Working of Gunn Diode and its characteristics

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December 06, 2020

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Introduction

- Gunn Diode Gunn Diode is a transferred electronic device, which is composed of only one type of semiconductor(N-type) and utilizes the Negative resistance characteristics to generate current at higher frequencies.
- Basically it is used to generate RF and microwave frequencies. It is composed of only N-type semiconductor because N-type semiconductors has electrons as majority charge carriers.
- And transferred electronic devices use such materials which have electrons as majority charge carrier.

Construction

- It is made up of three layers of N-type semiconductor.
- The semiconductor used in Gunn Diode are Gallium Arsenide(GaAs),Gallium Nitride(GaN), Cadmium Telluride(CdTe), Cadmium Sulphide(CdS), Indium Phosphide(InP), Indium Arsenide(InAs), Indium Antimonide(InSb) and Zinc Selenide(ZnSe).
- Among the three layers, the top most and the bottom most layer are heavily doped while the middle layer is lightly doped.
- The metal contacts are provided on extreme layers to facilitate biasing. The heat sink present there is used to withstand excessive heat on the diode and prevent it from damage.

Differences between Gunn diode and P-N junction diode

Gunn diode

- It only consists of N type semiconductor material
- It has N+ n N+ material

No depletion region is formed

P-N junction diode

- It consists of P & N type semiconductor material
- It has P type,N type and depletion region between these materials

Gunn Diode Working

- This diode is made of a single piece of N-type semiconductor such as Gallium Arsenide and InP (Indium Phosphide). GaAs and some other semiconductor materials have one extra-energy band in their electronic band structure instead of having only two energy bands, viz. valence band and conduction band like normal semiconductor materials.
- These GaAs and some other semiconductor materials consist of three energy bands, and this extra third band is empty at initial stage.

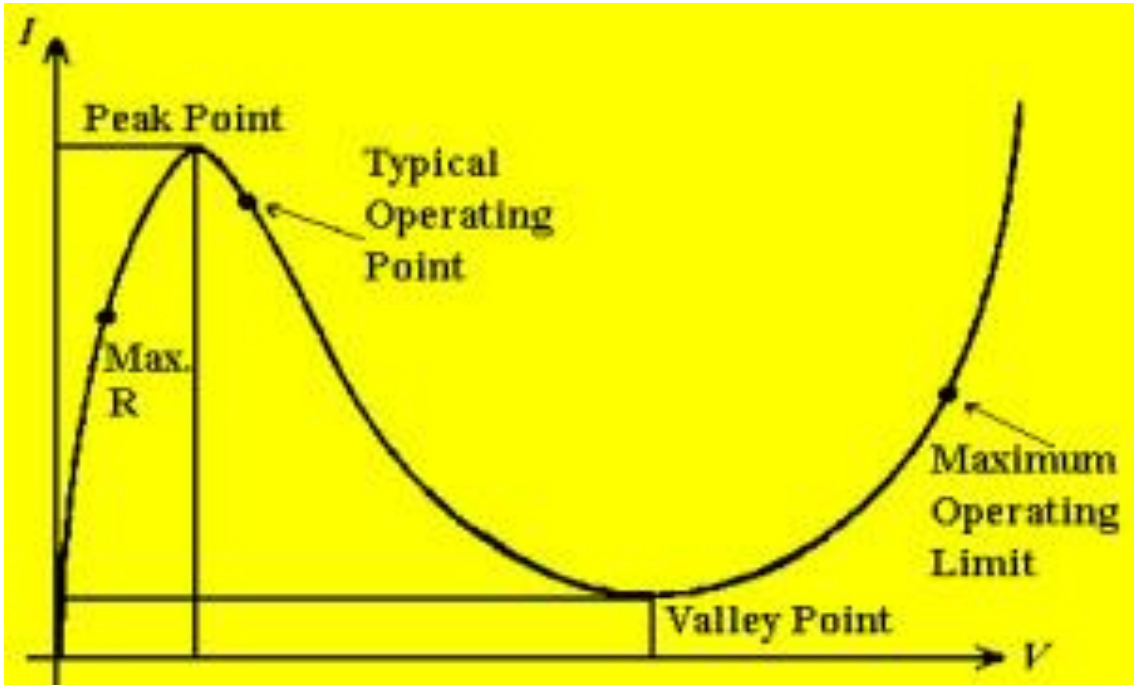
Gunn Diode Working Continue...

- If a voltage is applied to this device, then most of the applied voltage appears across the active region. The electrons from the conduction band having negligible electrical resistivity are transferred into the third band because these electrons are scattered by the applied voltage. The third band of GaAs has mobility which is less than that of the conduction band.
- Because of this, an increase in the forward voltage increases the field strength (for field strengths where applied voltage is greater than the threshold voltage value), then the number of electrons reaching the state at which the effective mass increases by decreasing their velocity, and thus, the current will decrease.

Gunn Diode Working Continue...

- Thus, if the field strength is increased, then the drift velocity will decrease; this creates a negative incremental resistance region in V-I relationship. Thus, increase in the voltage will increase the resistance by creating a slice at the cathode and reaches the anode. But, to maintain a constant voltage, a new slice is created at the cathode. Similarly, if the voltage decreases, then the resistance will decrease by extinguishing any existing slice.

Gunn Diode Characteristics



Gunn Diode Characteristics

- The current-voltage relationship characteristics of a Gunn diode are shown in the above graph with its negative resistance region. These characteristics are similar to the characteristics of the tunnel diode.
- As shown in the above graph, initially the current starts increasing in this diode, but after reaching a certain voltage level (at a specified voltage value called as threshold voltage value), the current decreases before increasing again. The region where the current falls is termed as a negative resistance region, and due to this it oscillates. In this negative resistance region, this diode acts as both oscillator and amplifier, as in this region, the diode is enabled to amplify signals.

Gunn Diode Applications

- Used as Gunn oscillators to generate frequencies ranging from 100mW 5GHz to 1W 35GHz outputs. These Gunn oscillators are used for radio communications, military and commercial radar sources.
- Used as sensors for detecting trespassers, to avoid derailment of trains.

Gunn Diode Application Continue...

- Used as efficient microwave generators with a frequency range of up to hundreds of GHz.
- Used for remote vibration detectors and rotational speed measuring tachometers.
- Used as a microwave current generator (Pulsed Gunn diode generator).
- Used in microwave transmitters to generate microwave radio waves at very low powers.
- Used as fast controlling components in microelectronics such as for the modulation of semiconductor injection lasers.

Gunn Diode Application Continue...

- Used as sub-millimeter wave applications by multiplying Gunn oscillator frequency with diode frequency.
- Some other applications include door opening sensors, process control devices, barrier operation, perimeter protection, pedestrian safety systems, linear distance indicators, level sensors, moisture content measurement and intruder alarms.

Gunn Diode Advantages

- High bandwidth
- High reliability
- Low manufacturing cost
- Fair noise performance (does not use avalanche principle).
- Relatively low operating voltage

Gunn Diode Disadvantages

- Low efficiency below about 10 GHz
- Poor stability – frequency varies with bias and temperature
- FM noise high for some applications
- Small tuning range