COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

# Electronics

## CTE 207

## Lecture 4

## - Characteristic of Diode -

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# The Diode Symbol



- The primary usefulness of the diode is its ability to allow current in only one direction and to prevent current in the other direction as determined by the bias.

- If you take a block of silicon and dope half of it with a trivalent impurity and the other half with a pentavalent impurity, a boundary called the pn junction is formed between the resulting p-type and n-type portions of a semiconductor diode Fig.1.

- In electronics, bias refers to the use of a dc voltage to establish certain operating conditions for an electronic device.

# The Diode Symbol

- There are two practical bias conditions for a diode: forward and reverse.
- The lead attached to the n-type semiconductor is called the cathode.
- Thus, the cathode is the negative side of the diode.
- The positive side of the diode that is, the lead attached to the p-type semiconductor is called the anode.

# The Diode Symbol

- When a voltage source is connected to a diode such that the positive side of the voltage source is on the anode and the negative side is on the cathode, the diode becomes a conductor and allows current to flow.
- Voltage connected to the diode in this direction is called forward bias.
- But if you reverse the voltage direction, applying the positive side to the cathode and the negative side to the anode, current doesn't flow.
- In effect, the diode becomes an insulator. Voltage connected to the diode in this direction is called reverse bias.

# The Diode Symbol



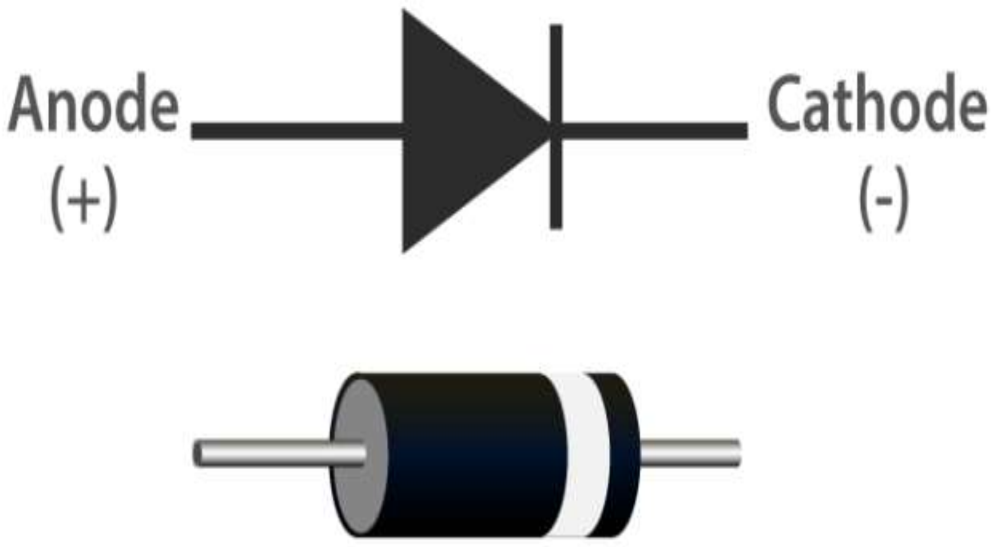


Fig. 1. Semiconductor diode symbol

# The PN Junction



- When you take a block of silicon and dope part of it with a trivalent impurity and the other part with a pentavalent impurity, a boundary called the PN junction is formed between the resulting p-type and n-type portions.

- The PN junction is the basis for diodes, certain transistors, solar cells, and other devices.

# The PN Junction

- If a piece of intrinsic silicon is doped so that part is n-type and the other part is p-type, a PN junction forms at the boundary between the two regions and a diode is created, as indicated in Fig. 2.

- The p region has many holes (majority carriers) from the impurity atoms and only a few thermally generated free electrons (minority carriers).

- The n region has many free electrons (majority carriers) from the impurity atoms and only a few thermally generated holes (minority carriers).

# Depletion Region

- A diode consists of an n region and a p region separated by a pn junction, as illustrated in Fig. 2.

- The n region has many conduction electrons, and the p region has many holes.

- With no external voltage, the conduction electrons in the n region are randomly drifting in all directions.

# Depletion Region



- Free electrons in the n region near the pn junction begin to diffuse across the junction and fall into holes near the junction in the p region.

- For every electron that diffuses across the junction and combines with a hole, a positive charge is left in the n region and a negative charge is created in the p region, forming a barrier potential.

- This action continues until the voltage of the barrier repels further diffusion.

# Depletion Region



- As this buildup occurs, the electrons in the n region must overcome both the attraction of the positive ions and the repulsion of the negative ions in order to migrate into the p region.

- Thus, as the ion layers build up, the area on both sides of the junction becomes essentially depleted of any conduction electrons or holes and is known as the depletion region Fig 3.

- Before the PN junction is formed, recall that there are as many electrons as protons in the n-type material, making the material neutral in terms of net charge.

# Depletion Region



- The same is true for the p-type material.

- The term depletion refers to the fact that the region near the pn junction is depleted of charge carriers (electrons and holes) due to diffusion across the junction.

- The depletion region is formed very quickly and is very thin compared to the n region and p region.

# Barrier Potential



- Any time there is a positive charge and a negative charge near each other, there is a force acting on the charges as described by Coulomb's law.

- In the depletion region there are many positive charges and many negative charges on opposite sides of the PN junction.

- The forces between the opposite charges form an electric field, as illustrated in Fig.3 b by the arrows between the positive charges and the negative charges.

- This electric field is a barrier to the free electrons in the n region, and energy must be expended to move an electron through the electric field.

# Barrier Potential



- That is, external energy must be applied to get the electrons to move across the barrier of the electric field in the depletion region.

- The potential difference of the electric field across the depletion region is the amount of voltage required to move electrons through the electric field.

- This potential difference is called the barrier potential and is expressed in volts.

- The typical barrier potential is approximately 0.7 V for silicon and 0.3 V for germanium at 25°C.

# The PN Junction & Depletion region



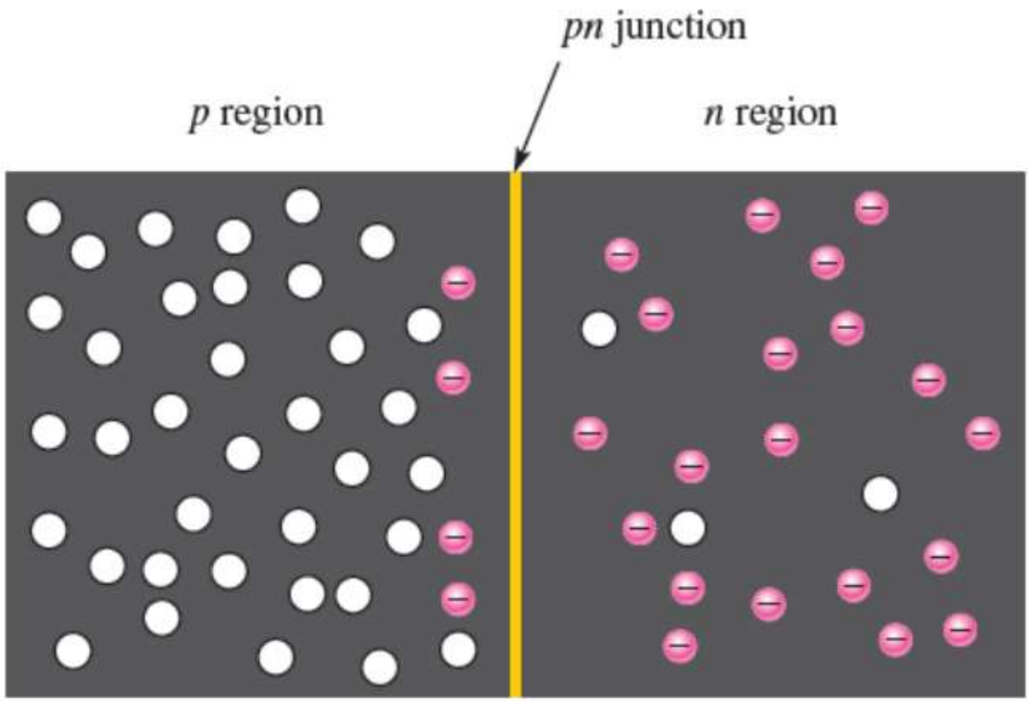


Fig. 2. PN Junction

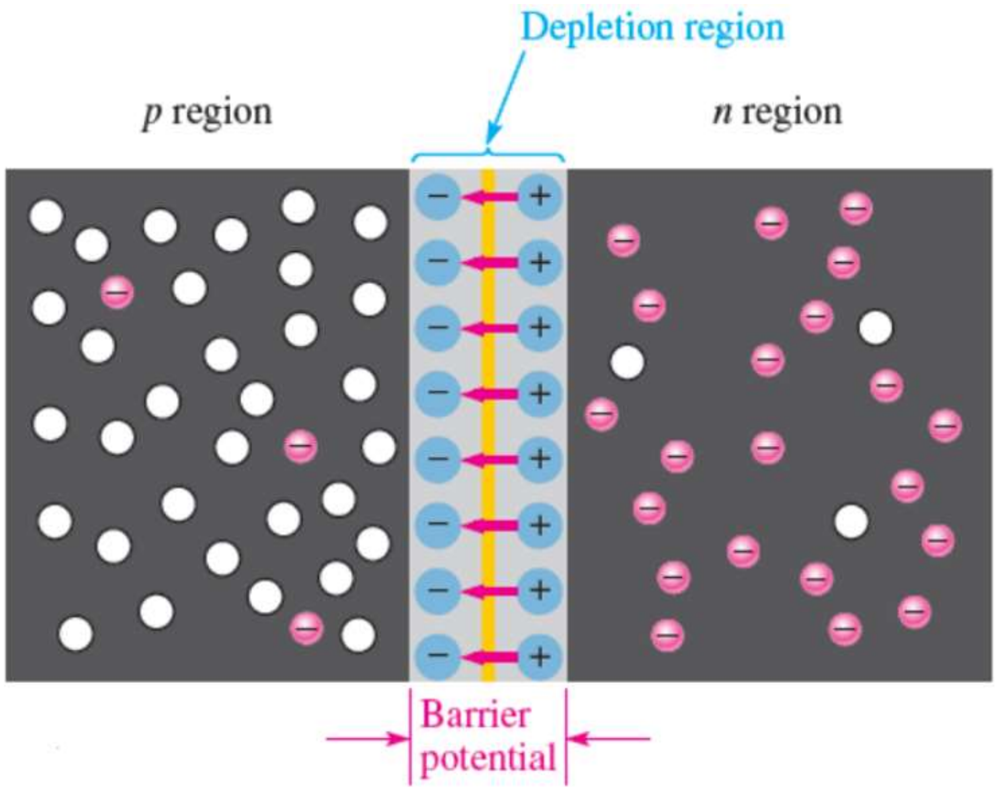


Fig. 3. Depletion region