SEMICONDUCTORS

Presented by

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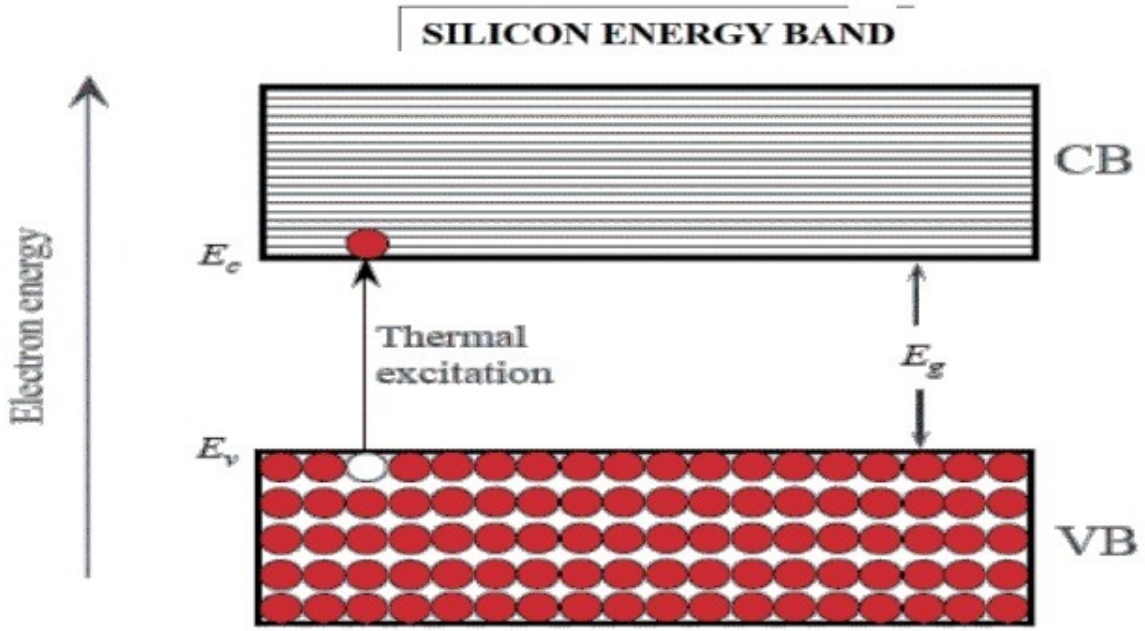
Overview

- Introduction
- What are N-type and P-type semiconductors?
- What are Diodes?
- Forward Bias & Reverse Bias
- Characteristics Of Ideal Diode
- Shockley Equation
- I – V Characteristics of Diodes

Introduction:

Semiconductors are materials whose electrical properties lie between Conductors and Insulators.

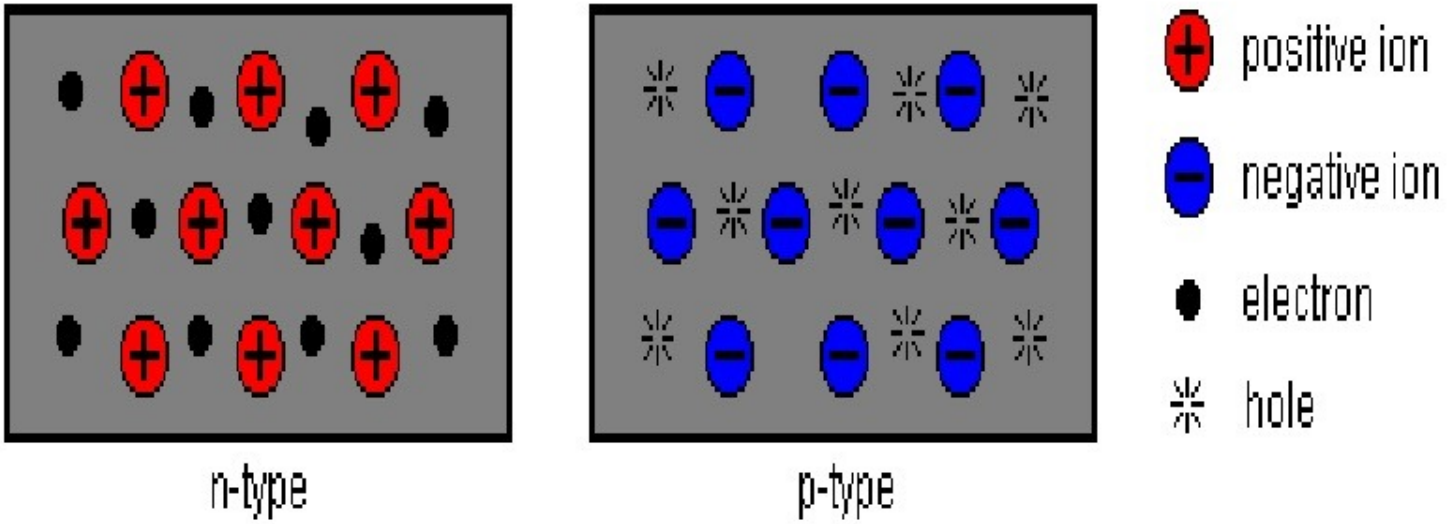
Ex : Silicon and Germanium



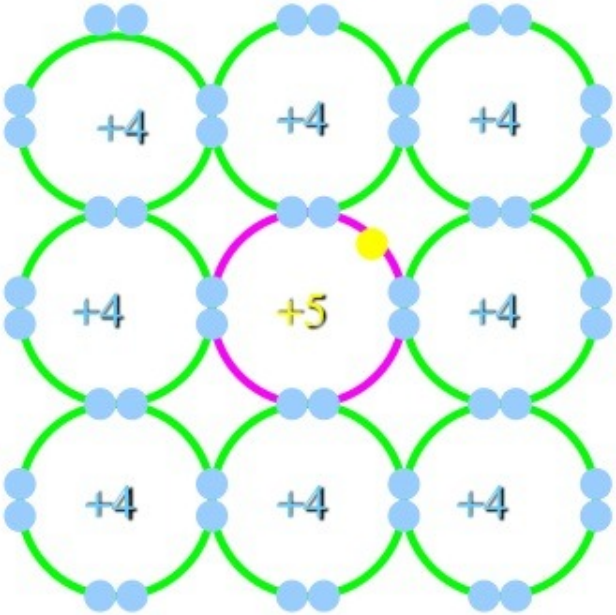
What are N-type and P-type ?

- Semiconductors are classified in to N-type and P-type semiconductor

- N-type: A N-type material is one in which electrons are majority charge carriers i.e. they are negatively charged materials (-----)
- P-type: A P-type material is one in which holes are majority carriers i.e. they are positively charged materials (++++)



N-Type Material

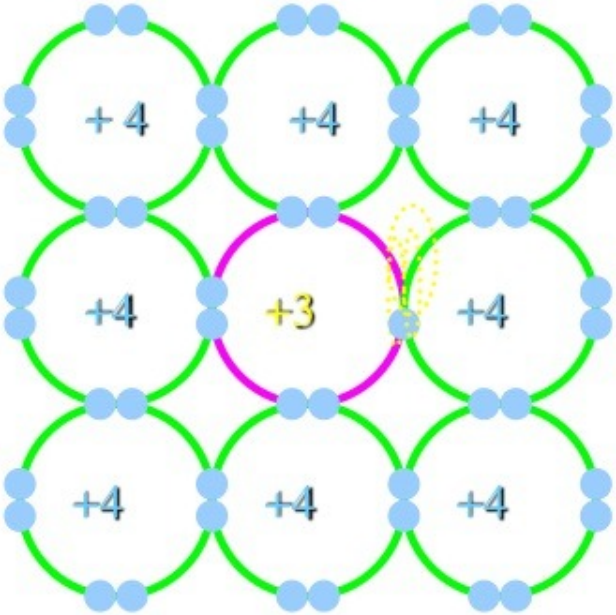


2D diagram

When extra valence electrons are introduced into a material such as silicon an n-type material is produced.The extra valence electrons are introduced by putting impurities or dopants into the silicon. The dopants used to create an n-type material are Group V elements. The most commonly used dopants from Group V are arsenic, antimony and phosphorus.

The 2D diagram to the left shows the extra electron that will be present when a Group V dopant is introduced to a material such as silicon. This extra electron is very mobile.

P-Type Material



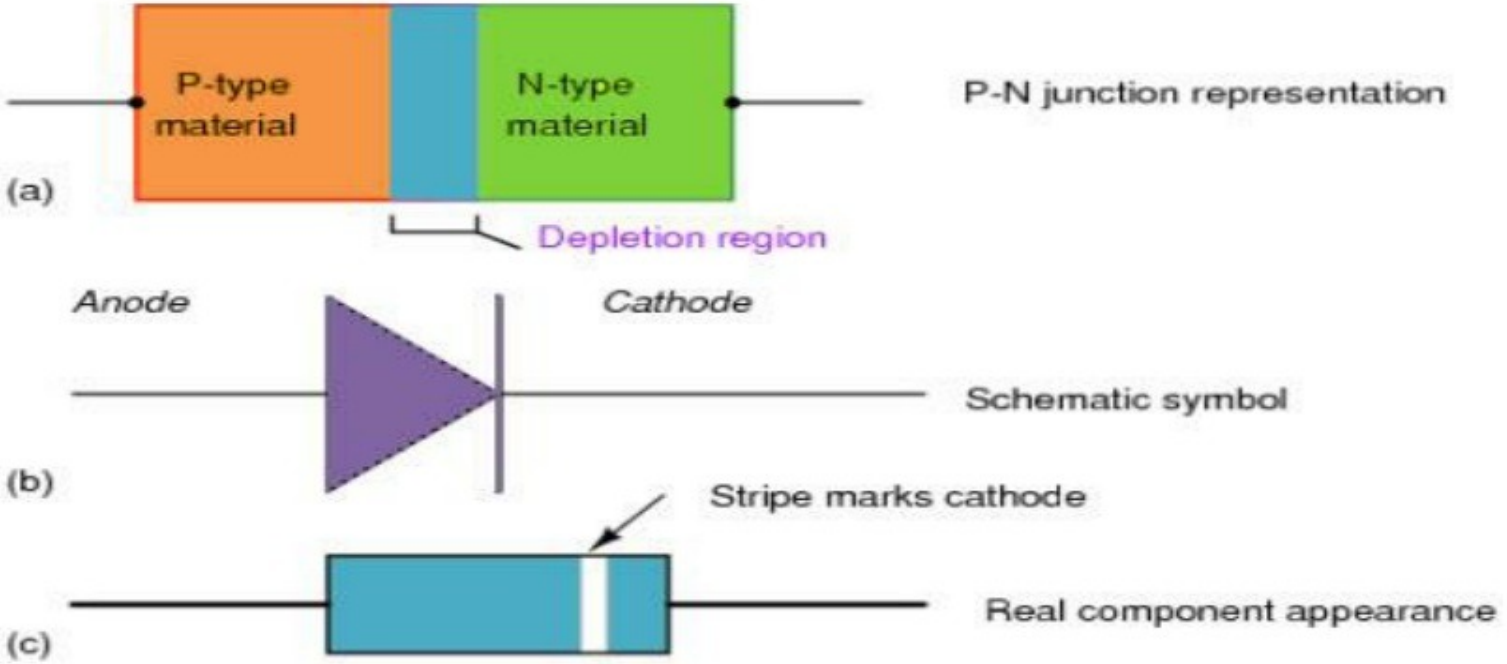
2D diagram

P-type material is produced when the dopant that is introduced is from Group III. Group III elements have only 3 valence electrons and therefore there is an electron missing. This creates a hole (h+), or a positive charge that can move around in the material. Commonly used Group III dopants are aluminum, boron, and gallium.

The 2D diagram to the left shows the hole that will be present when a Group III dopant is introduced to a material such as silicon. This hole is quite mobile in the same way the extra electron is mobile in a n-type material.

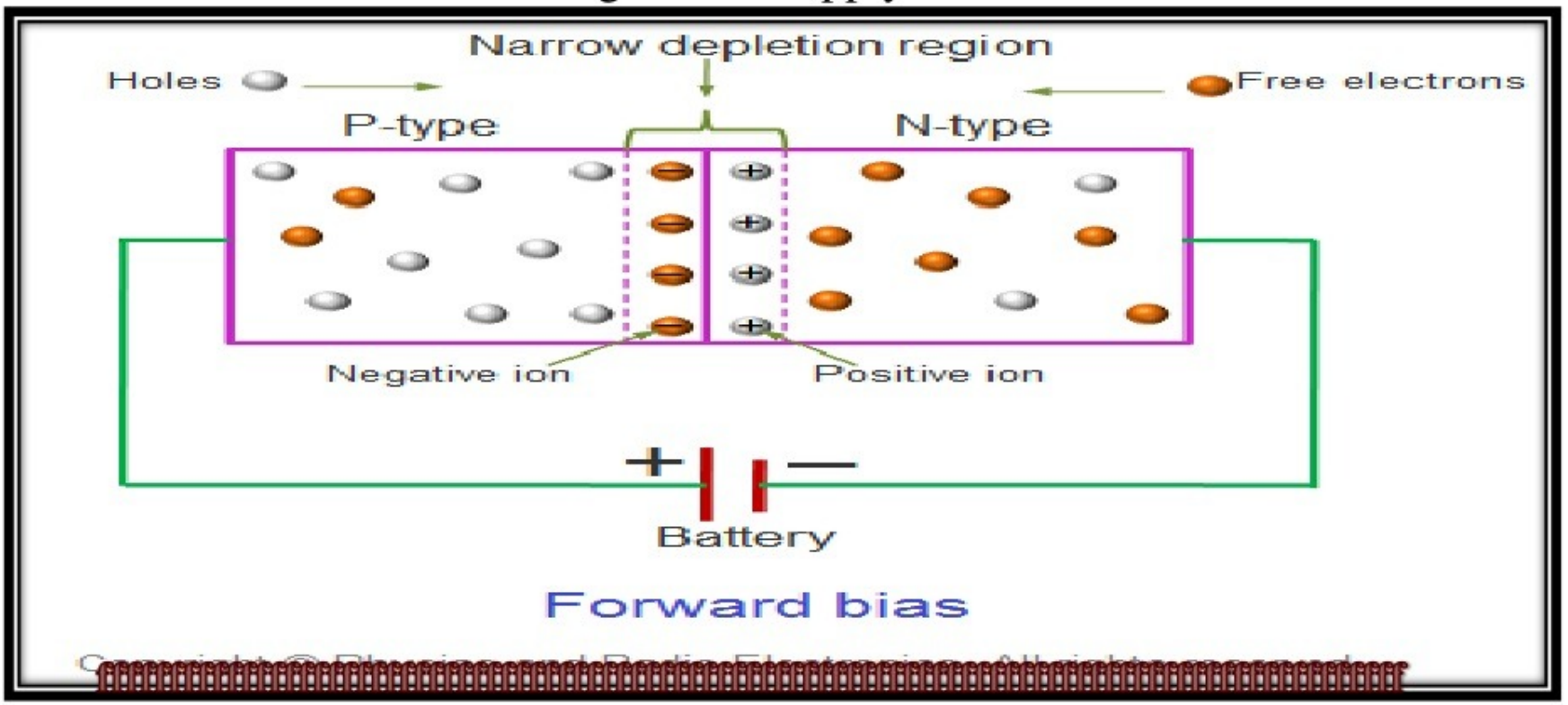
Diodes

Electronic devices created by bringing together a *p*-type and *n*-type region within the same semiconductor lattice It is represented by the following symbol, where the arrow indicates the direction of positive current flow.



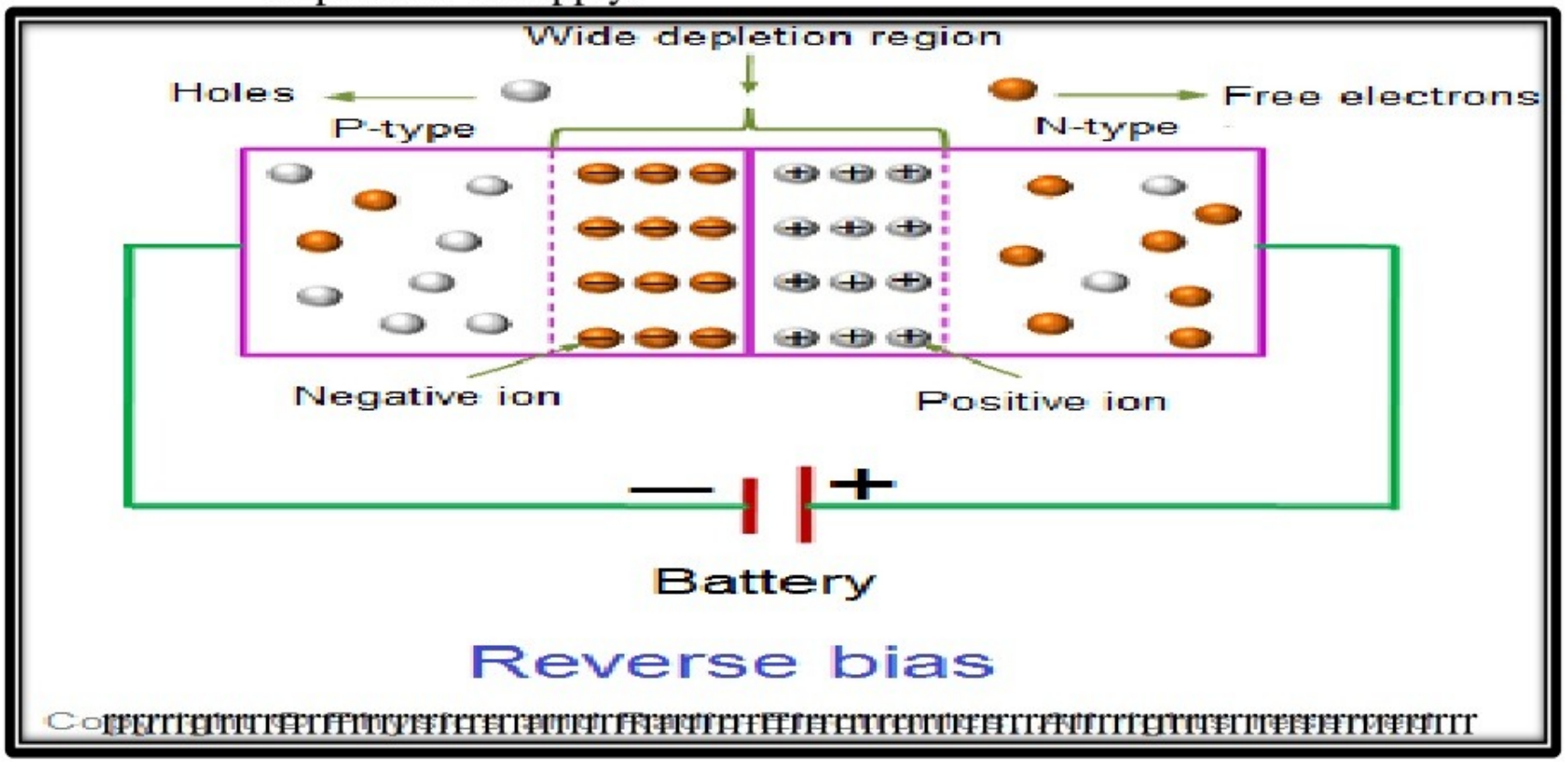
Forward Bias

Forward Bias : Connect positive of the Diode to positive of supply…negative of Diode to negative of supply



Reverse Bias

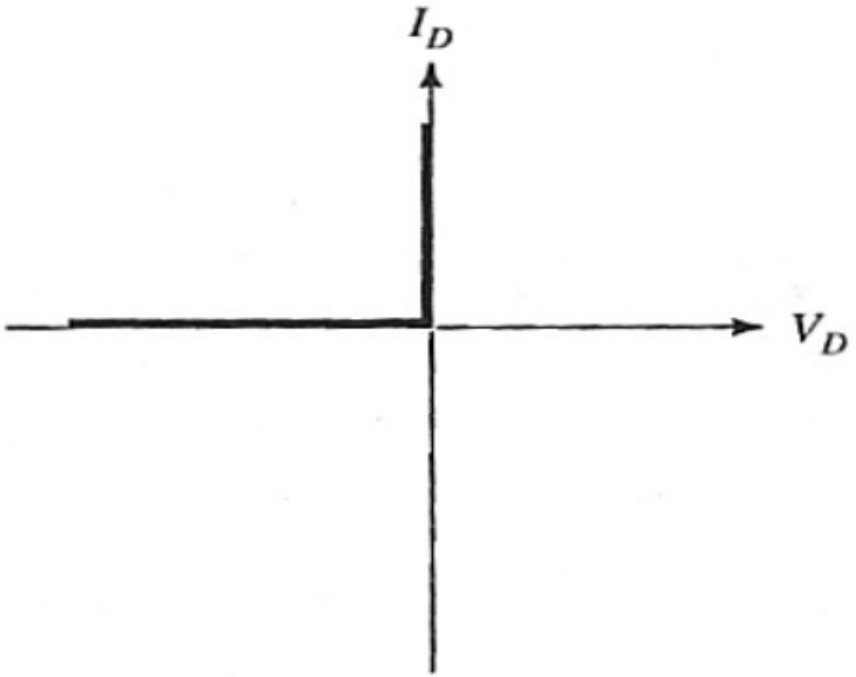
Reverse Bias: Connect positive of the Diode to negative of supply…negative of diode to positive of supply.



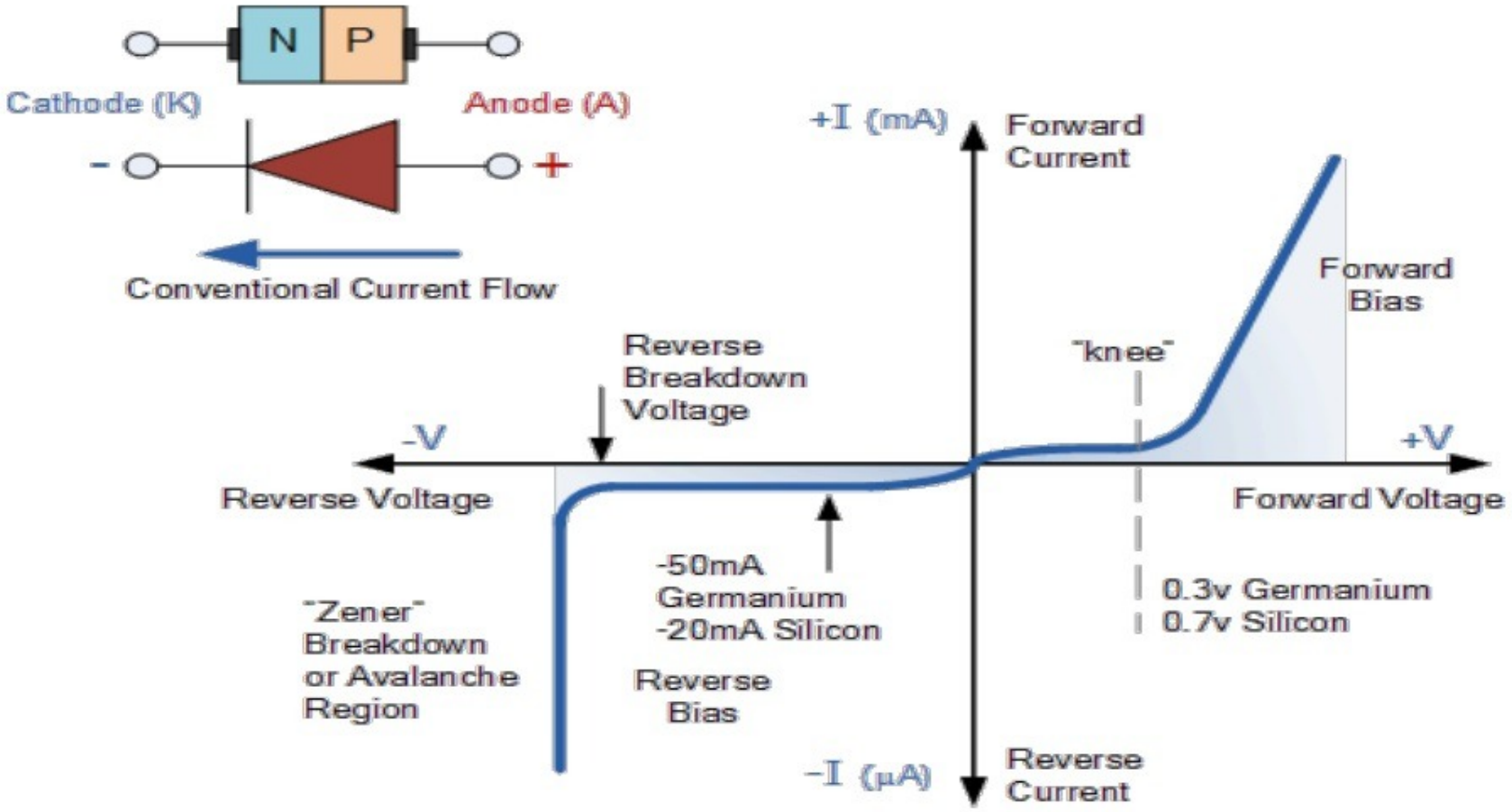
Characteristics of Diode

- Diode always conducts in one direction.
- Diodes always conduct current when "Forward Biased" (Zero resistance)
- Diodes do not conduct when Reverse Biased (Infinite resistance)

I-V characteristics of Ideal diode



I-V Characteristics of Practical Diode

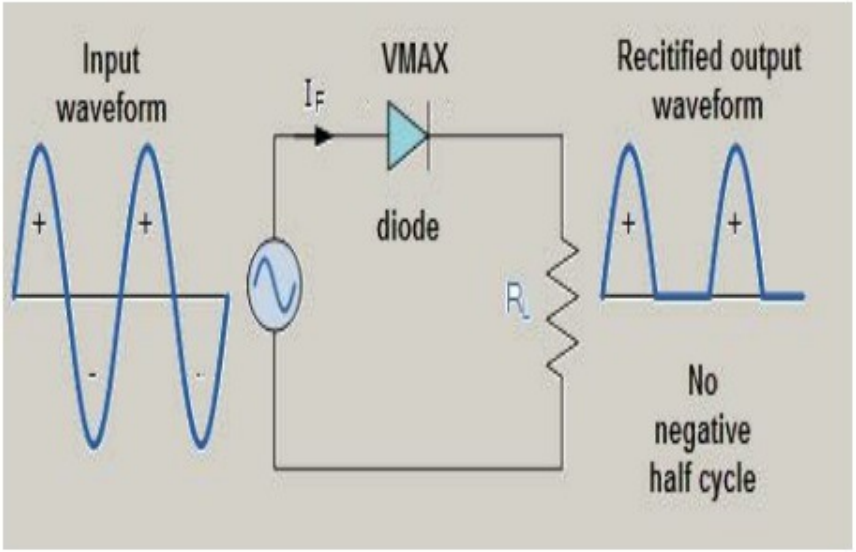


Rectification

- Converting ac to dc is accomplished by the process of rectification.
- Two processes are used:
  - Half-wave rectification;
  - Full-wave rectification.

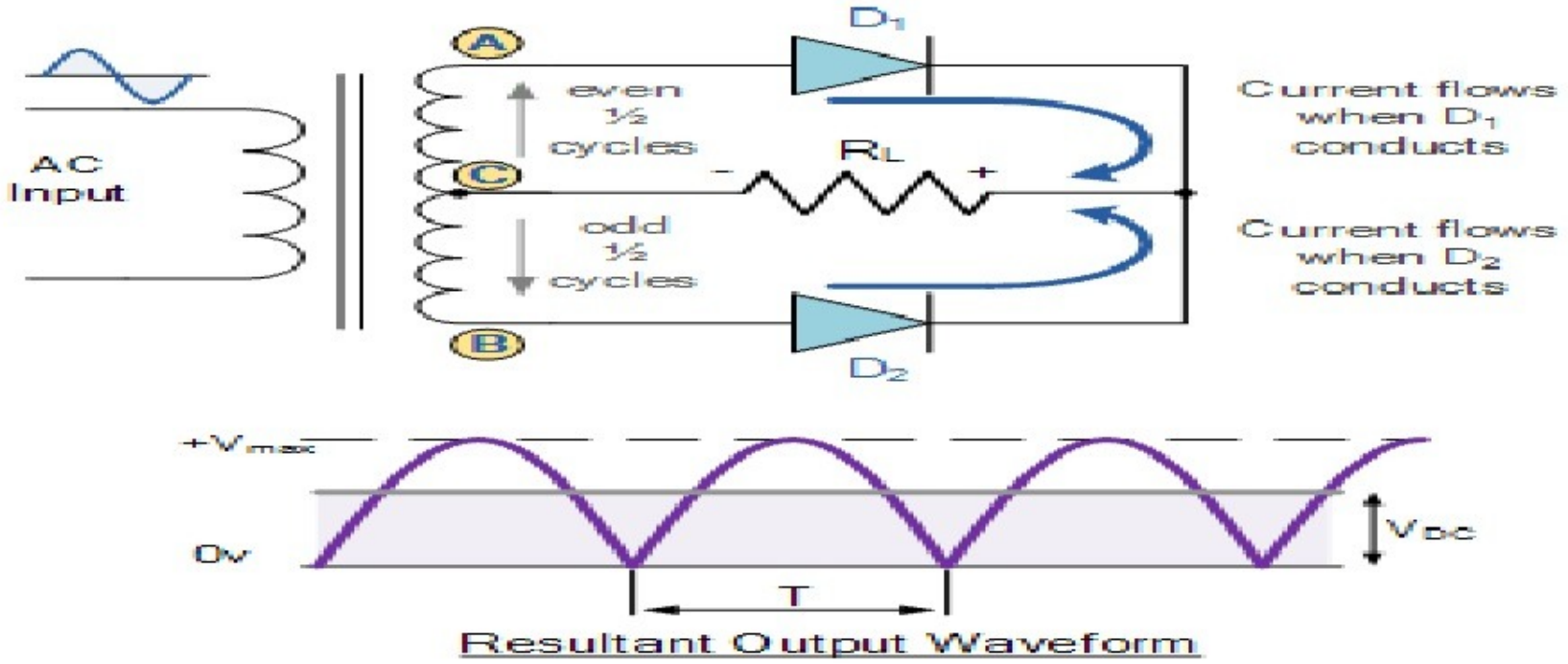
Half-wave Rectification

- Simplest process used to convert ac to dc.
- A diode is used to clip the input signal excursions of one polarity to zero.



Full-wave Rectification

- Both diodes are conducting in any polarity



Shockley Equation

- The transconductance curve on the previous slide is characterized by the following equation:

$$i_D = I_s \left(\exp\left(\frac{v_D}{V_T} \right) - 1 \right) \qquad V_T = \frac{kT}{q}$$

I_s is the saturation current ~10^{-14}

$V_T \approx 26\ \text{mV}$

V_d is the diode voltage

n – emission coefficient (varies from 1 - 2)

$k = 1.38 \times 10^{-23}$ J/K is Boltzmann's constant

$q = 1.60 \times 10^{-19}$ C is the electrical charge of an electron.

At a temperature of 300 K, we have

Thanks