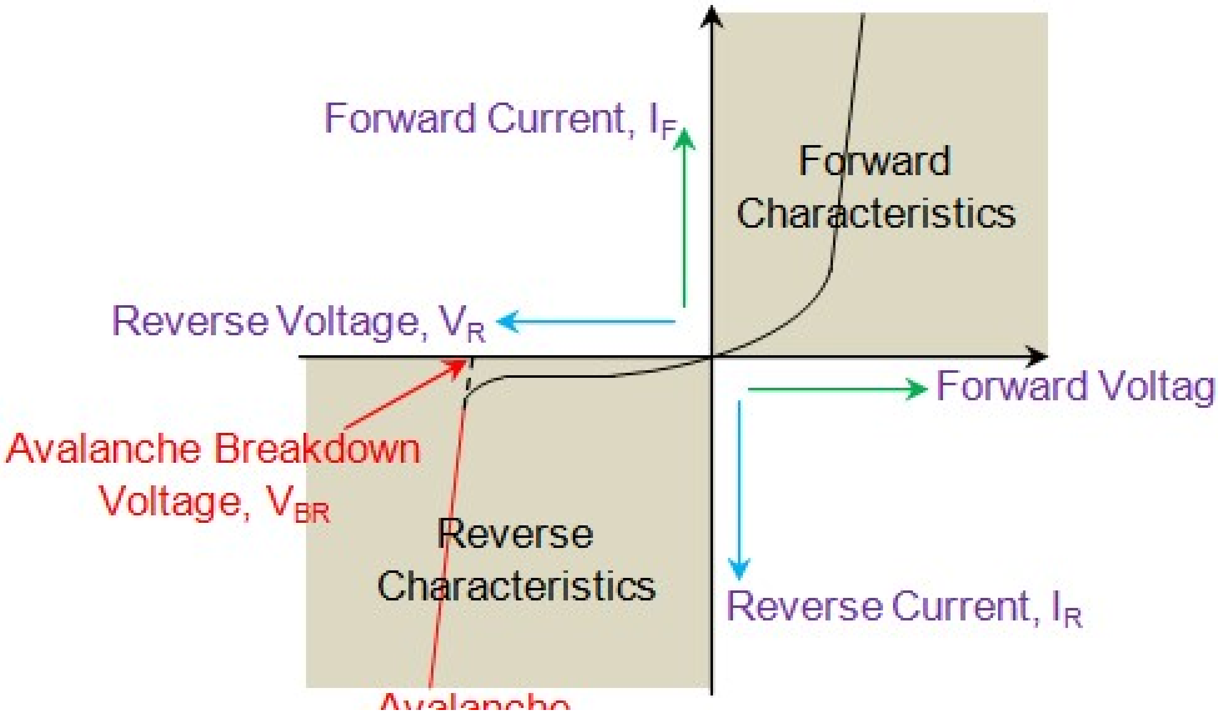
What is Avalanche Breakdown

A p-type semiconductor material in contact with an n-type semiconductor material forms a p-n junction in which a depletion region occurs around the plane of contact. The width of this depletion region is seen to vary depending on the bias applied at the terminals of the p-n junction i.e. an increase in the applied voltage reduces the width of the depletion region in case of forward bias, while it increases the depletion region width for the case of reverse bias. Further the span of the depletion region is found to be more for a lightly doped material when compared to that of a heavily doped material.

Figure 1 shows the I-V characteristics of such a p-n junction both for the case of forward- as well as reverse-bias. From the figure, it is clear that the current through the semiconductor rises with an increase in the magnitude of the applied voltage when the p-n junction is forward biased. Further it is seen that there will be a certain amount of minimum current flowing through the p-n junction under the reverse bias condition. This current is referred to as the reverse saturation current (I_s) and is due to the minority charge carriers in the semiconductor device.



Moreover I_s is observed to be almost independent of the applied voltage at its initial stage. However after reaching a particular point, the junction breaks-down leading to the heavy flow of reverse current through the device. This is because, as the magnitude of the reverse voltage increases, the kinetic energy of the minority charge carriers also increase. These fast moving electrons collide with the other atoms in the device to knock-off some more electrons from them. The electrons so released further release much more electrons from the atoms by breaking the covalent bonds. This process is termed as carrier multiplication and leads to a considerable increase in the flow of current through the p-n junction. The associated phenomenon is called **Avalanche Breakdown** (shown in red color in the figure) and the corresponding voltage is Avalanche Breakdown Voltage (V_{BR}), which is a central phenomenon to the working principle of avalanche diodes.

The efficiency of Avalanche breakdown can be expressed in terms of multiplication factor, M given by

$$M = \frac{1}{1 - |\frac{V}{V_{BR}}|^n} \quad Where,\ 2 < n < 6$$

Here, V and V_{BR} represent the applied voltage and the breakdown voltage, respectively. **Avalanche breakdown** occurs in lightly doped p-n junctions when the reverse voltage increases beyond 5 V. Further, it is difficult to control this phenomenon as the number of charge carriers generated cannot be directly controlled. Moreover the Avalanche breakdown voltage has positive temperature coefficient meaning which the **Avalanche breakdown** voltage increases with the increase in the junction temperature.