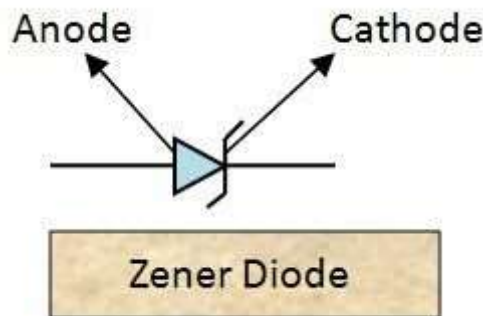


# Zener Diode

**Definition:** Zener diode is specially designed for operation in the breakdown region in reverse bias condition. It is also called breakdown diode. In order to achieve sharp breakdown voltage, it is properly doped. **American Scientist C. Zener** explained the phenomenon of the breakdown.

In the previous article, we have discussed diodes. Diodes can be classified into different types by its operational mechanism. Thus, they are designed in various ways for specific applications.

Different diodes used as switching elements are the zener diode, tunnel diode, Varactor diode, Schottky diode, power diodes, etc. We will discuss Zener diode and its applications in this article.

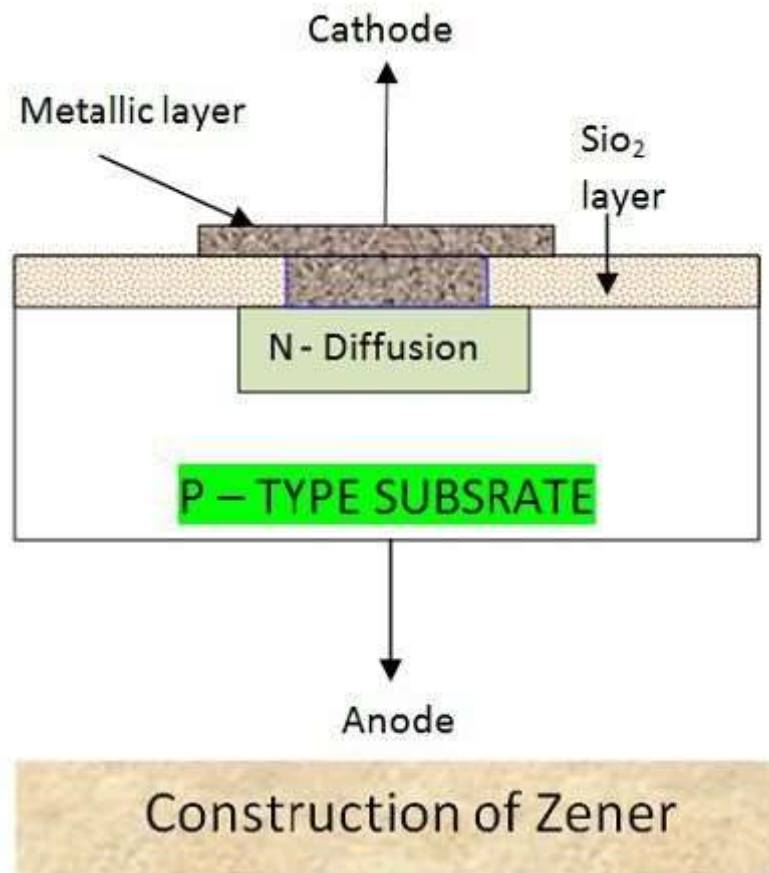


**Symbol of Zener Diode**

## Construction of Zener diode

There are various methods which are used for manufacturing Zener diodes such as **diffused structure**, **diffused** and **passivated structure** and **alloy diffused structure**. In diffused structure of zener diode, two N and P substrates diffused together and had metallic layers deposited on both the sides to connect anode and cathode terminals on both the sides.

In passivated structure of a Zener diode, the edges of the junction are covered by the layer of oxides of Silica.



Alloy diffused structures have all junction covered by the layer of Silica oxides to prevent the junctions. In general alloy diffused structures gives better performance at lower Zener voltages. On the contrary, passivated and diffused structure gives better performance at higher voltages.

## Working Principle of Zener Diode

A Zener diode is similar to conventional PN Junction diode except that it is properly doped to achieve sharp breakdown voltage. There are two types of mechanism by which breakdown can occur at reverse PN junction that are **avalanche** and **Zener breakdown**.

## Zener Breakdown

Zener breakdown occurs due to high reverse Voltage. When the high reverse voltage is applied the width of depletion layer increases. Due to this potential barrier increases and a high electric field is generated at the junction. This high electric field breaks the covalent bond and a large number of minority charge carrier are generated.

Thus, current increases suddenly due to the movement of minority charge carriers and sometimes it leads to the breakdown of the junction. This is called of **Zener breakdown**. This is observed in diodes having a reverse voltage of **less than 5 volts**.

# Avalanche Breakdown

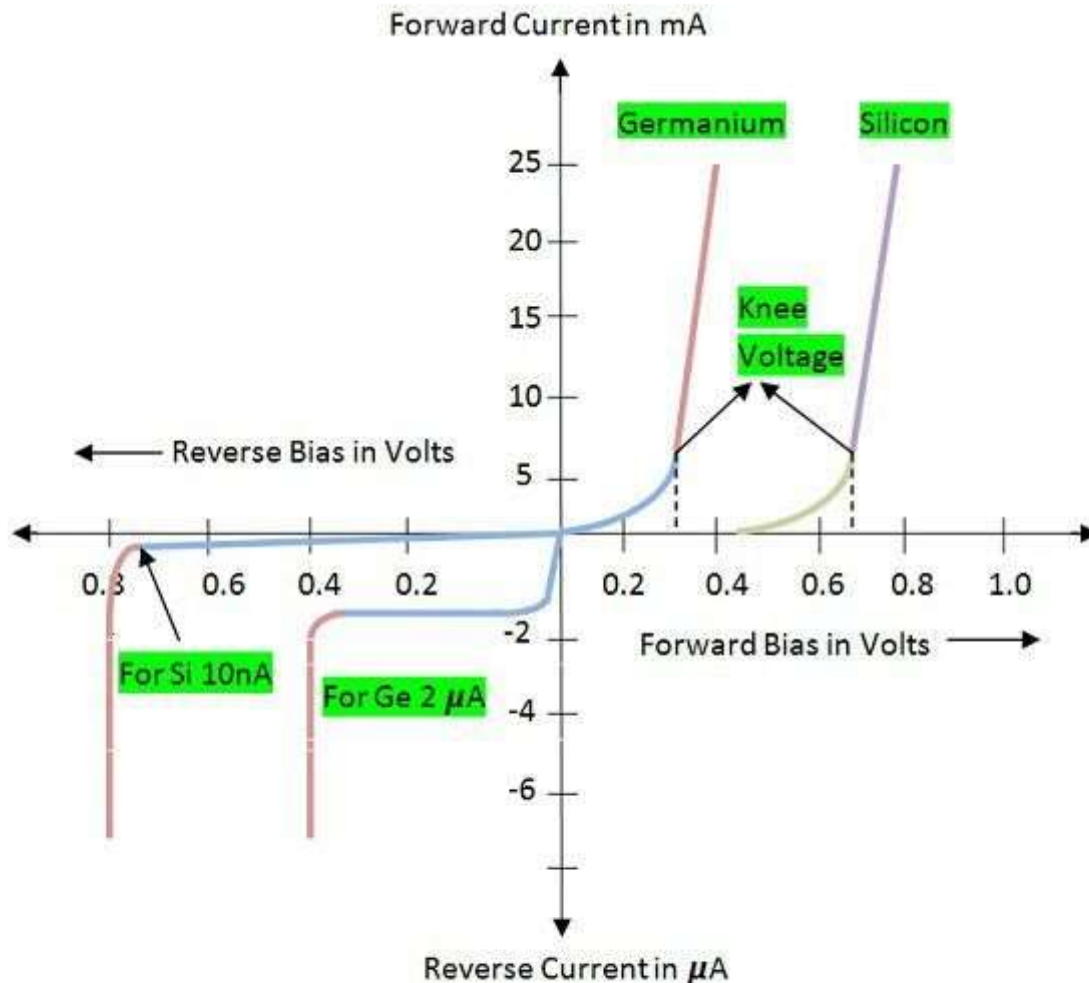
Avalanche Breakdown mechanism comes into picture when the reverse voltage becomes extremely high. At such a high reverse voltage, the minority carriers get extremely high kinetic energy. Due to which they easily detach electrons from the covalent bond.

Thus, these free electrons, in turn, collide with other atoms to liberate more electrons. In this way, the current becomes very large that it leads to the breakdown of the diode. **Avalanche breakdown** occurs when the reverse voltage becomes **higher than 5V**.

A Zener diode can use any of these two breakdown mechanisms. Although there are two types of breakdown mechanism, still only name Zener is preferred. Silicon and Germanium both can be used for the construction of Zener diode, but Silicon is often used because of it can operate at higher temperature, and current capability of silicon is high.

## Volt-Ampere Characteristics of Zener diode

We have already discussed earlier that when the reverse voltage increases at a particular point, the junction breakdowns due to large reverse current. The voltage at which current starts increasing rapidly and the stage of breakdown is reached it is called Zener Voltage. The current which increases rapidly is called **Zener Current**.



Zener Diode Characteristics for Germanium and Silicon

The diagram represents the Volt-Ampere Characteristics of Silicon and Germanium diodes. It is operated in breakdown region, and the current is limited by dynamic resistance called zener impedance. The magnitude of zener voltage is dependent on the amount of doping.

The forward Characteristics of Zener diode is similar to that of ordinary PN Junction Diode. But the reverse characteristics are slightly different. During the operation in breakdown region, it does not burn out immediately. As long as the current through the diode is limited by the external circuit within permissible values, it does not burn out.

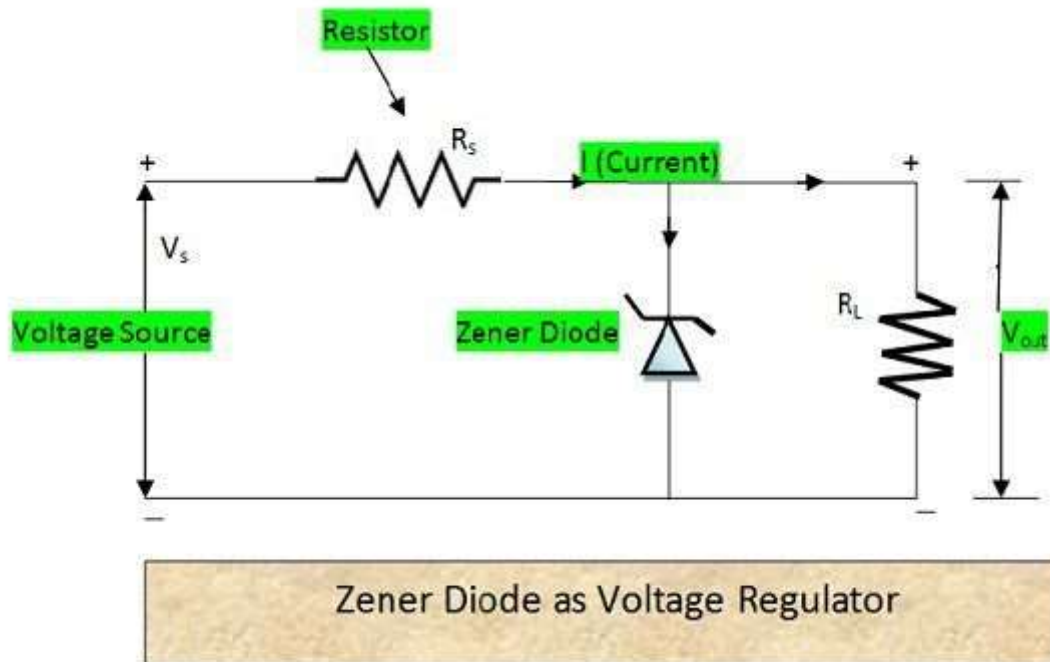
A heavily doped diode will have very thin depletion layer. Thus, Zener voltage will be very low. In this way, depletion layer and zener voltage can be controlled with the help of doping concentration.

**Zener impedance:** It is the dynamic resistance of a zener diode. It is represented by  $r_z$ .

$$r_z = \Delta V_z / \Delta I_z$$

# Applications of Zener Diode

**1. Zener Diode as Voltage Regulator:** Voltage regulator is a device which maintains constant output voltage without bothering about variation in input voltage and load current. Zener diode is used as the voltage regulator.



The supply voltage  $V_s$  and the resistance  $R_s$  are so designed that the diode operates in breakdown region. Besides, Resistor  $R_s$  is used to limit the value of reverse current through the diode. The diode voltage  $V_z$  which is same as the voltage across the load  $R_L$  is the zener voltage  $V_z$ .

Besides, the series resistor  $R_s$  absorbs the excess current to maintain constant output voltage. In this way, Zener diode maintains constant output voltage and eliminates the effect of voltage fluctuation and provide voltage regulation.

**2. For Switching Operations:** Zener diode is used as a switch. It is because of its ability to produce change from low current to high current. Thus, it is used as a switch.

**3. As Clipper:** Zener diode is used in wave shaping circuit as a clipper. It is used to clip input waveform in specific applications.

**4. As a reference element:** In various circuits reference elements are required for comparing voltages to a reference value. Thus, in such circuits, Zener diode is used as a reference element.

**5. Meter protection:** Zener diode is used in electronics circuit for the protection of multimeter. In some cases, excess current flows through a circuit and damage the multimeter. Thus, Zener diodes protect it from damage by providing voltage regulation.

Zener diode is significant to use in breakdown region. Due to its doping characteristics, the zener diode is made to use at high breakdown voltage.