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Optical Oscillator Using HEMT

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Abstract- **The existing processors have lower frequencies due to which multitasking operations and all the high end software which require more processing power cannot be performed efficiently. so the main task is to build a processor which has higher frequency of operation for which we need a device which can work on higher frequency and high electron mobility transistor is one such device which works on higher frequency relative to other devices, so with the help of hemt we will be designing an optical oscillator which can work on high frequency end the simulation of this oscillator will be performed on visual tcad software. here we will check the response of the oscillator by simulating it on the software so that a desired frequency can be obtained and the device can be fabricated so that multitasking operations can be achieved easily**

Keywords- **HEMT, TCAD S software, frequency , high electron mobility transistor**

I. INTRODUCTION

For High Speed and substantial Volume advanced communication framework optical communication and remote communication is required. In optical fiber communication high power, high frequency, high temperature, high linearity and high efficiency is required for commercial as well as in military applications. Over the past years, semiconductor device researchers have proposed many competing devices and technologies in order to satisfy this growing demands. One of the technologies to satisfy this requirement is OMMIC. Silicon transistors, Gallium arsenide high electron mobility transistor and hetero structure bipolar transistors, silicon germanium HBT's and silicon carbon metal semiconductor field effect transistors have established a well reputed position in these areas.

The HEMT structure is developed using COGENDA Visual TCAD software. This can be done using the GUI reference or the programming reference. The developed structure can then be used in the circuit schematic of the software and the required circuit can be implemented.
A High Electron Mobility Transistor (HEMT) , also known as Hetero Structure FET (HFET) or modulation doped FET (MODFET) , is a Field effect Transistor incorporating a junction between two materials with different band gaps (i.e a Hetero junction) as the channel instead of a doped region (as is generally case of MOSFET).

A commonly used material combination is GaAs with AlGaAs , though there is wide variation depended on the application of the device. Devices incorporating more indium generally show better high frequency performance, while in recent years gallium nitride HEMTS have attracted attentions due to there high power performance like other FETs HEMTs are used in integrated circuits as digital on off switches. FETs can also be used as amplifiers for large amounts of current using a small voltage as a control signal. Both of this uses are made possible by the FETs unique current voltage characteristics.

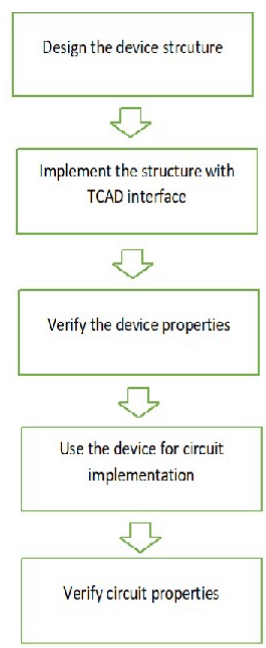

Fig. 1 Block diagram of proposed work.

HEMTs transistors are able to operate at higher frequencies then ordinary transistor, upto mm wave frequencies and are used in high frequency product such as cell phones, satellite tv receivers, voltage converters and radar equipments. They are widely used in satellite receiver , in low power amplifier in the defense industry.

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II.CONSTRUCTION AND WORKING PRINCIPLE OF HEMT

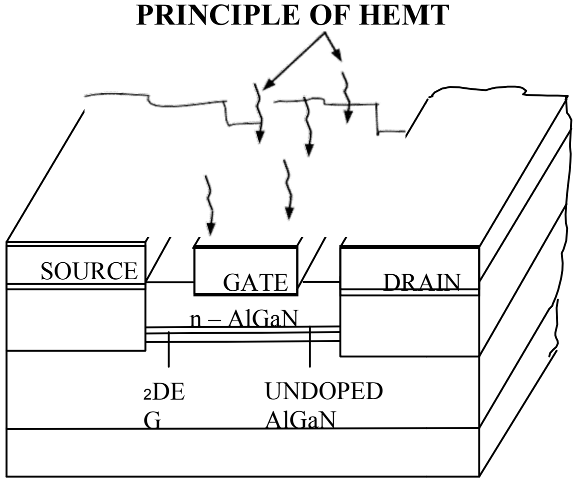

Fig .2 Basic construction of HEMT.

The key component inside a HEMT is the specific PN intersection that it employments. It is known as a hetero-intersection and comprises of an intersection that utilizations distinctive materials either side of the intersection. The most widely recognized material utilized are Aluminum Gallium Nitrate (AlGaN) and Gallium Nitrate (GaN). Gallium Nitrate is for the most part utilized in light of the fact that it gives an abnormal state fundamental electron versatility and this is critical to task of the gadget. Silicon has a much lower level of electron portability and thus it is never utilized in HEMT. There is a wide range of structures that can be utilized inside a HEMT, but all are having a similar assembling forms.

In the produce of a HEMT, initial an inherent layer of Gallium Nitrate is set down on the semi-protecting gallium nitrate layer. This is just around one micron thick. Around one micron thick is set down. A thin layer somewhere in the range of 30 and 60 angstroms of inherent Aluminum gallium nitrate is set down over this. Its motivation is to guarantee the detachment of the hetro-intersection interface from the imbecile aluminum gallium nitrate region. This is critical if the high electron mobility is to be achieved. The doped layer of aluminium gallium nitrate is about 500 angstroms thick is set down as in the above diagram. Precise control of the thickness of this layer is required and special techniques are required for control of this.

HEMTs, instead of a PN junction, metal semi-conductor junction is used, simplicity of which allows fabrication to close geometrical tolerance. HEMT is a hetrostructure field effect device. The term "High Electron Mobility Transistor" is given to the device because it has the benefit of better transport properties of electrons in a potential well of lightly doped semiconductor. A conventional HEMT structure consist of three metal electrode contacts (source, gate, drain) made to the surface of the semiconductor structure. The source and drain are ohmic contacts while the gate is a Schottky contact. A commonly used material combination is GaN while AlGaN which has a very wide band gap variation. The energy band diagram of two dissimilar material is shown in figure 1 in which the quantum well formation has been shown. A high concentration of electrons results in channel because electron from surrounding doped region of the device get trapped in the quantum well. This channel is below the surface of the device and separated from the impurity atom. The lack of scattering sites in channel results in high electron mobility.

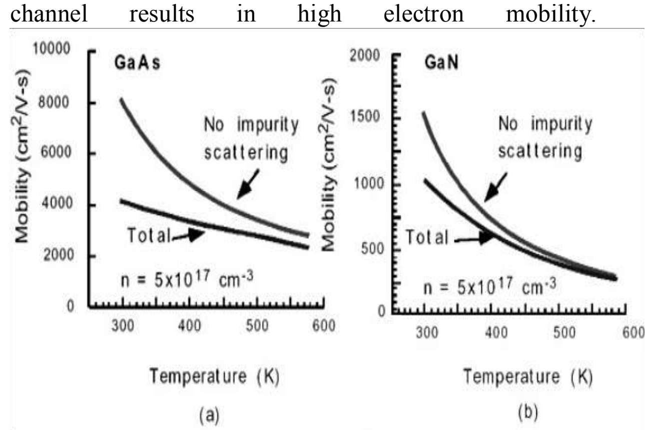

Fig. 3 (a) Temperature vs mobility for GaAs HEMT (b) Temperature vs mobility for GaN HEMT.

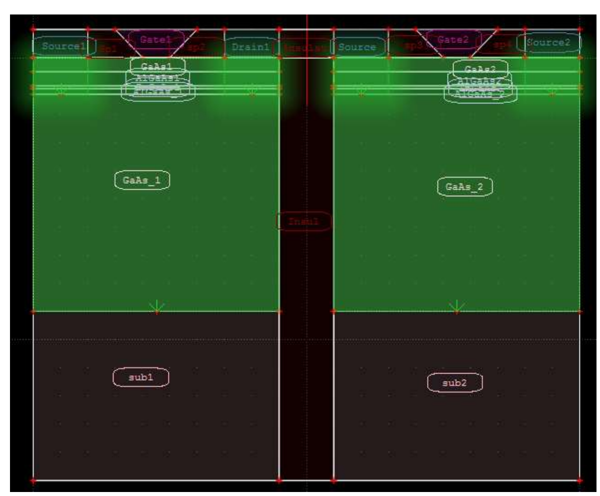

Fig. 4. Proposed work diagram.

Figure above has two dimensional electron gas(2-DEG) or quantum well is formed. The interface of AlGaAs and InGaAs. The high frequency behavior is due to the separation of the carrier electrons from their doner sites at the interface between the doped AlGaAs and doped InGaAs, where they are confined to a varying arrow layer in which motion is possible only parallel to the interface. The 2-DEG or plasma is of very high mobility, upto 9000 cm/volts sec and it has a major improvement over GaAs MESFETs with mobility of 4500cm/V s

TCAD

III. CONCLUSION

A Two Dimensional electron gas is formed in HEMT which has high mobility of electrons. If the concentration of n-aluminium gallium nitrite layer is increased than it is bound to increase the sheet of concentration of 2-DEG

Photo voltage develop at the schottky gate is calculated and it is found that it is increases with the increase of optical power. At optical power of 1.5mW the optical voltage at the schottky barrier generated is 0.3923 and it gets imposed to the gate biasing voltage, the results also show that the optical voltage saturates at the higher value of incident optical power. Verification of the same with reference model shows that the percentage error is 4.16, which is in the range of 5%. The project design, simulated and analyzed circuits developed with pseudomorphic HEMTs using the VTCAD software the work mainly focus on improvement of speed of digital circuits with the use of high speed transistors. Initially a conventional HEMT circuit was designed, simulated and investigated for its frequency response. However sufficient frequency could not be obtained using conventional HEMTs. Hence the data rate that could be supported by using conventional HEMTs in digital circuits would be insufficient.

Further considering the potential advantage of InGaAs a pseudomorphic double heterojunction HEMT structure was developed which further highly enhance the unity gain cutoff frequency of HEMT from 20Ghz in conventional HEMT to 80GHz in pseudo orphic structure Once appropriate DC and AC characteristics where achieved using the pseudo orphic HEMTs, basic digital circuits were implemented using this structure and the circuits where further analyzed for their timing and delay response.

The effect of gate delay of each transistors on the performance of each circuit was observed. It is found that the inverter circuit experiences the lowest delay and the XOR circuit experiences the highest delay. The circuit of NAND and NOR gates have delay between that of inverter and XOR gate circuit Because of its potential advantages HEMTs can be used for high speed digital circuits, microwave monolithic integrated circuits (mmics), opto electronic integrated circuit (oeics). InGaAS HEMTs could be the technology of choice when the CMOS roadmap comes to an end.

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