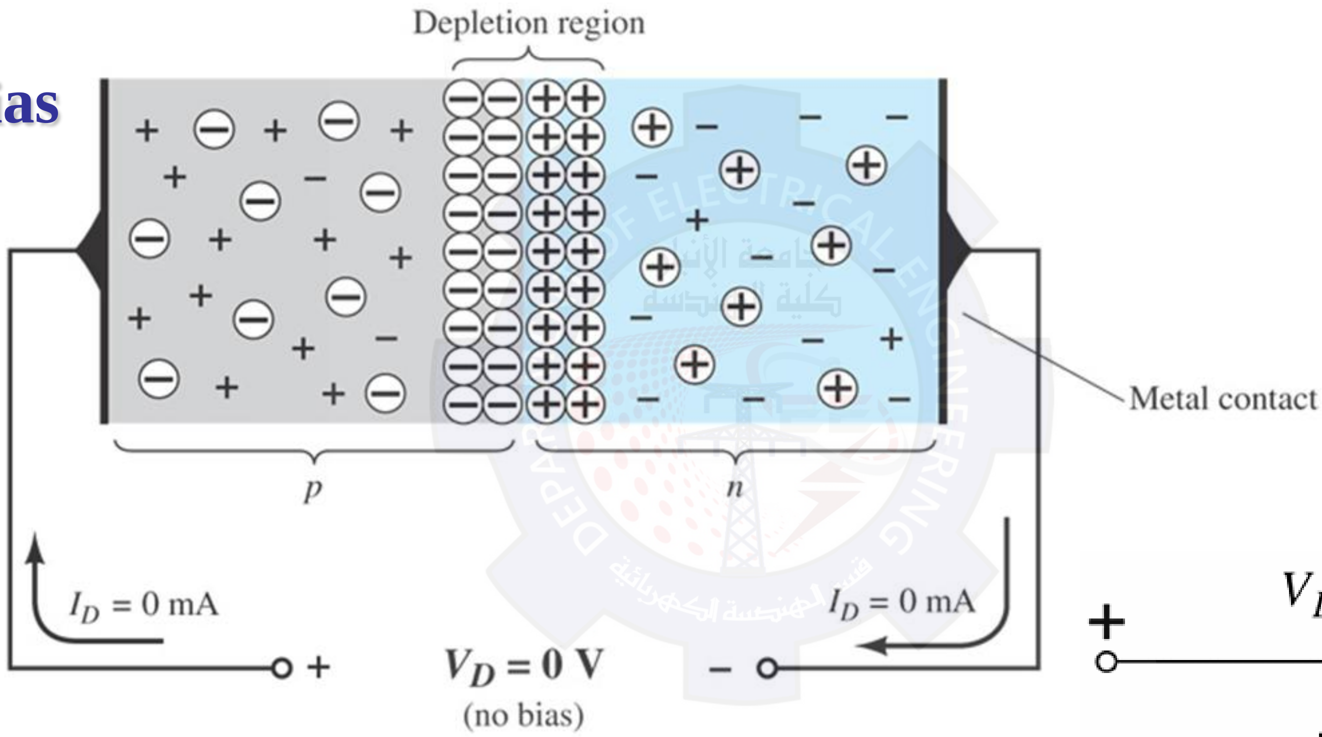


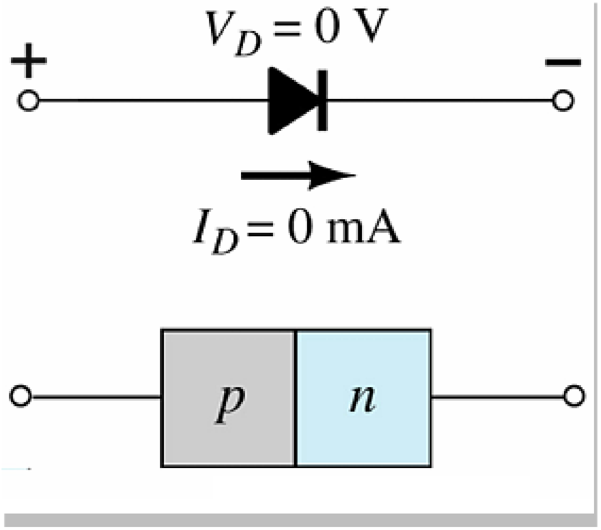
Forward bias



Diode Operating Conditions

No Bias





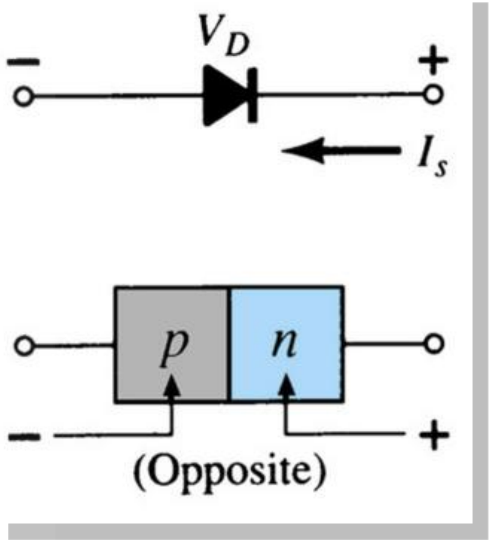
- **No external voltage is applied: $V_D = 0$ V**
- **No current is flowing: $I_D = 0$ A**
- **Only a modest depletion region exists**

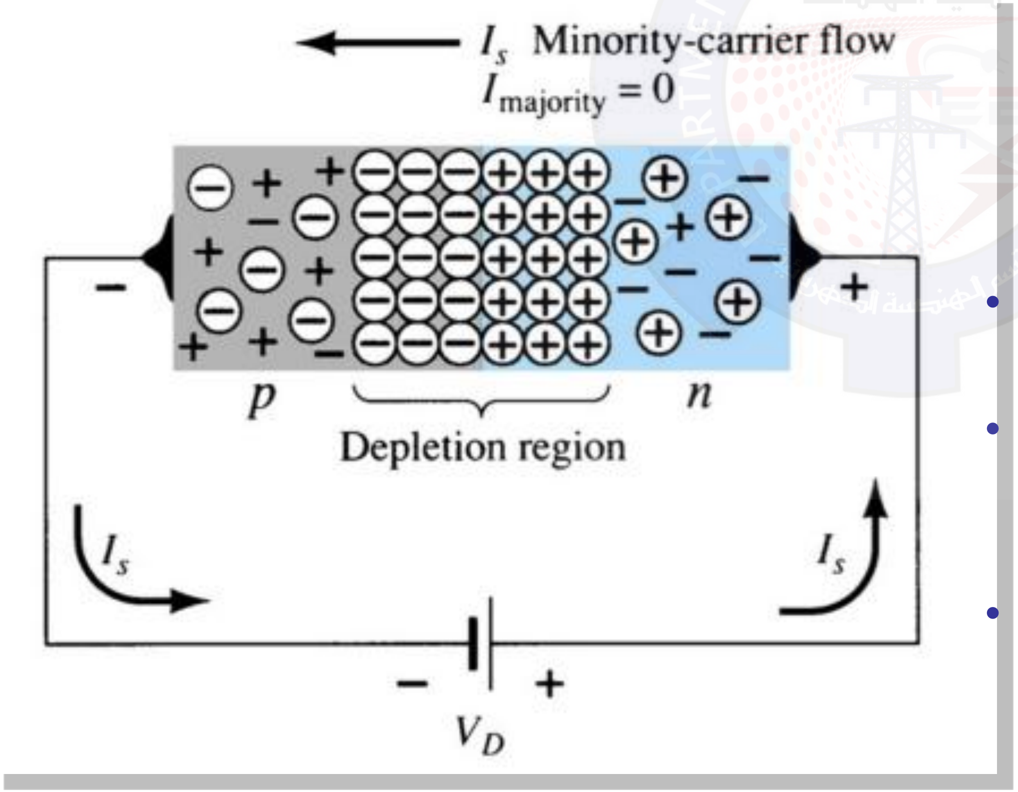
Diode Operating Conditions

Reverse Bias

Reverse Bias

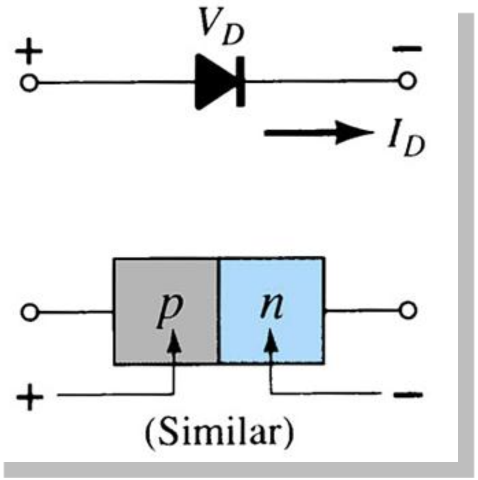
External voltage is applied across the *p-n* junction in the opposite polarity of the *p-* and *n-*type materials.





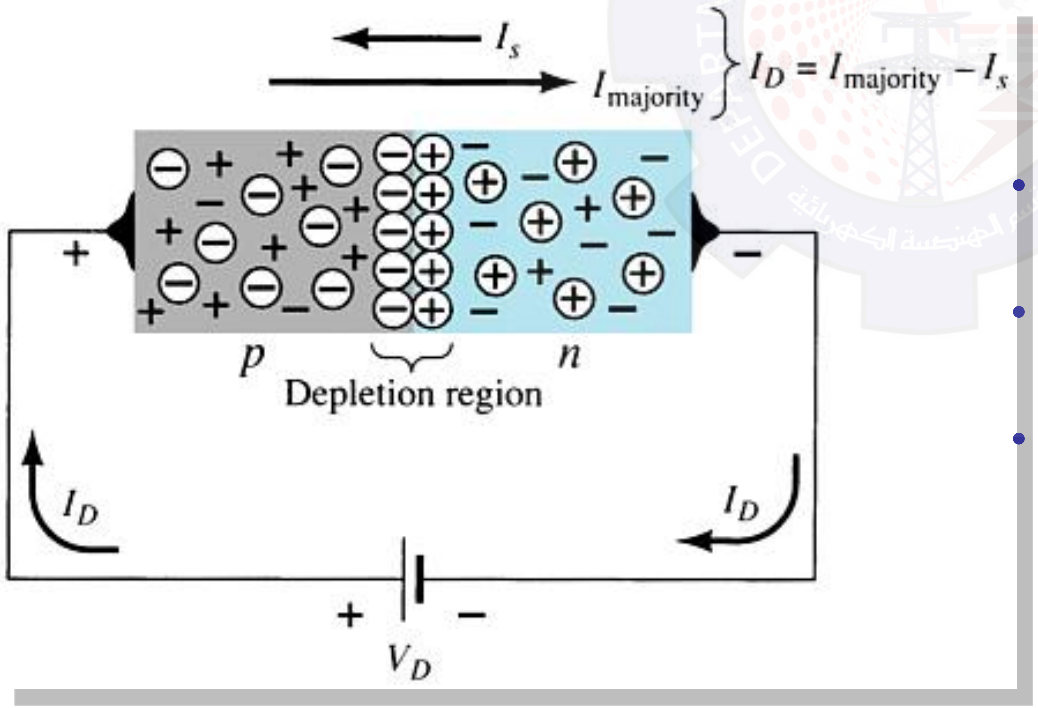
- **The reverse voltage causes the depletion region to widen.**
- **The electrons in the *n-*type material are attracted toward the positive terminal of the voltage source.**
- **The holes in the *p-*type material are attracted toward the negative terminal of the voltage source.**

Diode Operating Conditions



Forward Bias

External voltage is applied across the *p-n* junction in the same polarity as the *p*- and *n*-type materials.



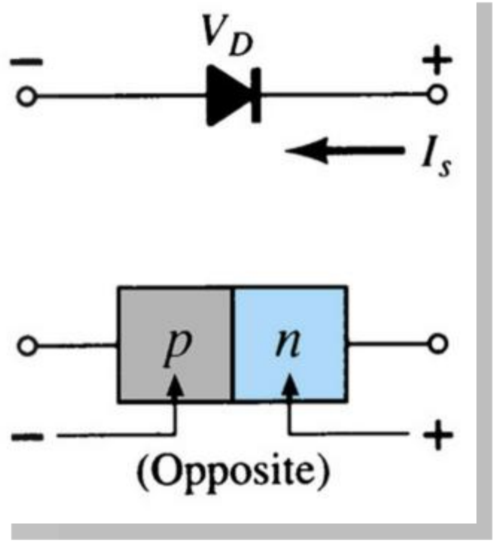
- **The forward voltage causes the depletion region to narrow.**
- **The electrons and holes are pushed toward the *p-n* junction.**
- **The electrons and holes have sufficient energy to cross the *p-n* junction.**

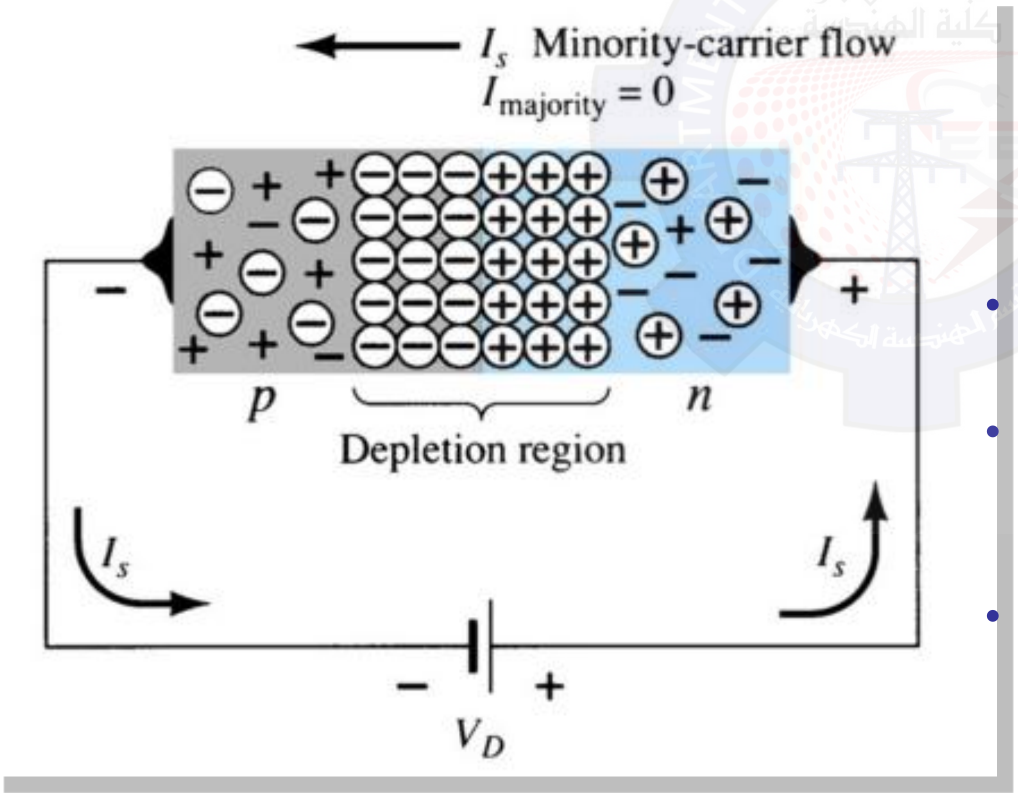
Diode Operating Conditions

Reverse Bias

Reverse Bias

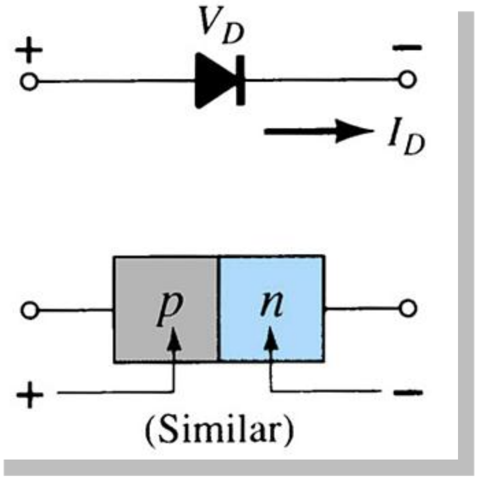
External voltage is applied across the *p-n* junction in the opposite polarity of the *p*- and *n*-type materials.





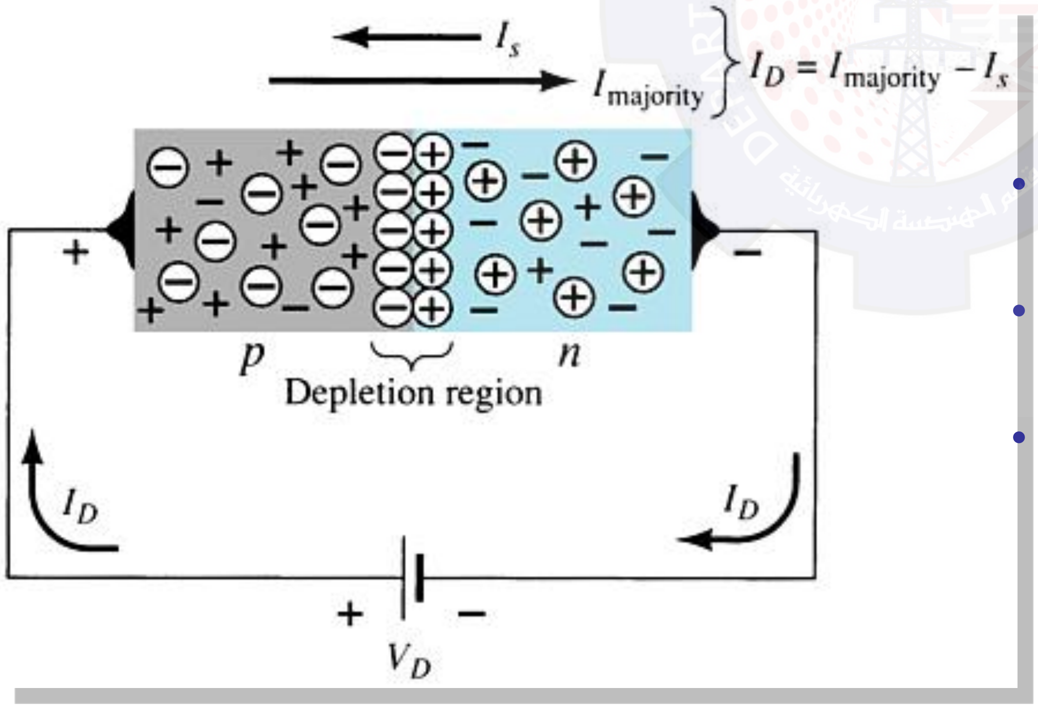
- **The reverse voltage causes the depletion region to widen.**
- **The electrons in the *n*-type material are attracted toward the positive terminal of the voltage source.**
- **The holes in the *p*-type material are attracted toward the negative terminal of the voltage source.**

Diode Operating Conditions



Forward Bias

External voltage is applied across the *p-n* junction in the same polarity as the *p*- and *n*-type materials.



- **The forward voltage causes the depletion region to narrow.**
- **The electrons and holes are pushed toward the *p-n* junction.**
- **The electrons and holes have sufficient energy to cross the *p-n* junction.**

Actual Diode Characteristics

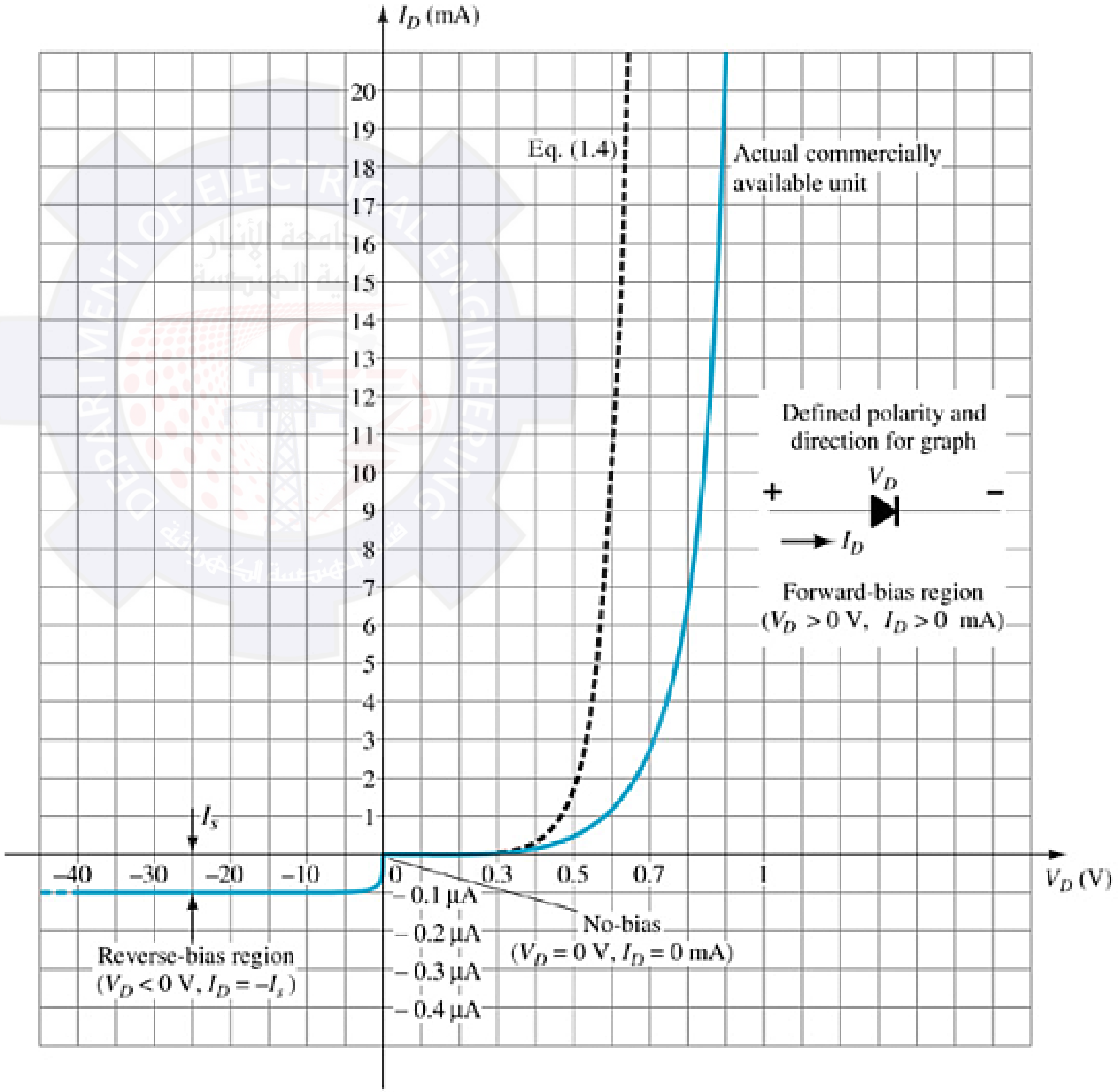
Note the regions for no bias, reverse bias, and forward bias conditions.

Carefully note the scale for each of these conditions.

The reverse saturation current is seldom more than a few microamperes.

$$I_D = I_S\left(e^{V_D/nV_T} - 1\right)$$

$$V_T = \frac{kT}{q}$$



Diode equation

$$I_D = I_S\left(e^{V_D/nV_T} - 1\right)$$

$$V_T = \frac{kT}{q}$$

where

V_T : is called the thermal voltage.

I_s : is the reverse saturation current.

V_D : is the applied forward-bias voltage across the diode.

n : is a factor function of operation conditions and physical construction. It has range between 1 and 2. assume n=1 unless otherwise noted.

K : is Boltzman's constant =1.38 x 10^{-23}

T: is temperature in kelvins = 273+temperature in C.

q : is the magnitude of electron charge = 1.6 x 10^{-19} C.