How Tunnel Diode Works?

Step 1: Unbiased Tunnel Diode

When no voltage is applied to the tunnel diode, it is said to be an unbiased tunnel diode. In tunnel diode, the conduction band of the n-type material overlaps with the valence band of the p-type material because of the heavy doping. Because of this overlapping, the conduction band electrons at n-side and valence band holes at p-side are nearly at the same energy level.

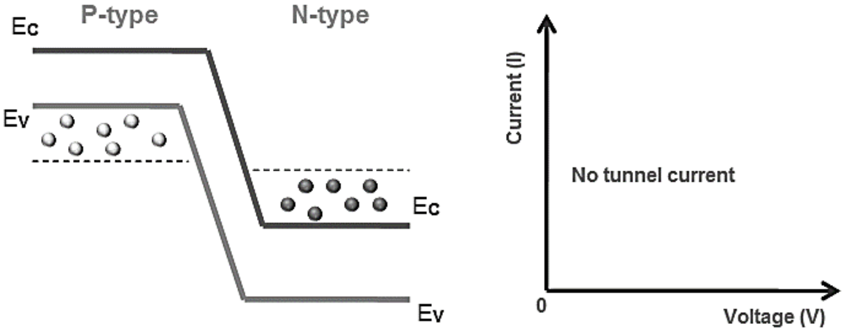

Figure: Unbiased Tunnel Diode

When the temperature increases, some electrons tunnel from the conduction band of n-region to the valence band of p-region. In a similar way, holes tunnel from the valence band of p-region to the conduction band of n-region. However, the net current flow will be zero because an equal number of charge carriers (free electrons and holes) flow in opposite directions.

Step 2: Small Voltage Applied to the Tunnel Diode

When a small voltage is applied to the tunnel diode which is less than the built-in voltage of the depletion layer, no forward current flows through the junction. However, a small number of electrons in the conduction band of the n-region will tunnel to the empty states of the valence band in p-region. This will create a small forward bias tunnel current. Thus, tunnel current starts flowing with a small application of voltage.

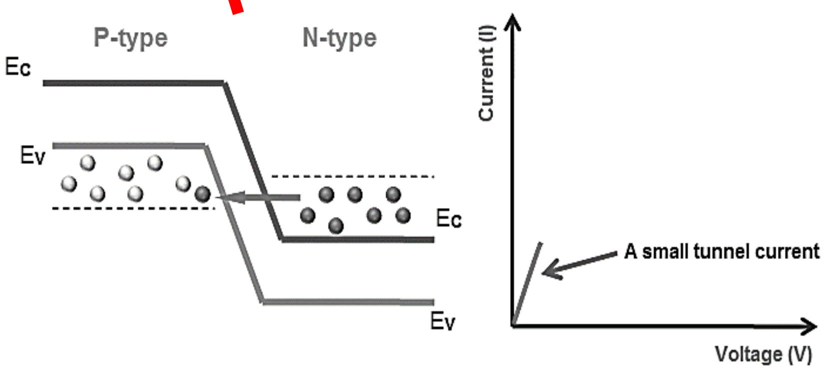

Figure: Small Tunneling

Step 3: Applied Voltage is Slightly Increased

When the voltage applied to the tunnel diode is slightly increased, a large number of free electrons at n-side and holes at p-side are generated. Because of the increase in voltage, the overlapping of the conduction band and valence band is increased.

In simple words, the energy level of an n-side conduction band becomes exactly equal to the energy level of a p-side valence band. As a result, maximum tunnel current flows.

2.2 Schottky diode

Schottky diode is a metal-semiconductor junction diode that has less forward voltage drop than the P-N junction diode and can be used in high-speed switching applications. In a normal p-n junction diode, a p-type semiconductor and an n-type semiconductor are used to form the p-n junction. When a p-type semiconductor is joined with an n-type semiconductor, a junction is formed between the P-type and N-type semiconductor. This junction is known as P-N junction. In Schottky diode, metals such as aluminum or platinum replace the P-type semiconductor. The Schottky diode is named after German physicist Walter H. Schottky. Schottky diode is also known as Schottky barrier diode, surface barrier diode, majority carrier device, hot-electron diode, or hot carrier diode. Schottky diodes are widely used in radio frequency (RF) applications.

When aluminum or platinum metal is joined with N-type semiconductor, a junction is formed between the metal and N-type semiconductor. This junction is known as a metal-semiconductor junction or M-S junction. A metal-semiconductor junction formed between a metal and n-type semiconductor creates a barrier or depletion layer known as a Schottky barrier. The metal-semiconductor junction can be either non-rectifying or rectifying. The non-rectifying metal-semiconductor junction is called Ohmic contact. The rectifying metal-semiconductor junction is called non-Ohmic contact.

Schottky diode can switch on and off much faster than the p-n junction diode. Also, the Schottky diode produces less unwanted noise than p-n junction diode. These two characteristics of the Schottky diode make it very useful in high-speed switching power circuits.

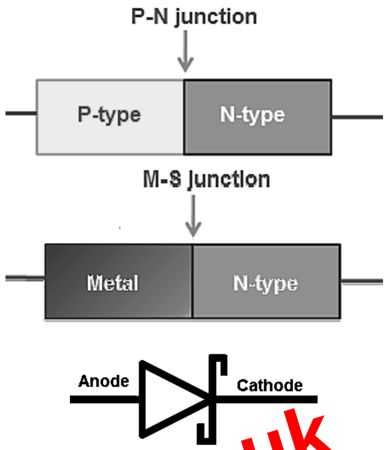

Figure: Schottky Diode

When sufficient voltage is applied to the Schottky diode, current starts flowing in the forward direction. Because of this current flow, a small voltage loss occurs across its terminals. This voltage loss is known as voltage drop. A silicon diode has a voltage drop of 0.6 to 0.7 volts, while a Schottky diode has a voltage drop of 0.2 to 0.3 volts. Voltage loss or voltage drop is the amount of voltage wasted to turn on a diode. In silicon diode, 0.6 to 0.7 volts is wasted to turn on the diode, whereas in Schottky diode, 0.2 to 0.3 volts is wasted to turn on the diode. Therefore, the Schottky diode consumes less voltage to turn on. The voltage needed to turn on the Schottky diode is same as that of a germanium diode. But germanium diodes are rarely used because the switching speed of germanium diodes is very low as compared to the Schottky diodes.

What is a Schottky Barrier?

Schottky barrier is a depletion layer formed at the junction of a metal and n-type semiconductor. In simple words, Schottky barrier is the potential energy barrier formed at the metal-semiconductor junction. The electrons have to overcome this potential energy barrier to flow across the diode. The rectifying M-S junction forms a rectifying Schottky barrier. This rectifying Schottky barrier is used for making a device known as Schottky diode. The non-rectifying metal-semiconductor junction forms a non-rectifying Schottky barrier.

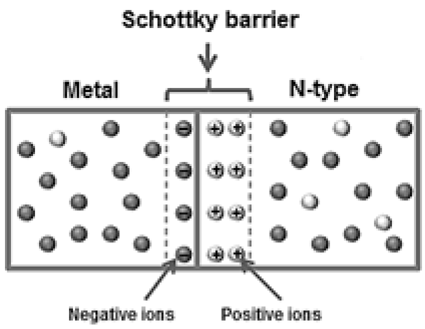

Figure: Schottky Barrier