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Effect of the Improved-Shaped Gate in HEMT Transistors Performance

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Abstract

In this paper the effect of the Gate shape on the operation of HEMTS is evaluated via simulations and Two transistors with different Gate Shapes are simulated. Simulations show that with the improved Gate-shaped (wedge-shaped), the performance of the transistor is improved. Therefore, when the Gate Voltage and Drain Voltage are increased, the curve Drain Current versus Drain voltage and Gate Voltage is also increased, means the transistors-conductance increases.

Keywords: hemt; gate; performance; transistors.

1. Introduction

High Electron Mobility Transistors is a promising device for high-frequency and high-power applications. A device of particular interest is the high electron mobility transistor (HEMT), which is also known as a modulation doped field effect Transistor. HEMTs are more popular than any other transistors for its important properties like high speed, high power, high operating frequency, high breakdown voltage etc. Basically, HEMTs are made by group III-V materials. Two most important material combinations, AlGaAs/GaAs and AlGaN/GaN are more preferable due to their higher band gap energy.

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These devices offer operational advantages, because a two-dimensional electron gas (2DEG) is formed at the heterojunction of two semiconductor materials with different bandgap energies, and where the smaller bandgap material has a higher electron affinity than the larger bandgap material. Additionally, electrons that originate in the doped transfer to the 2DEG, allowing a high electron mobility due to reduced ionized impurity. This combination of high carrier concentration and high carrier mobility gives the HEMT a very large transconductance and a strong performance advantage over metal-semiconductor field effect transistors (MESFETs) for high-frequency applications [1,4,6]. Actually, the advantages of a HEMT are its ability to locate a large electron density in a very thin layer very close to the gate while simultaneously eliminating ionized impurity scattering. The AlGaAs layer in a HEMT is fully depleted under normal operating conditions and since the electrons are confined to the heterojunction, device behavior closely resembles that of a MOSFET. The advantages of the HEMT over the Si MOSFET are the higher mobility and maximum electron velocity in GaAs compared with Si, and the smoother interfaces possible with an AlGaAs/GaAs heterojunction compared with the Si/SiO2 interface. The higher performance of the HEMT translates into an extremely high cutoff frequency, and devices with fast access times [5]. The device can be modified in different way to improve the DC and RF performance and to make the device more powerful. One way is to change the physical properties of the device and another way is to change the materials that are used in the device. The device performance can be increased by the change of the length or structure of the gate [6]. Here in this work, two transistors with Normal and Wedge gate shape are simulated and compared. Also, the improved performance of the device is observed by results.

2. Simulation method

We have made two transistors with different Gate shapes in simulation. HEMT structure is based on the GaAs-AlGaAs-InGaAs-InP. The device is based on a GaAs substrate. There is also two doping- regions above and below InGaAs region as additional carrier Suppliers. They are important for improving the Transistor Performance. The simulation is first performed to obtain the condition of the structure for 3 different gate biases: 0, -0.2, and -0.4 V, with the source and drain grounded. Then Drain Current (ID) versus Drain-Source Voltage (VDS) curves is calculated in three separate drain voltage sweeps from 0 up to 2 V. Each series of the drain biasing is performed after loading the solutions with the respective gate bias [2,3].

3. Gate shape effect on current-voltage curve

In this section a normal gate HEMT and a wedge-shaped gate HEMT are simulated and compared. The structure of a normal gate HEMT and a wedge-shaped gate HEMT are shown in figure 1 and 2 respectively. The whole device is mounted on a Silicon carbide (Si C) substrate. The main reason of using Si C is, it can be used in very high voltage. In wedge-shaped type of HEMT, the length of the foot print is smaller than a normal gate HEMT. Basic mechanism for both the transistor is almost same. 2DEG is formed in between the Barrier and channel layer through which the current flows from source to drain. Drain current of a device is very important parameter. If the drain current is high then the device is perfect to use as an amplifier or switch [3]. In figure 3 and 4, the drain current for both the Normal gate HEMT and Wedge-shaped gate HEMT are observed by changing the drain voltage and drain current curve versus gate Voltage in figure 5 and 6 are shown. By comparing results in different cases, we conclude the performance of the transistor in Wedge gate shape is improved because the drain current is being increased. Therefore, the effect of the gate shaped on the performance of the device is obvious.

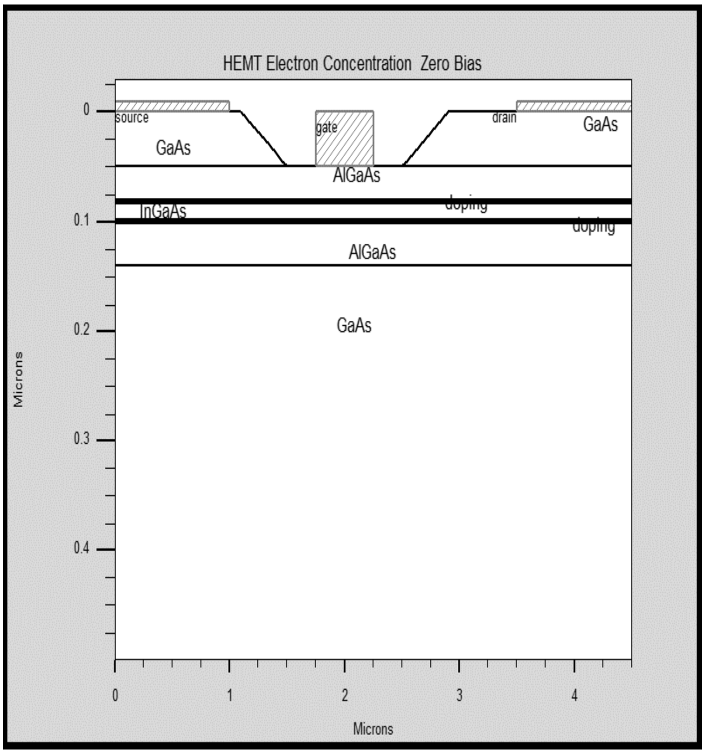

Figure 1: Graph for the structure of the Normal Gate Shape

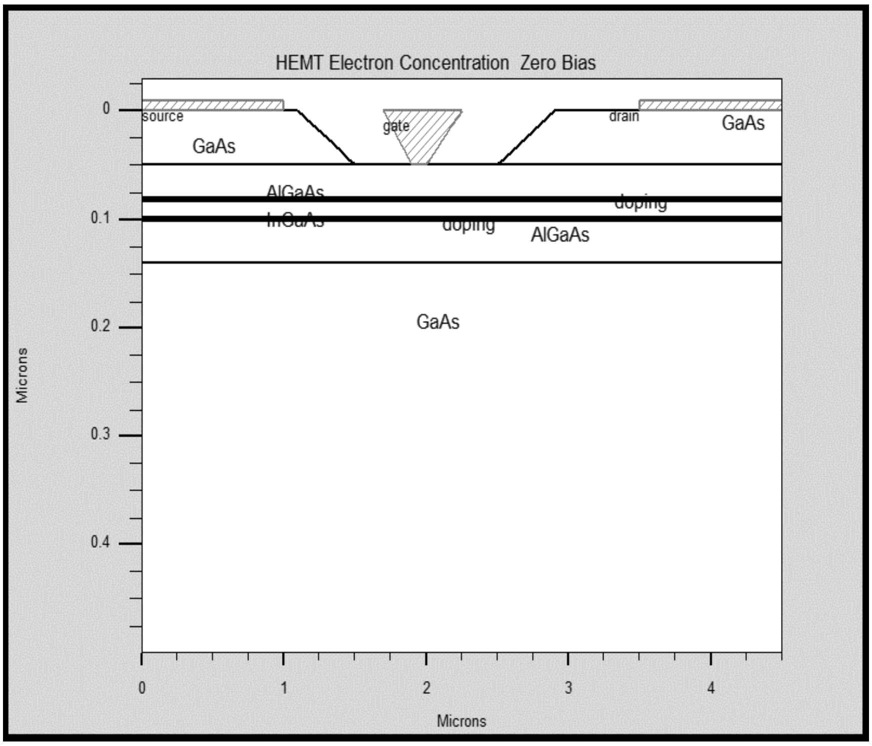

Figure 2: Graph for the Structure of the Wedge Gate shape

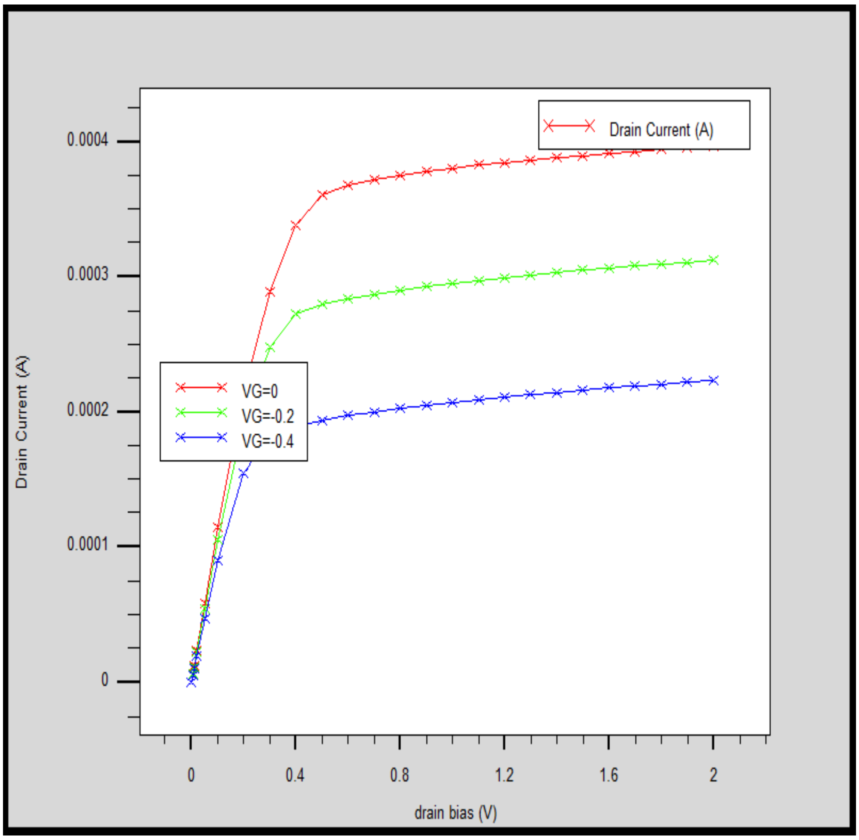

Figure 3: Graph for drain current versus drain voltage for different gate voltage (with normal gate shape)

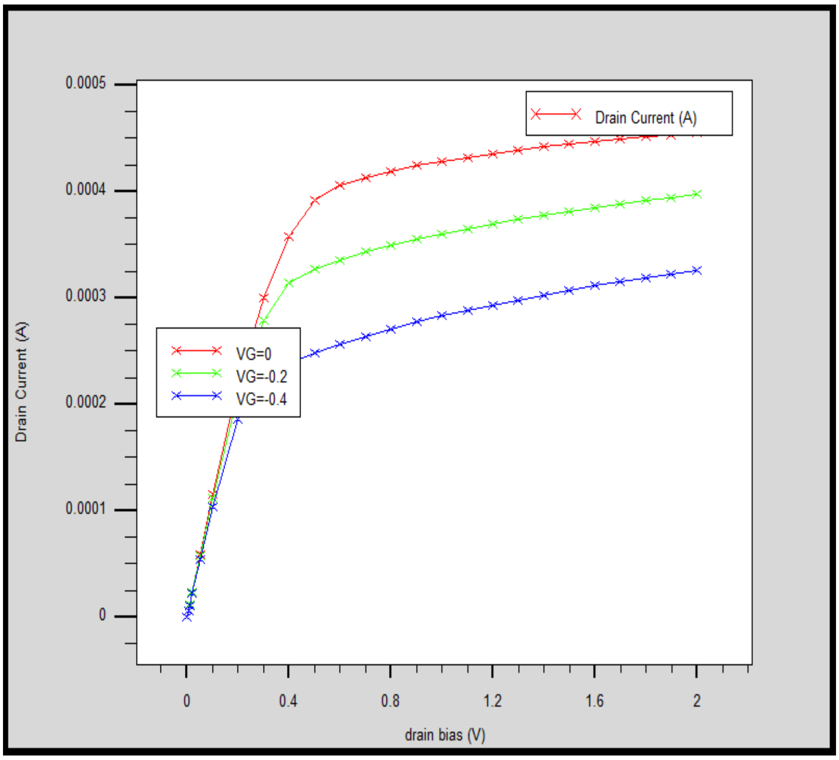

Figure 4: Graph for drain current versus drain voltage for different gate voltage (with wedge gate shape)

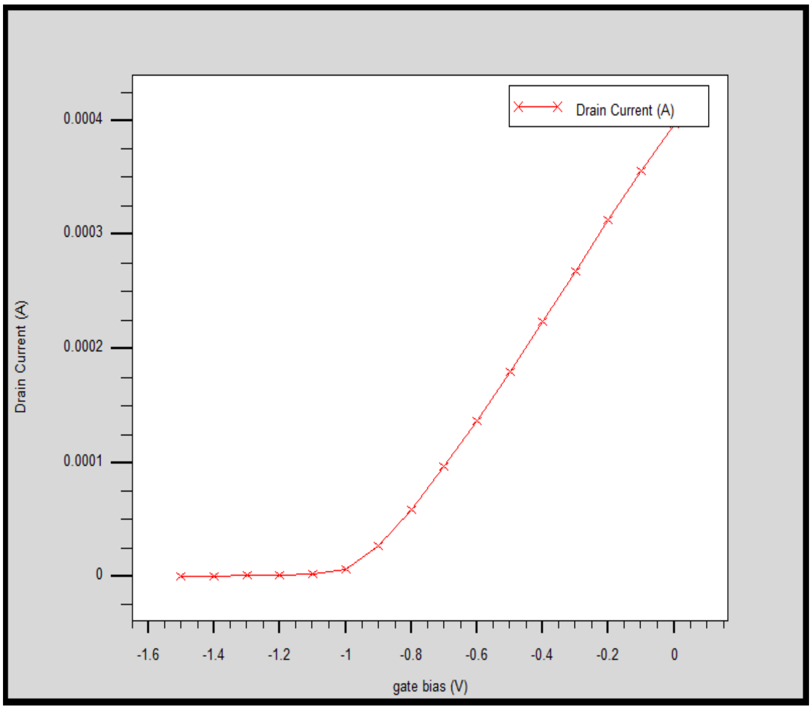

Figure 5: Graph for drain current versus gate voltage for Normal gate shape transistor

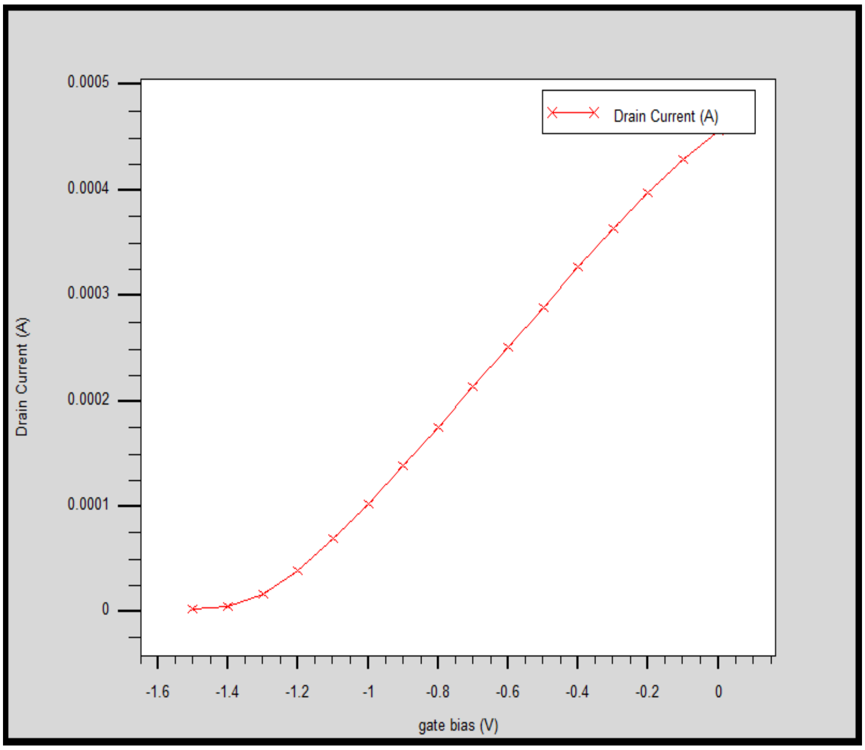

Figure 6: Graph for drain current versus gate voltage for Wedge gate shape transistor

4. Conclusion

In this paper The effect of the Gate shapes on the performance of the Hemt transistors has been studied and The results of simulation have been presented for two different gate shapes. The obtained results show that by using

Wedge-shaped gate the drain current is increased . Therefore, by changing the structure and length of the gate ,the performance is improved.

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