Analog Electronics

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1st **semester**

Chapter Two
Diode and its Application

Lecture 3

Diode

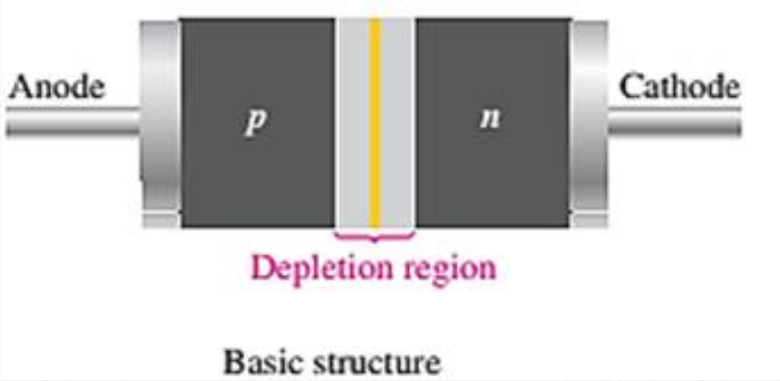
Diode is a **semiconductor** device, **made** from a small piece of semiconductor material, such as **silicon**.

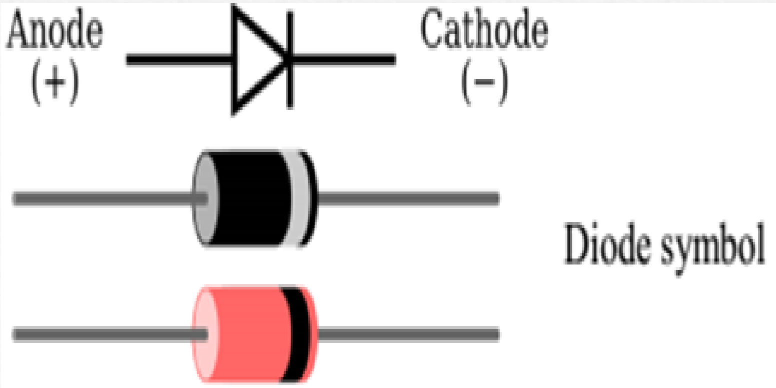
It is consisting of **two part** that divided in equal, the **first half** is doped as a p region and **second half** is doped as an n region.

Theses two part with the depletion region in between produced the **pn** junction.

The **p region** is called the **anode** and **n region** is called the **cathode**.

It conducts current in one direction and offers high resistance in other direction. The basic diode structure and symbol are shown in Fig.1.





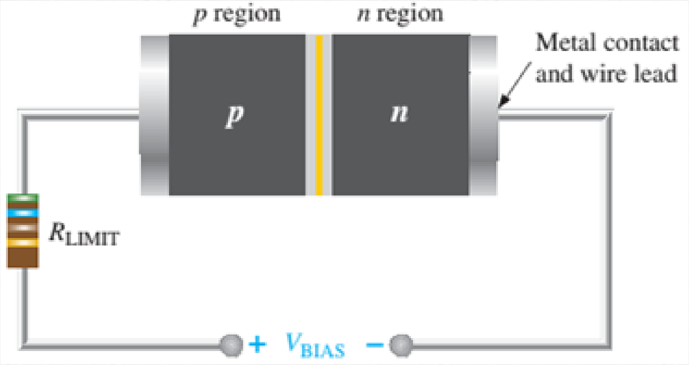
Forward Bias

Bias is the application of a **dc voltage to a diode** to make it either **conduct current or not**.

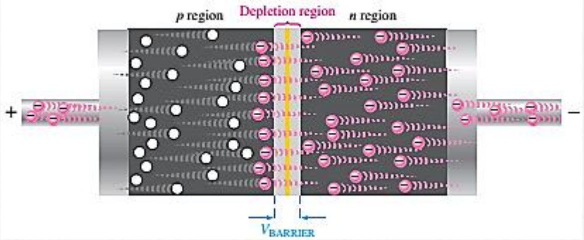
Forward bias is the condition that allows current through the pn junction. This external bias voltage is designated as VBIAS.

The **resistor limits** the forward current to a value that will not damage the diode.

In the **forward bias**, the negative side of VBIAS is connected to the n region of the diode, and the positive side is connected to the p region. The **bias voltage,** VBIAS, must be greater than the **barrier potential**; the bias must be greater than **0.3V for germanium** or **0.7V for silicon** diodes.



- **Negative side** of bias voltage '**pushes**' free electrons towards pn junction.
- The **negative side of the source** also **provides** a **continuous flow of electrons** through the external connection (conductor) and into the n region as shown in Figure 3.
- The bias-voltage source **imparts** sufficient energy to the **free electrons** to overcome the depletion region's barrier potential and move on through into the p region.



- Since unlike charges attract, the positive side of the bias-voltage source **attracts** the valence electrons toward the left end of the p region.
- The holes in the p region provide the medium for these valence electrons to move through the p region. The holes, (majority in p region), move to the right toward the junction.
- As the electrons flow out of the p region through the external connection (conductor), these electrons become **conduction electrons** in the **metal conductor**.
- As more electrons move into the depletion region, positive ions are **reduced**.
- As more hole's flow into the depletion region on the other side of the pn junction, the **number of negative ions is reduced**.
- This **reduction in positive and negative ions causes** the depletion region to narrow.

Reverse Bias

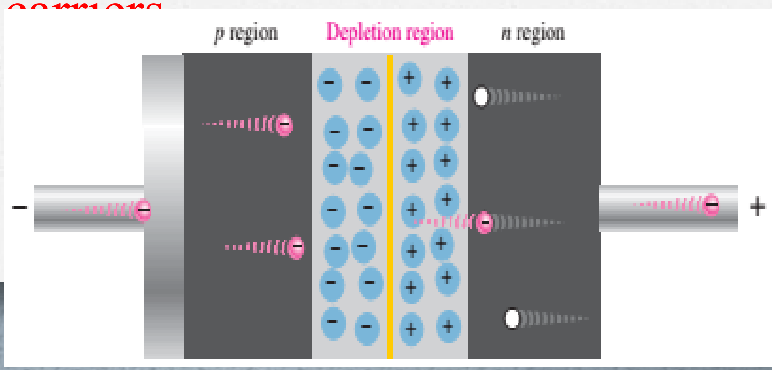
Reverse bias is the condition that essentially **prevents current** through the diode. Figure 4 shows a DC voltage source connected across a diode in the direction to produce reverse bias.

The positive side of VBIAS is connected to the n region of the diode, and the **negative side** is connected to the **p region**.

Also, **note** that the depletion region is shown much wider than in **forward bias or equilibrium.**

The **positive side** of the bias-voltage source **pulls** the free electrons, (**majority in the N region**), **away** from the **pn** junction.

As electrons move away from the junction, **more positive ions** are created. This **results** in a widening of the depletion region and a depletion of the majority carriers.



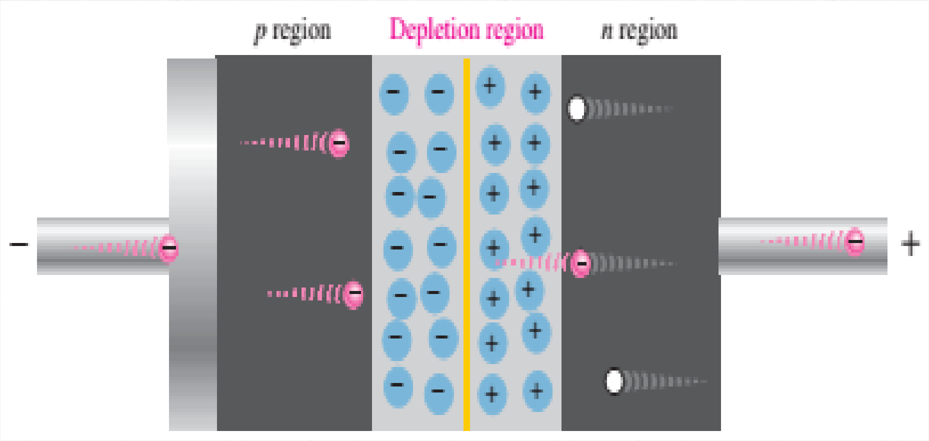
Reverse Bias

In p region, electrons from the negative side of the battery enter as **valence electrons**. It moves from **hole** to **hole** toward the **depletion region**, creating **more negative ions**.

This can be viewed as **holes being pulled towards** the **negative side**.

The **electric field** increases in strength until the potential **across** the depletion region equals the bias voltage.

At this point, a very small **reverse current** exist that can usually be neglected.

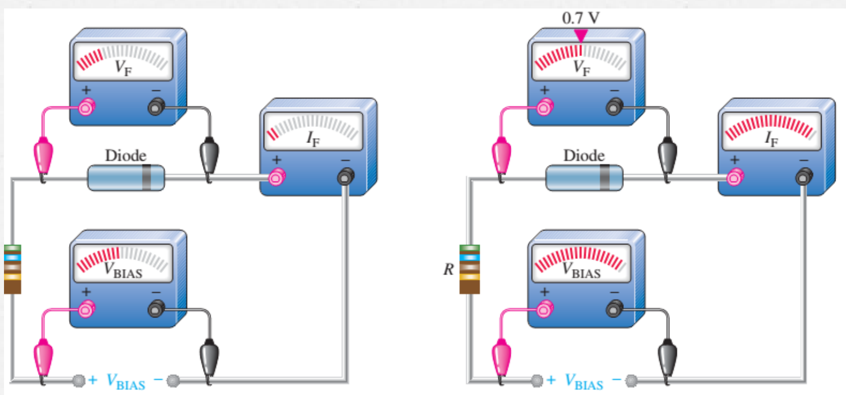


- **Voltage-Current (V-I) Characteristic of A Diode**
- **V-I Characteristic for Forward Bias**

The **current in forward biased** called **forward current** and is **designated** I_f.

At 0V (Vbias) across the diode, there is **no forward current**. Figure 5 illustrates what happens as the forward-bias voltage is increased positively from 0 V.

The **resistor is used** to limit the forward current to a value that will **not overheat the diode and cause damage**.



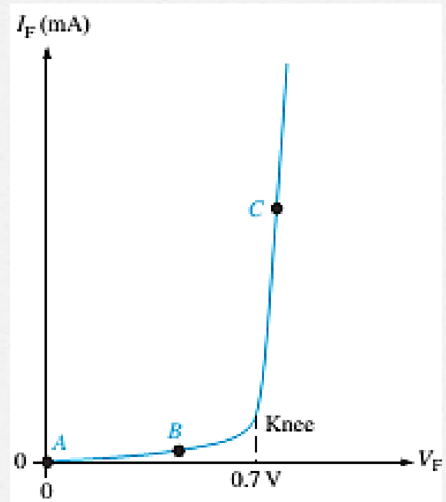


Figure 5: Relationship of voltage and current in a forward-biased diode.

With a **gradual increase of V_{bias}**, the forward voltage and forward current **increase**.

A portion of **forward-bias voltage (V_f) drops** across the limiting resistor.

The continuing **increase of V_f** causes a **rapid increase of forward current**

but the **voltage** across the diode increases only **gradually above 0.7 V.**

The **resistance of the forward-biased** diode is not constant, **but** it changes over the entire curve.

Therefore, it is **called dynamic resistance.**