NOTES ON

GUNN DIODE

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— The Gunn diode is named after a researcher at IBM, who in 1963 is credited with having been first person to notice the effect.

— The mechanism behind the transferred electron effect was first published by Ridley and Watkins in a research paper in year 1961. Further the work was progressed by Hilsum in 1962 and then in 1963 John Battiscombe and J-B. GUNN independently observed the first transferred electron oscillation using Gallium Arsenide (GaAs) Semiconductor

— Gunn diodes provides an easy and useful method of generating microwave signals. Simply by placing the Gunn diode in a resonant waveguide cavity and applying a voltage to the diode, it is able to generate the signal.

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03/04/20

— GUNN DIODE ?

o Gunn diode is a transferred electronic device, which is composed of only one type of Semiconductor i.e., N-type and utilizes the negative resistance characteristics to generate current at high frequencies. It is used to generate RF and microwave frequencies.

o It is composed of only N-type Semiconductor because N-type Semiconductor has electrons as majority carriers and the transfer ~~circuit~~ electronic devices use such materials which have electrons as majority charge carriers.

The Symbol of Gunn diode is shown in Fig. 1

Fig. 1. Symbol of Gunn diode

For such devices, the P-type semiconductor is of no use because it consists of holes as majority carriers. Therefore, Gunn diode is made up of only N-type semiconductor, not P-type.

② CONSTRUCTION OF GUNN DIODE

- It is made up of three layers of N-type semiconductors. The semiconductors 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).
- The construction of Gunn diode is shown in Fig. 2

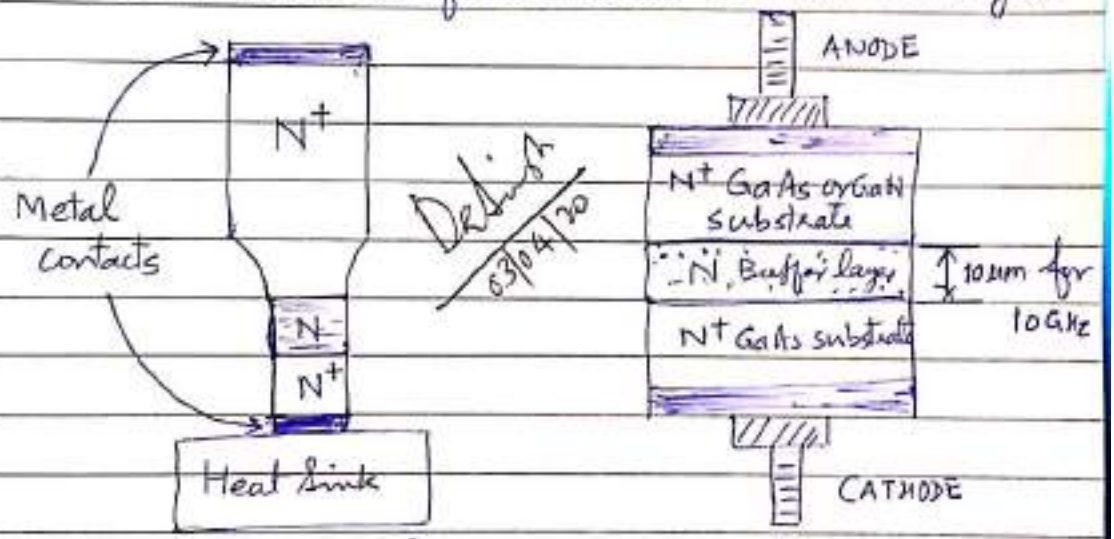

Fig. 2 Construction of Gunn diode

- Among these three layers the top most and the bottom most are heavily doped, while the middle layer is lightly doped in comparison to the extreme layers. The middle layer is an epitaxial layer grown on the N-type substrate and the top most layer is formed by ION IMPLATATION technique.

The metallic contacts are provided on extreme layers to facilitate biasing. The heat sink is there

so that the diode can withstand excessive heat and can be prevented from damage.

THEORY OF GUNN DIODE

Dr Singh 03/04/20

Gunn diodes are negative resistance devices, which are normally used as low power oscillators at microwave frequencies in transmitters and also as local oscillator in receiver front ends. J.B. Gunn in 1963 discovered microwave oscillation in GaAs, InP and CdTe. There are semiconductors having a closely spaced energy valley in the conduction band as shown in Fig. 3(a) for GaAs.

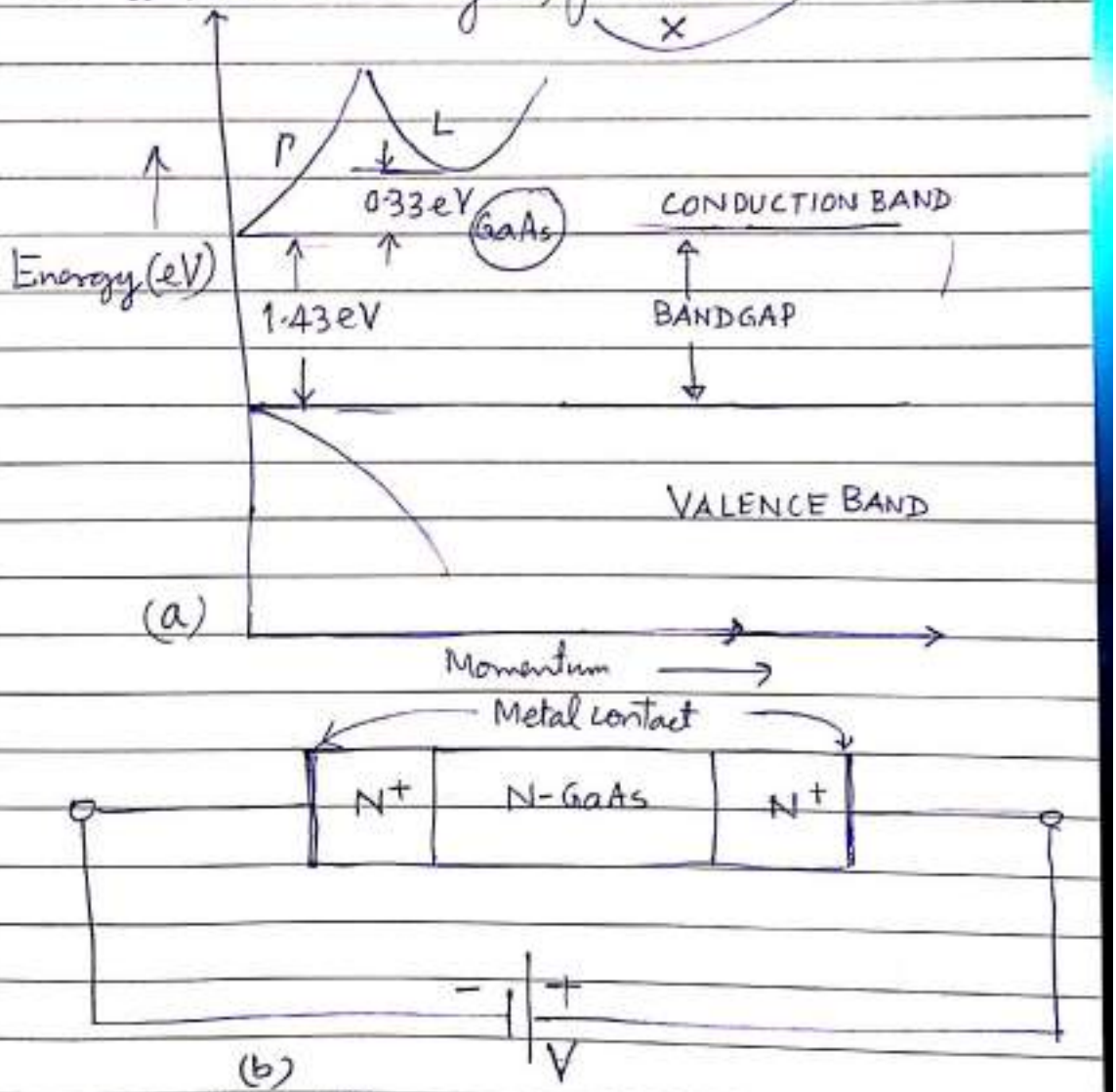

Fig. 3 (a) Multi-valley conduction band energies of GaAs
(b) Circuit diagram of Gunn diode

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When a dc voltage is applied across the material, an electric field is established across it. At low electric field in the material, most of the electrons will be located in the lower energy central valley Γ. At higher electric field, most of the electrons will be transferred into the high energy satellite L and X valleys, where the effective electron mass is larger and hence electron mobility is lower than that in the low energy Γ valley. Since the conductivity is directly proportional to the mobility and hence the current decreases with increase in electric field or voltage in an intermediate range, beyond a threshold value V_{th} as shown in Fig 4. This is called the

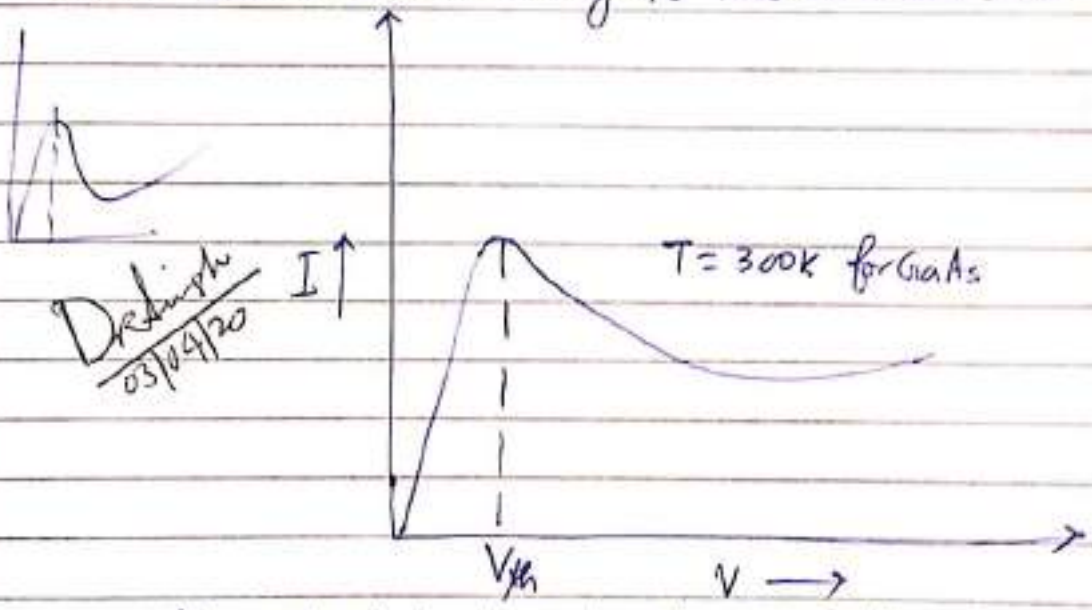
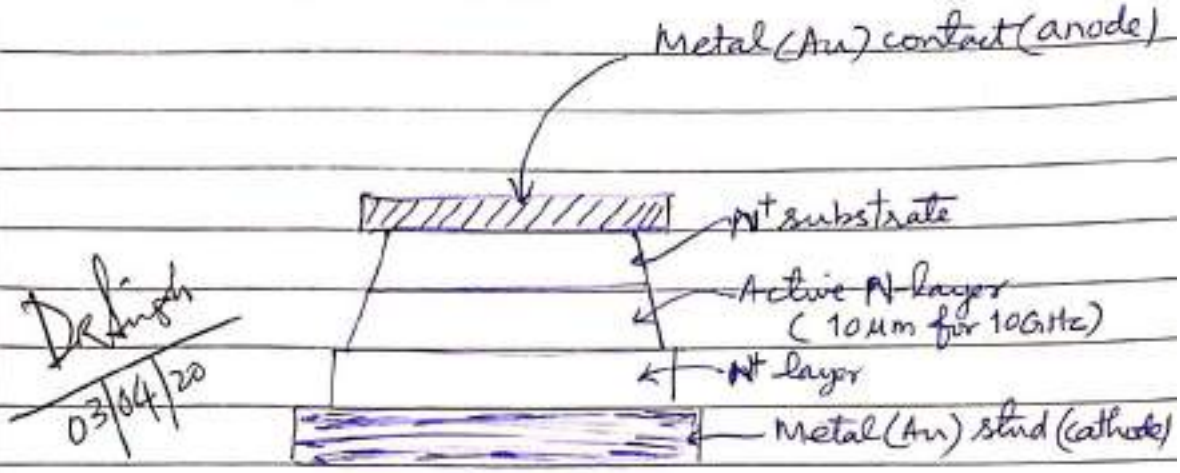


Fig. 4 V-I characteristics of GaAs

transferred electron effect (Gunn effect) and the device is also called Transfer Electron Device (TED) or GUNN DIODE. Thus the material behaves as negative resistance device over a range of applied voltages and can be used in microwave oscillators.

(P.T.O.)

The basic structure of a Gunn diode is shown in Fig. 2 (alternately shown in Fig. 5(a)), which is



(a)

Fig. 5 Construction detail of Gunn diode

of N-type GaAs semiconductor with regions of high doping (N^+). Although there is no junction this is called diode with reference to the positive end (anode) and negative end (cathode) of the dc voltage applied across the device. If voltage or electric field at low 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, V_{th} a high electric field (3.2 kV/m for GaAs) is produced across the active region 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. Since GaAs is poor conductor, considerable heat is generated in the diode. The diode will be bonded into heat sink (Au-Stud).

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The electrical equivalent circuit of a Gunn diode is shown in Fig. 6, where C_j and $-R_j$ are the

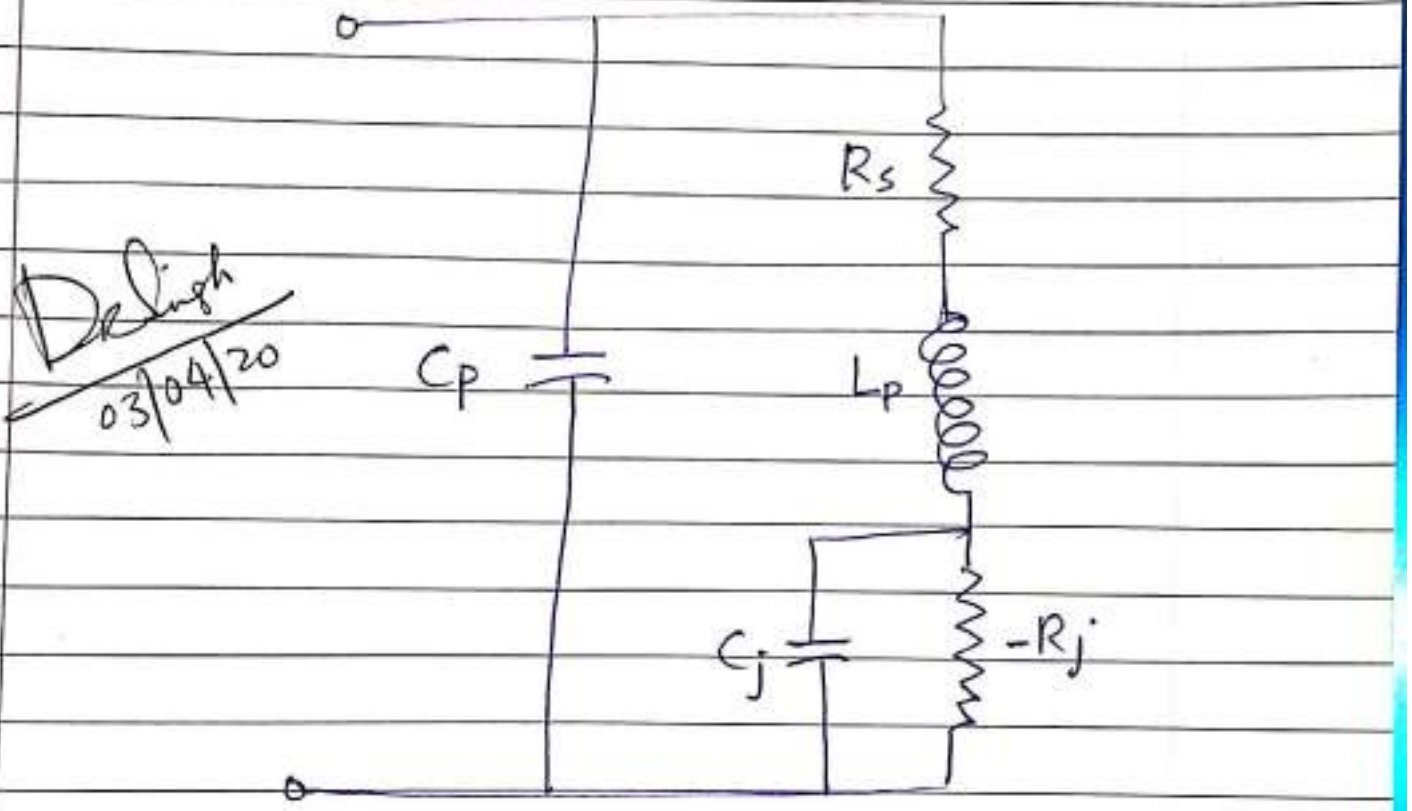

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Fig: 6 Electrical equivalent ckt of a Gunn diode.

diode capacitance and resistance respectively, R_s includes the total resistance of lead, ohmic contacts and the bulk resistance of the diode, C_p and L_p are the package capacitance and inductance respectively. The negative resistance has a value that typically lies in the range -5 to $-20\ \Omega$.

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