

Schottky diode

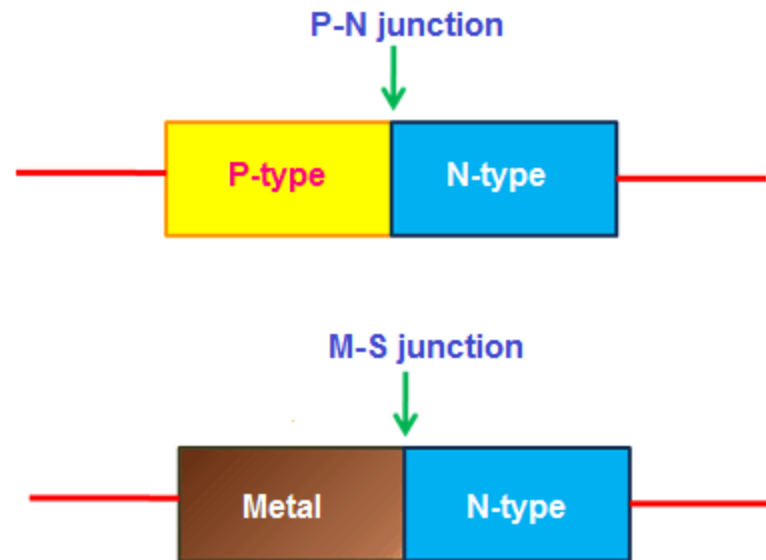
Schottky diode definition

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.

What is a schottky diode?

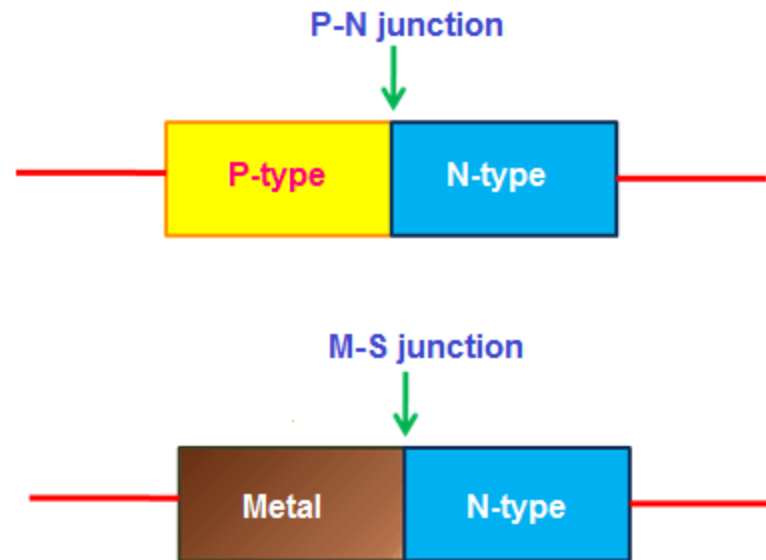
In a normal [p-n junction diode](#), a [p-type semiconductor](#) and an [n-type semiconductor](#) are used to form the [p-n junction](#). When a p-type semiconductor is joined with an n-type semiconductor, a junction is formed between the P-type and N-type semiconductor. This junction is known as P-N 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.

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.

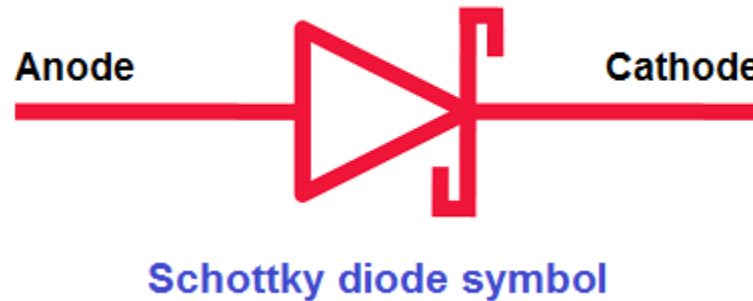


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Symbol of schottky diode

The symbol of schottky diode is shown in the below figure. In schottky diode, the metal acts as the anode and n-type semiconductor acts as the cathode.



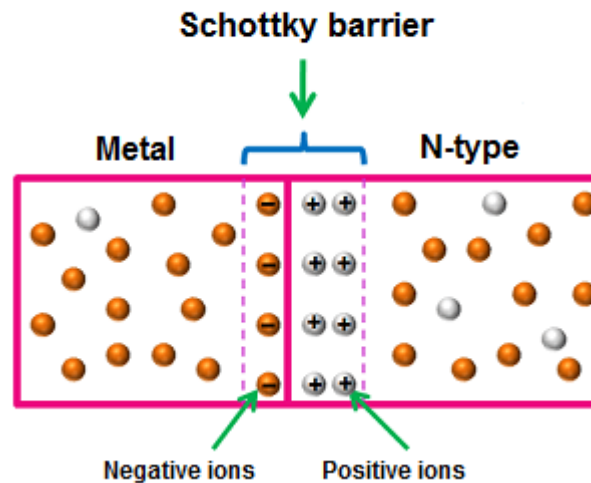
Metal-semiconductor (M-S) junction

Metal-semiconductor (M-S) junction is a type of junction formed between a metal and an n-type semiconductor when the metal is joined with the n-type semiconductor. Metal-semiconductor junction is also sometimes referred to as M-S junction.

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.

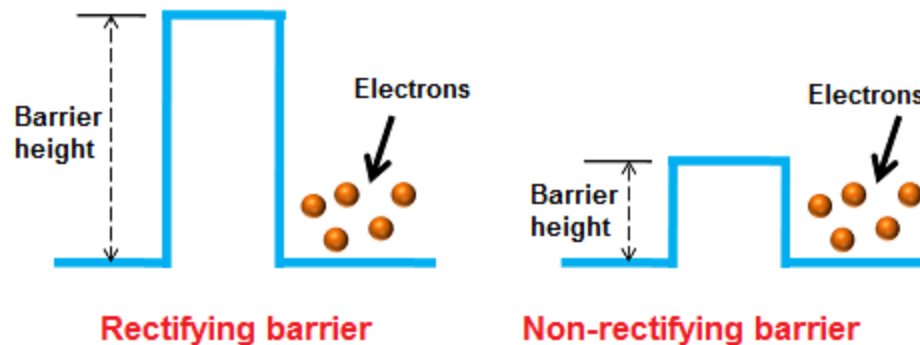
The rectifying metal-semiconductor junction forms a rectifying schottky barrier. This rectifying schottky barrier is used for making a device known as schottky diode. The non-rectifying metal-semiconductor junction forms a non-rectifying schottky barrier.



One of the most important characteristics of a schottky barrier is the schottky barrier height. The value of this barrier height depends on the combination of semiconductor and metal.

The schottky barrier height of ohmic contact (non-rectifying barrier) is very low whereas the schottky barrier height of non-ohmic contact (rectifying barrier) is high.

In non-rectifying schottky barrier, the barrier height is not high enough to form a [depletion region](#). So depletion region is negligible or absent in the ohmic contact diode.

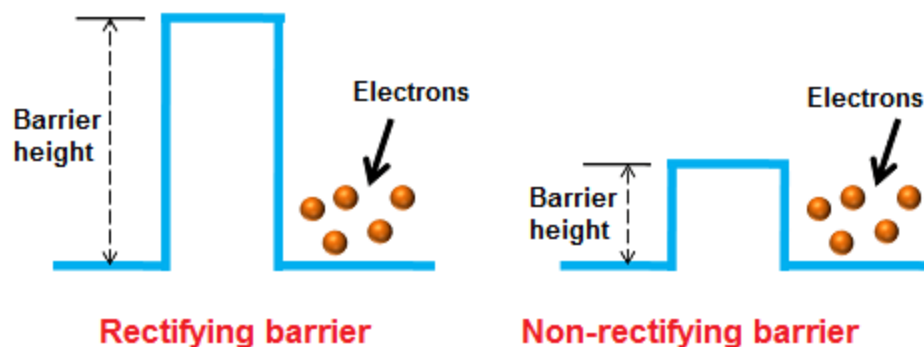


On the other hand, in rectifying schottky barrier, the barrier height is high enough to form a depletion region. So the depletion region is present in the non-ohmic contact diode.

The non-rectifying metal-semiconductor junction (ohmic contact) offers very low resistance to the electric current whereas the rectifying metal-semiconductor junction offers high resistance to the electric current as compared to the ohmic contact.

The rectifying schottky barrier is formed when a metal is in contact with the lightly doped semiconductor, whereas the non-rectifying barrier is formed when a metal is in contact with the heavily doped semiconductor.

The ohmic contact has a linear current-voltage (I-V) curve whereas the non-ohmic contact has a non-linear current-voltage (I-V) curve.



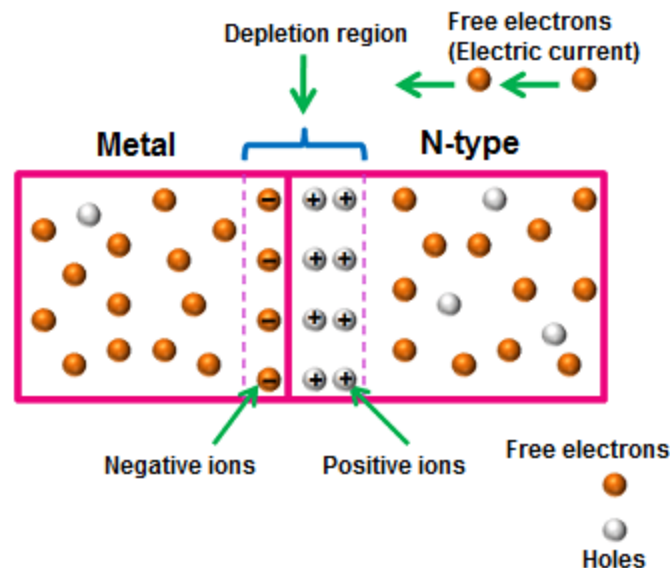
How schottky diode works?

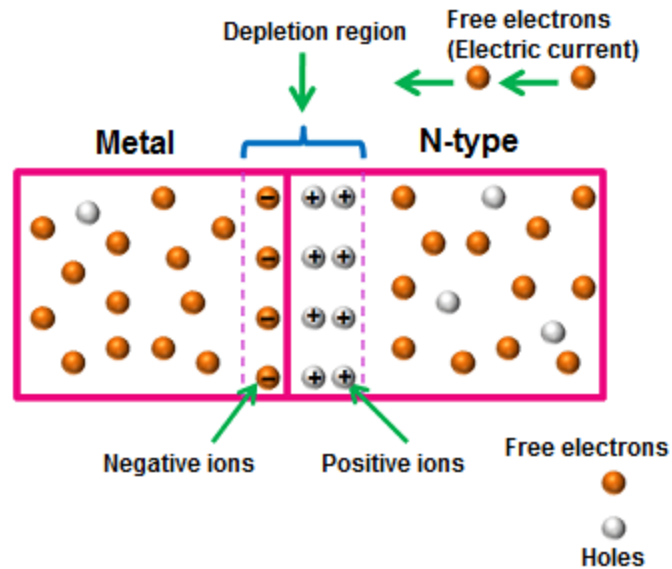
Unbiased schottky diode

When the metal is joined with the n-type semiconductor, the conduction band electrons (free electrons) in the n-type semiconductor will move from n-type semiconductor to metal to establish an equilibrium state.

We know that when a neutral [atom](#) loses an electron it becomes a positive ion similarly when a neutral atom gains an extra electron it becomes a negative ion.

The conduction band electrons or [free electrons](#) that are crossing the junction will provide extra electrons to the atoms in the metal. As a result, the atoms at the metal junction gains extra electrons and the atoms at the n-side junction lose electrons.



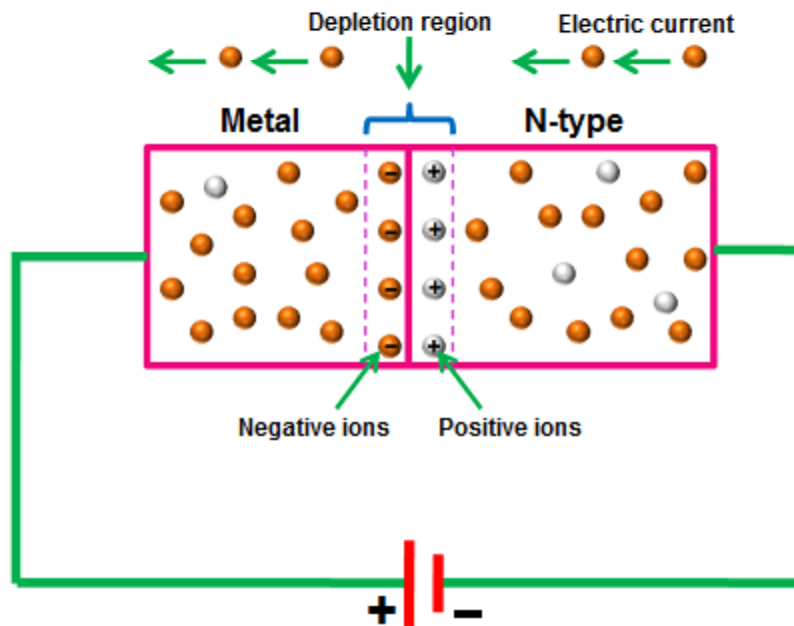


The atoms that lose electrons at the n-side junction will become positive ions whereas the atoms that gain extra electrons at the metal junction will become negative ions. Thus, positive ions are created the n-side junction and negative ions are created at the metal junction. These positive and negative ions are nothing but the depletion region. Since the metal has a sea of free electrons, the width over which these electrons move into the metal is negligibly thin as compared to the width inside the n-type semiconductor. So the built-in-potential or built-in-voltage is primarily present inside the n-type semiconductor. To overcome this barrier, the free electrons need energy greater than the built-in-voltage. In unbiased schottky diode, only a small number of electrons will flow from n-type semiconductor to metal. The built-in-voltage prevents further electron flow from the semiconductor conduction band into the metal. The transfer of free electrons from the n-type semiconductor into metal results in energy band bending near the contact.

Forward biased schottky diode

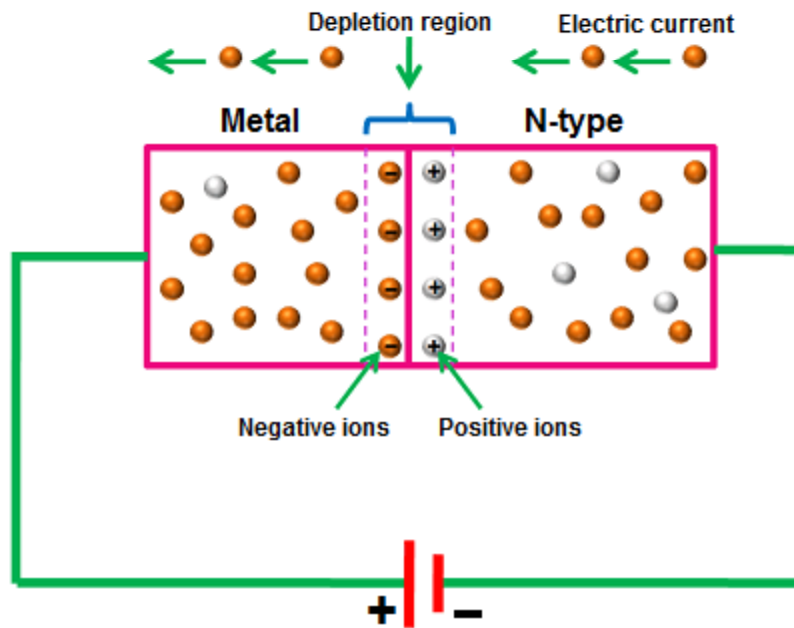
If the positive terminal of the battery is connected to the metal and the negative terminal of the battery is connected to the n-type semiconductor, the schottky diode is said to be forward biased.

When a forward bias voltage is applied to the schottky diode, a large number of free electrons are generated in the n-type semiconductor and metal. However, the free electrons in n-type semiconductor and metal cannot cross the junction unless the applied voltage is greater than 0.2 volts.



If the applied voltage is greater than 0.2 volts, the free electrons gain enough energy and overcomes the built-in-voltage of the depletion region. As a result, electric current starts flowing through the schottky diode.

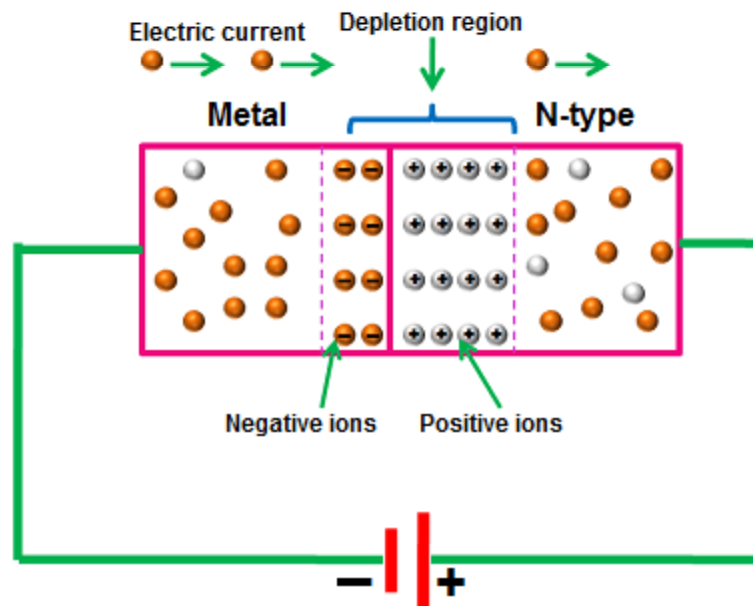
If the applied voltage is continuously increased, the depletion region becomes very thin and finally disappears.



Reverse bias schottky diode

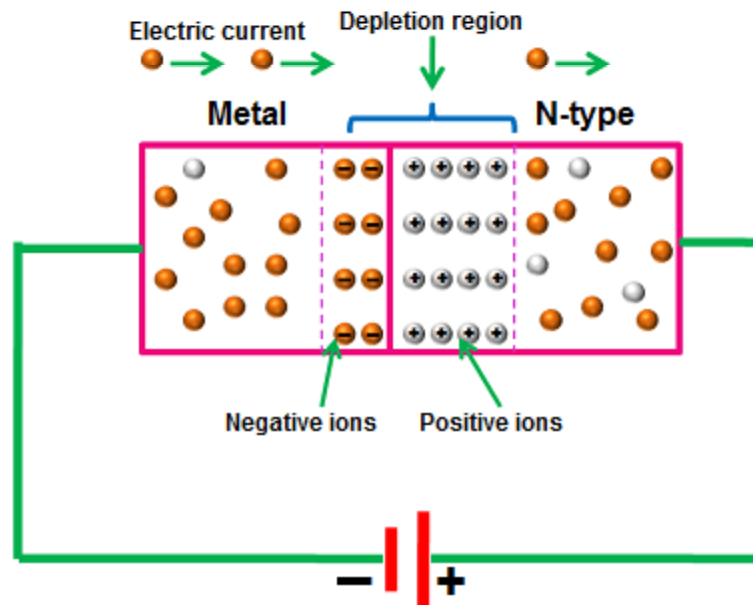
If the negative terminal of the battery is connected to the metal and the positive terminal of the battery is connected to the n-type semiconductor, the schottky diode is said to be reverse biased.

When a reverse bias voltage is applied to the schottky diode, the depletion width increases. As a result, the electric current stops flowing. However, a small leakage current flows due to the thermally excited electrons in the metal.



If the reverse bias voltage is continuously increased, the electric current gradually increases due to the weak barrier.

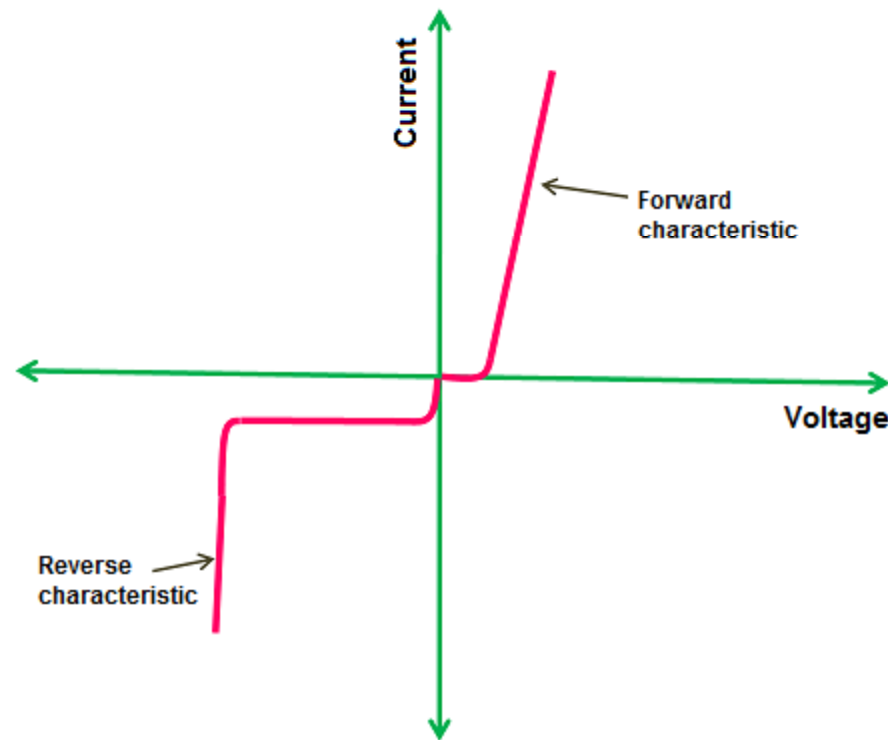
If the reverse bias voltage is largely increased, a sudden rise in electric current takes place. This sudden rise in electric current causes depletion region to break down which may permanently damage the device.



V-I characteristics of schottky diode

The V-I (Voltage-Current) characteristics of schottky diode is shown in the below figure. The vertical line in the below figure represents the current flow in the schottky diode and the horizontal line represents the voltage applied across the schottky diode.

The V-I characteristics of schottky diode is almost similar to the P-N junction diode. However, the forward voltage drop of schottky diode is very low as compared to the P-N junction diode.

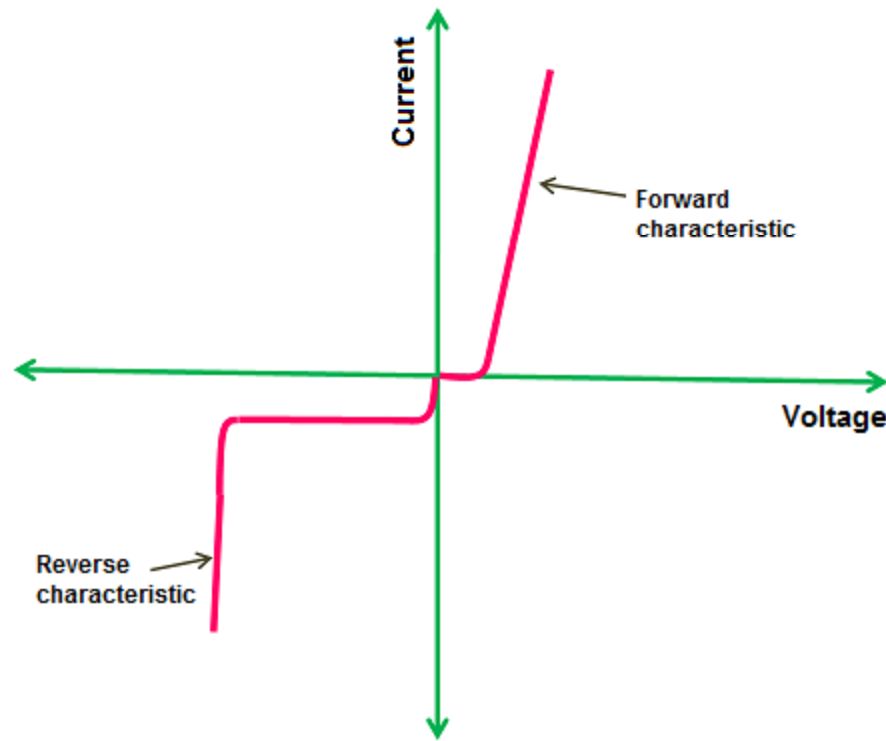


V-I characteristics of schottky diode

The forward voltage drop of schottky diode is 0.2 to 0.3 volts whereas the forward voltage drop of silicon P-N junction diode is 0.6 to 0.7 volts.

If the forward bias voltage is greater than 0.2 or 0.3 volts, electric current starts flowing through the schottky diode.

In schottky diode, the reverse saturation current occurs at a very low voltage as compared to the silicon diode.



V-I characteristics of schottky diode