AVALANCHE TRANSIT TIME DEVICES- IMPATT DIODE

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The process of having a delay between voltage and current, in avalanche together with transit time, through the material is said to be Negative resistance. The devices that helps to make a diode exhibit this property are called as **Avalanche transit time devices**.

Examples: IMPATT DIODE

The IMPATT microwave diode uses avalanche breakdown combined and the charge carrier transit time to create a negative resistance region which enables it to act as an oscillator.

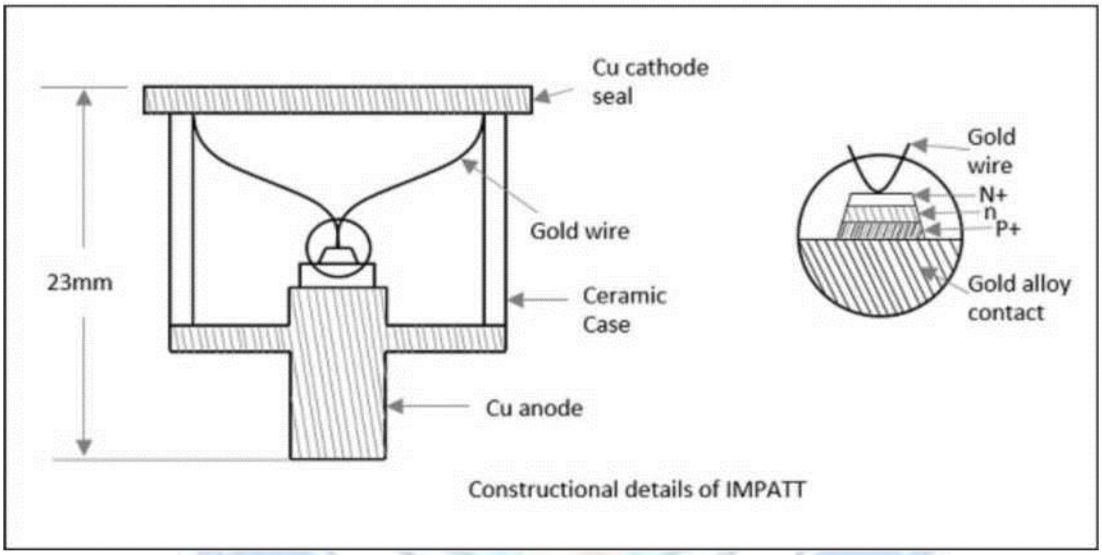

Figure 3.27 Constructional Detail of IMPATT

- The IMPATT diode has a very similar I-V characteristic to any other form of PN junction diode.
- It conducts in the forward direction once the turn on voltage has been reached.
- In the reverse direction it blocks current flow, until the diode breakdown voltage is reached.
- At this point avalanche breakdown occurs and current flows in the reverse direction.

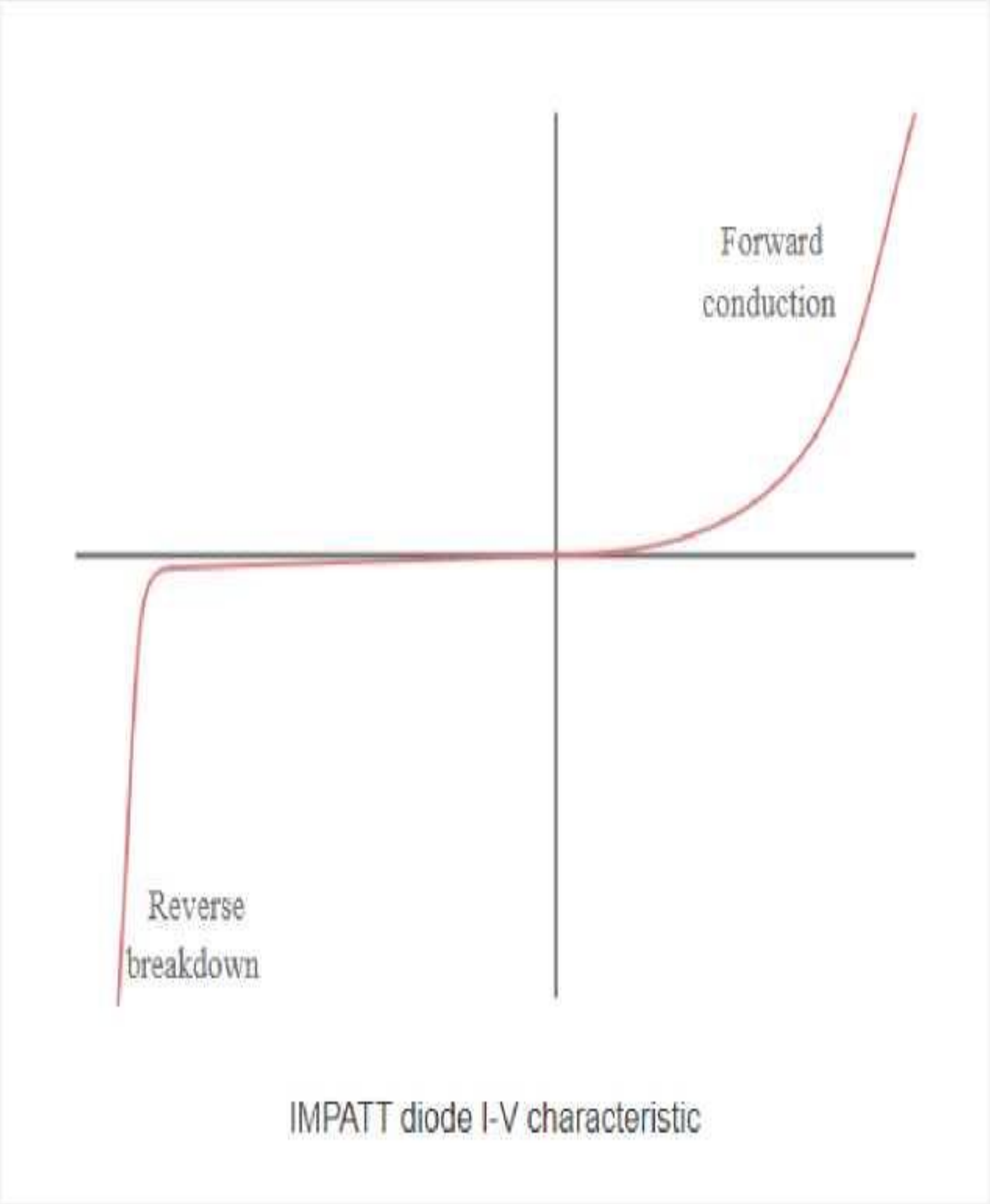

Figure 3.28 IMPATT diode VI characteristics

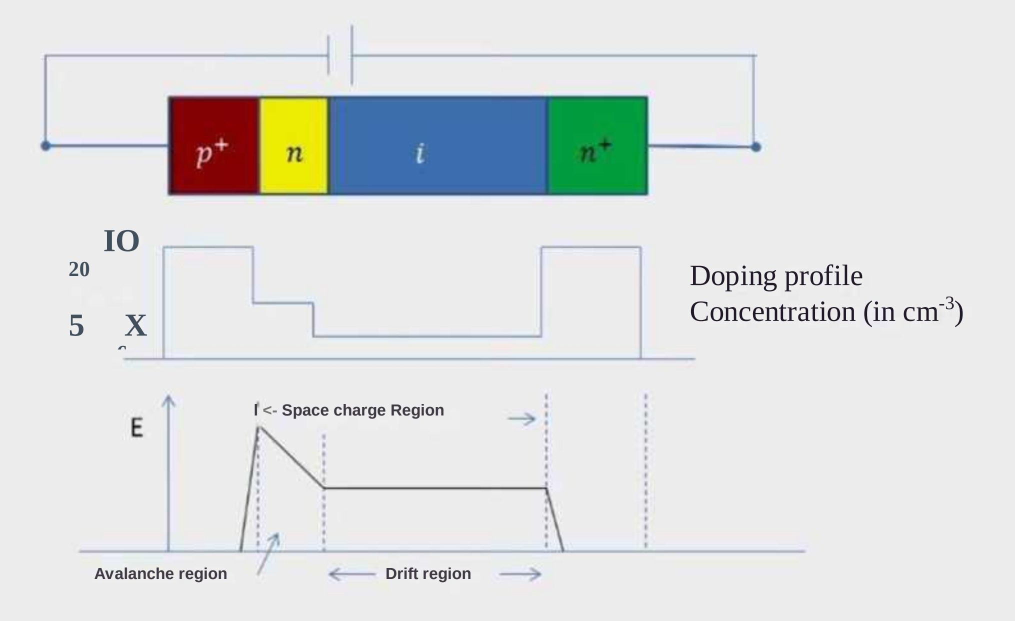

Figure 3.29 IMPATT diode doping profile

- Due to the heavy doping in the p-region the depletion region will be mostly in the n - region
- In the electric field distribution of IMPATT

(1) Avalanche region.......... extreme high electric field strength -charge multiplication in RB

(2) Drift region .... carriers generated during drift

Operation:- A very high voltage 400 kV/cm is applied to the IMPATT diode, resulting in a very high current. A normal diode would easily break down under this condition, but IMPATT diode is constructed such that it will withstand these conditions repeatedly. Such a high potential gradient back biasing the diode causes a flow of minority carriers across the junction.

If it is now assumed that oscillations exist, we may consider the effect of a positive swing of the RF voltage superimposed on top of the high dc voltage. Electron and hole velocity has now become so high that these carriers form additional holes and electrons by knocking them out of the crystal structure, by so called impact ionization. We have two steps to understand the operation

Step I-These additional carriers continue the process at the junction and the voltage will be exceeded during the whole of the +ve RF cycle. The avalanche current multiplication will be taking place during this entire time. Since avalanche is a multiplication process, it is not instantaneous or we can say it is a cumulative process. This process takes time such that the current pulse maximum, at the junction, occurs at the instant when the RF voltage across the diode is zero and going negative. A 900 phase difference between voltage and current has been obtained.

Step II- The current pulse in the IMPATT diode is situated at the junction. However it does not stay there because of the reverse bias, the current pulse flows to the cathode, at a drift velocity depending on the presence of the high dc field. The time taken by the pulse to reach the cathode depends on this velocity and on the thickness of the highly doped n+ layer. The thickness of the drift space is adjusted such that time taken for current pulse to arrive at the cathode corresponds to further 900 phase difference.

Thus voltage and current are 1800 out of phase and a dynamic RF negative resistance has been proved to exist. In summary, negative resistance phenomenon is taken into account by using

1. The impact multiplication avalanche effect, which causes the minority current to lag the microwave output voltage by 900. phase shift
2. The effect of transit time through the drift region, this results in the external current lagging the microwave voltage by a further 900 phase shift.