UNIT-3 - TRAVELLING WAVE SOLID STATE DEVICES

MICROWAVE SOLID STATE DEVICES: Introduction – Classification – Applications - Transfer Electronic Devices - Gunn Diode – Principles - RWH Theory – Characteristics - Basic Modes of Operation - Gunn Oscillation Modes. LSA Mode.

INTRODUCTION TO OPTICAL FIBERS:

Evolution of fiber optic system- Element of an Optical Fiber Transmission link- Ray Optics- Optical Fiber Modes and Configurations –Mode theory of Optical Propagation - Overview of Modes-Key Modal concepts- Linearly Polarized Modes –Single Mode fibers-Graded Index fiber structure, Fiber materials.

Introduction:

The transferred electron devices or Gunn diodes make use of two terminl device based on the phenomenon known as transferred electron effect.

Transferred electron effect: some materials like GaAs exhibit a negative differential mobility (i.e., a decrease in the carrier velocity with an increase in the electric field) when biased above a thersold value of the electric field. The electrons in the lower-energy band will be transferred into the higher-energy band. The behaviour is called transferred electron effect and device is called transferred electron device or Gunn diode.

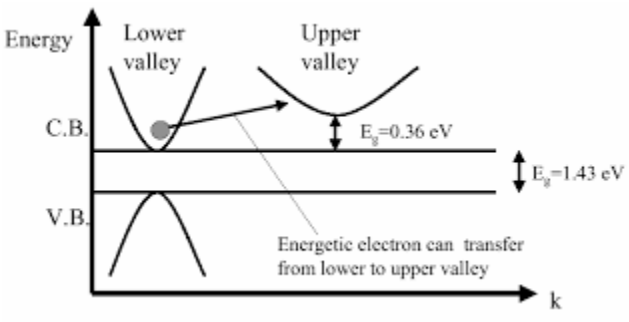


Figure – Gunn Didoe - Energy Band Diagram

In the high-energy band the effective electron mass is larger and hence the electron mobility is lower than what it is in the lower-energy band.

The conductivity is directly proportional to the mobility, there is an intermediate range of electric field strengths for which the fraction of electrons that are transferred into the high-energy low mobility conduction band is such that the average mobility, and hence conductivity decreases with an increase in electric field strength.

The Gunn diodes are negative resistance devices which are normally used as low power oscillator at microwave frequencies in transmitter and also as load oscillator in receiver front ends.

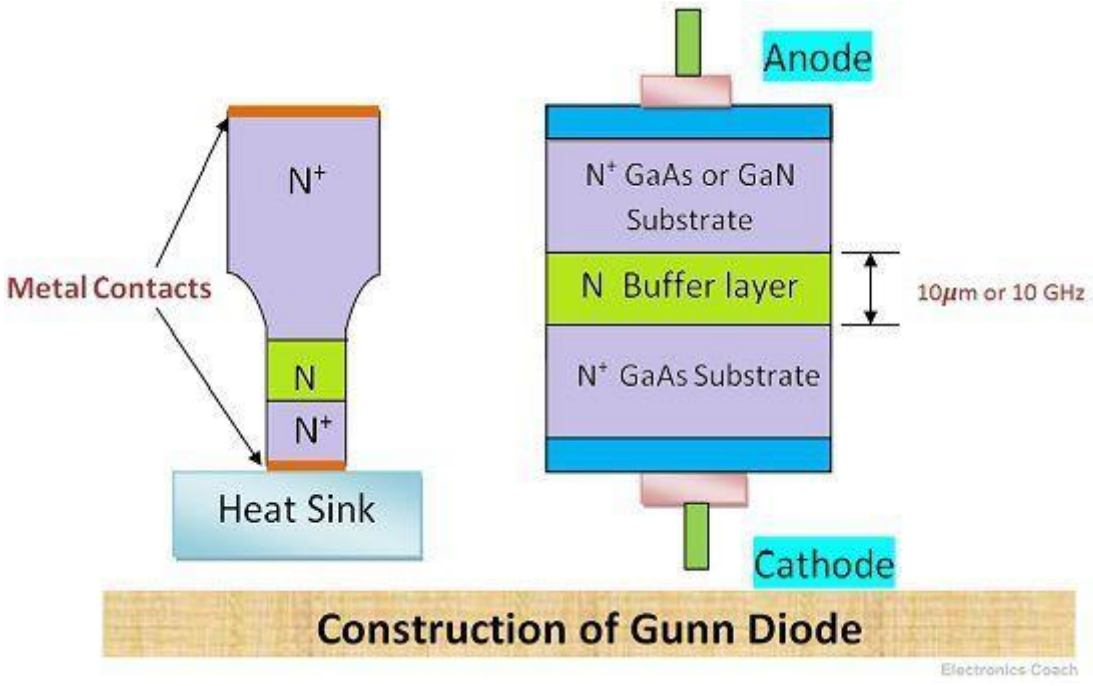
TEDs are fabricated from compound semiconductor, such as gallium arsenite (GaAs), indium phosphide (InP), Cadmium telluride (GdTe).

The positive resistances absorb the power (Passive device), whereas negative resistances generate power (active devices).

Difference between Microwave Transistor and Transferred Electron Devices (TEDs)

1. TEDs are bulk devices having no junction or gates as compared to microwave transistors which operate with either junction or gates.
2. The majority of transistors are fabricated from elemental semiconductors, such as silicon or germanium, whereas TEDs are fabricated from compound semiconductors, such as gallium arsenide, indium phosphide or a cadmium telluride.
3. TEDs operate with hot electrons whose energy is very much greater than the thermal energy. Transistors operate with worm electrons whose energy is not greater than their thermal energy (0.026eV at room temperature).

Gunn Effect Diodes – GaAs Diode:



Gunn-effect diodes are named after J.B.Gunn (1963), who discovered periodic fluctuation of current passing through the n-type gallium arsenide specimen when the applied voltage exceeded a certain critical value.

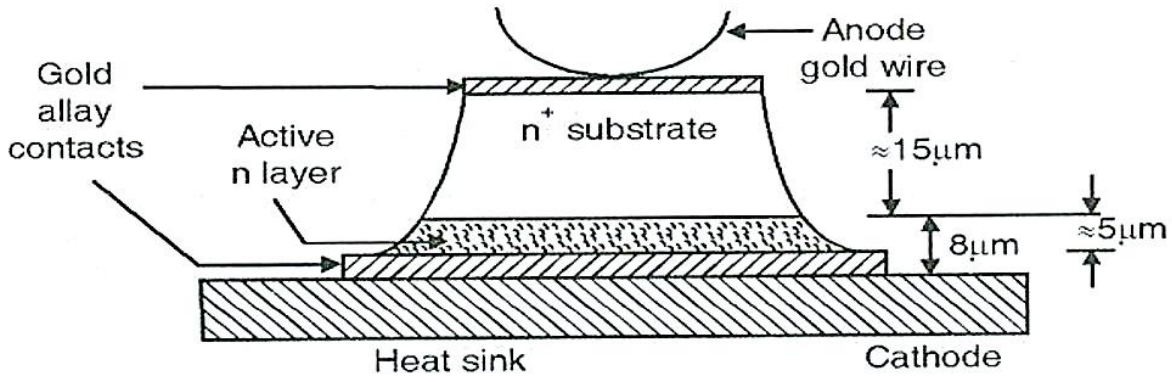


Figure – Gunn Diode Structure

Gunn effect can be explained on basis of two-valled theory of Ridley Watkins-Hilsum (RWH) theory or the transferred electron mechanisum.

The basic structure of a Gunn diode, which consists of n-type GaAs semiconductor with negative of high doping (n+).

Eventhrough there is no junction this is called a diode with reference to the positive end (anode) and negative end (cathode) of the dc voltage applied across the device.

If the voltage or an electric field at lo level is applied to the GaAs, initially the current will increase with a rise in the voltage.

When the diode voltage exceeds a certain threshold value, Vth, a highelectron field (3.2KV/m for GaAs) is produced across the active regions and electrons are excited from their initial lower valley to the higher valley where they become virtually immobile.

If the rate at which electrons are transferred is very high, the current will decrease with increase in voltage, resulting in equivalent negative resistance effect.

Negative resistance: The carrier drift velocity is linearly increased from zero to a maximum when the electric field is varied from zero to a threshold value. When the electric field is beyond the threshold value of 3000v/cm, the drift velocity is decreased and the diode exhibits negative resistance.

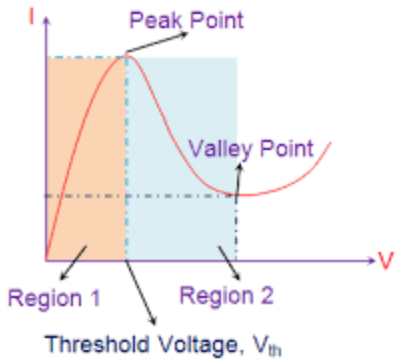
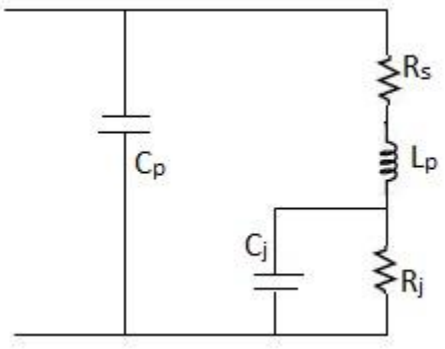


Figure 2 V-I Characteristics of Gunn Diode

GaAs is a poor conductor, considerable heat is generated in the diode. The diode should be well bonded into a heat sink.

The electrical equivalent circuit of a Gunn diode is shown in figure,



Where,

Cj- diode capacitance

Rj –Diode Resistance

Rs – Total resistance of leads, ohmic contact, bulk resistance of diode

Lp – Package inductance

Cp – Package Capacitance

The negative resistance has a value that typically lies in the range -5 to -20 ohm.