COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Electronics Fundamentals

CTE 204

Lecture 5

- Operation States of Diode -

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Forward Bias State

- Forward-Bias Condition ($\boldsymbol{VD} > 0$).
- Forward bias is the condition that permits current through a diode.
- A forward-bias or “on” condition is established by applying the positive potential to the p-type material and the negative potential to the n-type material.
- A semiconductor diode is forward-biased when the association p-type and positive and n-type and negative has been established.

Forward Bias State

- When V is large enough so that E battery > E, Holes are swept from the p to n regions, and Electrons are swept from the n to p regions, then We now have current.

- When it overcomes the barrier potential VB the external voltage source provides the n-region electrons with enough energy to penetrate the depletion region and move through the junction, where they combine with the p-region holes.

Forward Bias State

- Notice that the negative terminal of the source is connected to the n region, and the positive terminal is connected to the p region.

- The negative terminal of the bias-voltage source pushes the conduction-band electrons in the n region toward the pn junction, while the positive terminal pushes the holes in the p region also toward the pn junction. Recall that like charges repel each other.

Forward Bias State

- Then they move as valence electrons from hole to hole toward the positive connection of the bias-voltage source.
- The movement of these valence electrons is the same as the movement of holes in the opposite direction.
- Thus, current in the p region is formed by the movement of holes (majority carriers) toward the pn junction.
- Fig. 1 shows a dc voltage connected in a direction to forward-bias the pn junction.

Forward Bias State

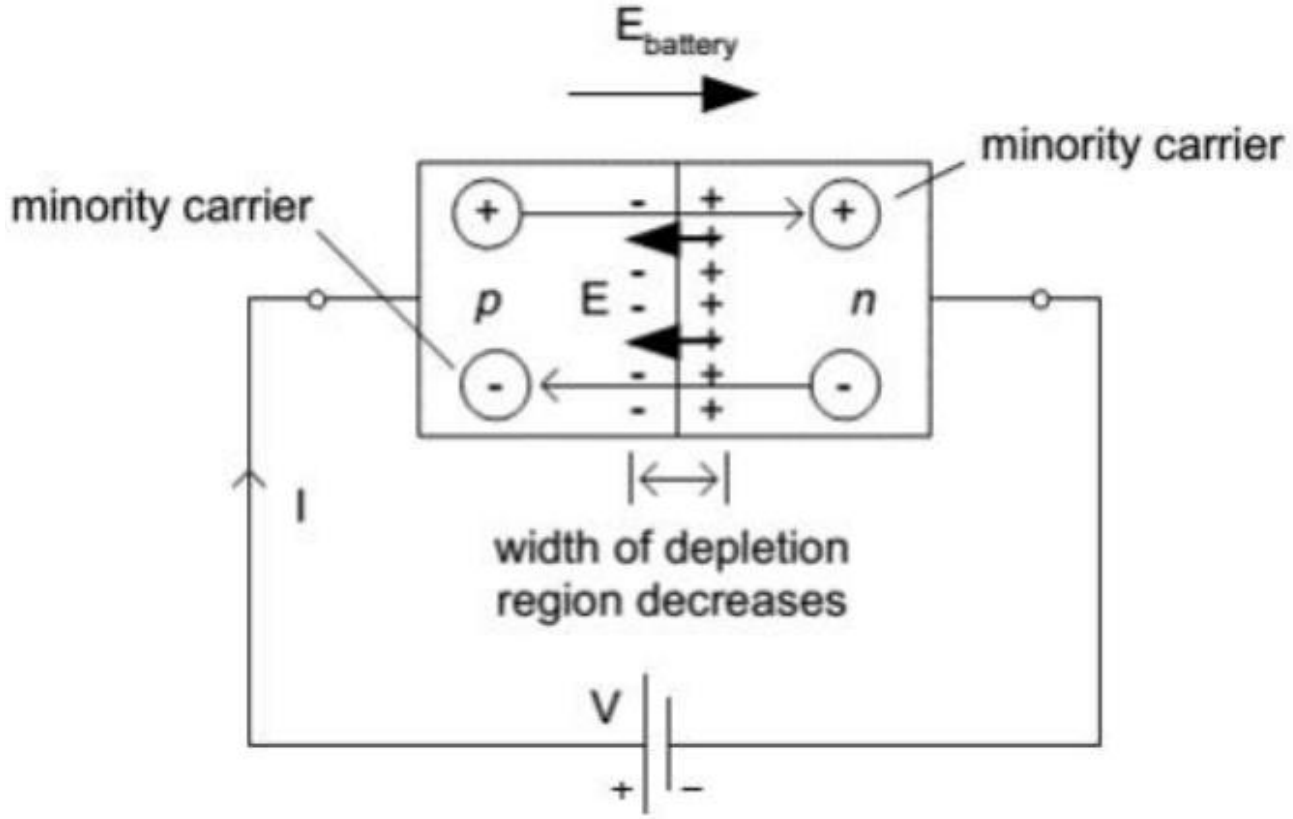

Fig. 1. Forward Biasing

Reverse Bias State

- Reverse-Bias Condition ($\boldsymbol{VD} < 0$).
- If an external potential of V volts is applied across the p-n junction.
- Such that the positive terminal is connected to the n-type material and the negative terminal is connected to the p-type material as shown below, the number of uncovered positive ions in the depletion region of the n-type material will increase due to the large number of “free” electrons drawn to the positive potential of the applied voltage.

Reverse Bias State

- For similar reasons, the number of uncovered negative ions will increase in the p-type material.
- The net effect, therefore, is a widening of the depletion region.
- Consequently, the “majority carriers” cannot flow through the region.
- The current that exists under reverse-bias conditions is called the reverse saturation current and is represented by Is.

Reverse Bias State

- An electric field E is created in the depletion region because of the uncovered charges near the junction.
- holes in the p material are opposed by E in the depletion region, as are electrons in the n material.
- Hence, little current flows (only the drift current Is) unless the junction breaks down.

Reverse Bias State

- This occurs when E battery is strong enough to strip electrons from the covalent bonds of the atoms, which are then swept across the junction.
- Reverse bias is the condition that prevents current flow through the diode.
- Fig. 2 shows a dc voltage source connected to reverse-bias the diode.

Reverse Bias State

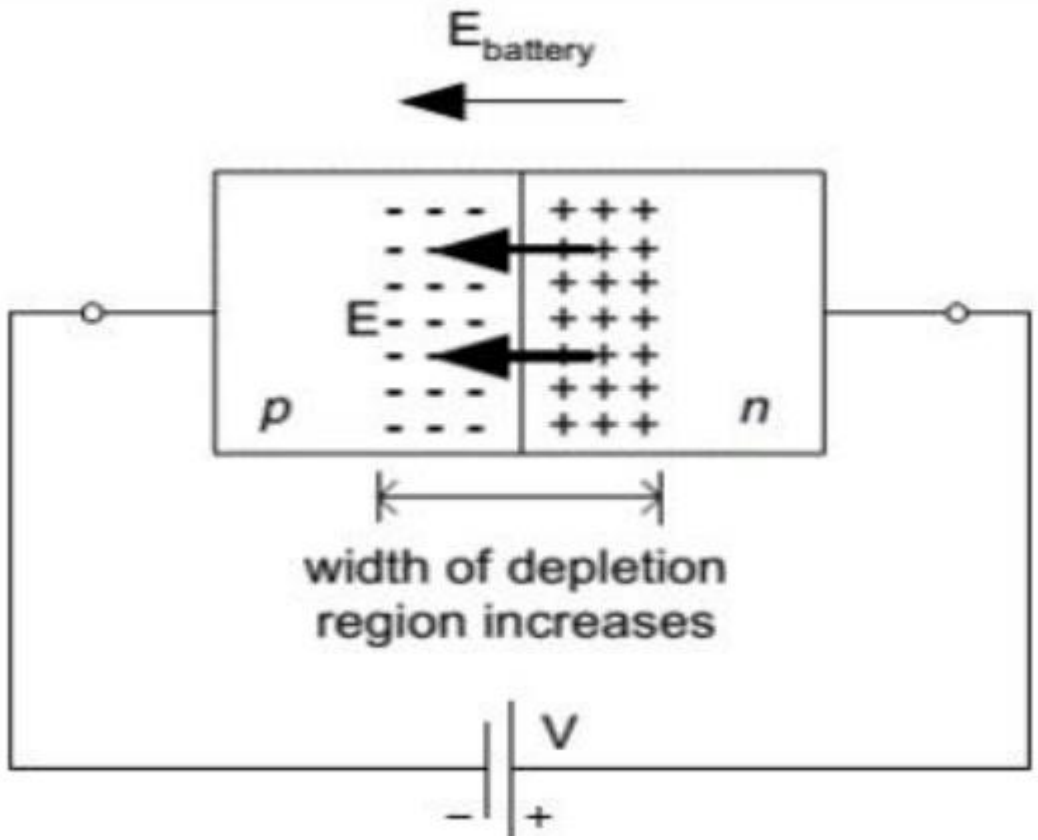

Fig. 2. Reverse Biasing

Characteristic of the Diode

- The upper right quadrant of the graph represents the forward-biased condition Fig 3.
- There is a tiny forward current (IF) for forward voltages VF below the barrier potential.
- Once the forward voltage reaches the barrier potential, the current increases drastically and must be limited by a series resistor.
- The voltage across the forward-biased diode remains approximately equal to the barrier potential.

Characteristic of the Diode

- The lower left quadrant of the graph represents the reverse-biased condition Fig 3.
- As the reverse voltage (VR) increases to the left, the current remains near zero until the breakdown voltage (VBR) is reached.
- When a breakdown occurs, there is a large reverse current which, if not limited, can destroy the diode.
- Most diodes should not be operated in the reverse breakdown.

Current–Voltage Characteristic of the Diode

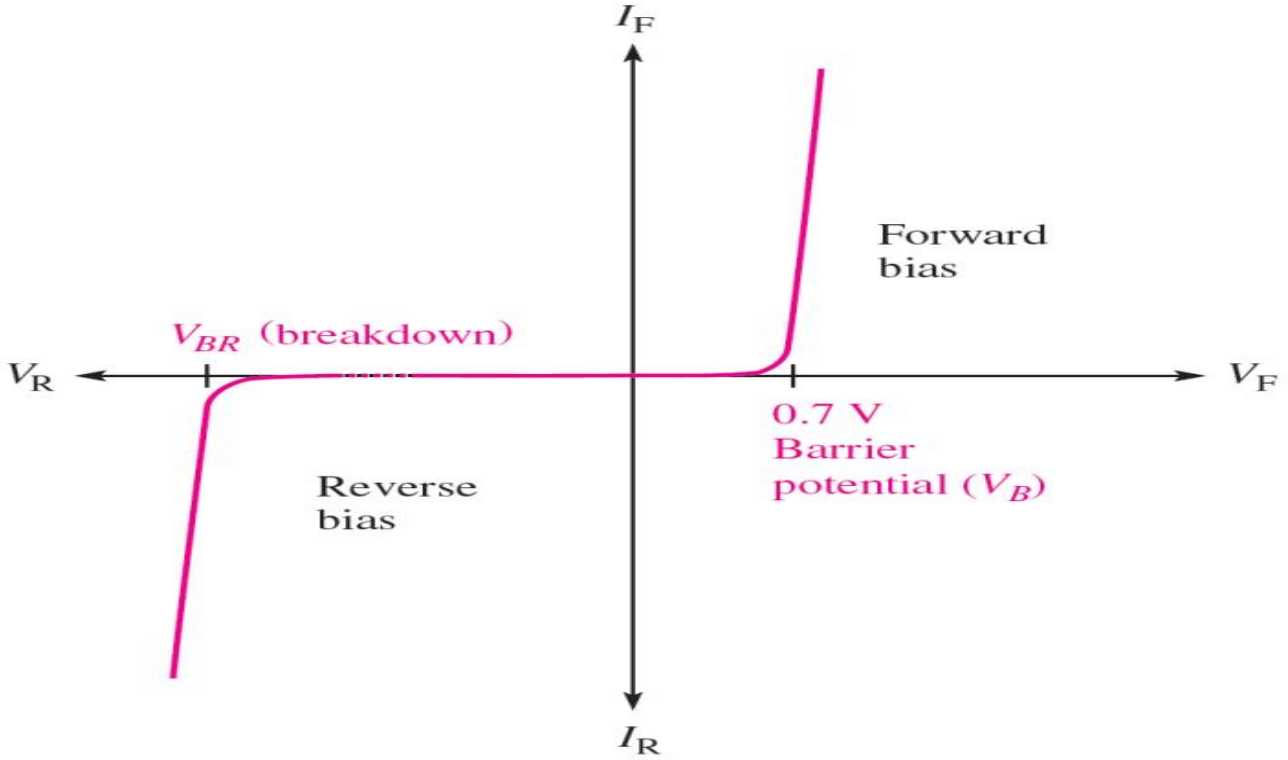

Fig. 3. General diode V-I characteristic curve