Simulation of Existing Current Density Model for N-Type Gallium Nitride Schottky Diode at Low Bias.

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ABSTRACT

In recent times based on the unique properties of n-GaN (n-type Gallium Nitride) Schottky diode, such as wide energy band gap and high thermal stability compared to that of silicon (Si) and gallium arsenide (GaAs), the performance of n-GaN has been investigated. Current density for n-GaN Schottky diode at low bias for existing current density is carried out through the method of simulation. The simulation of current density for n-GaN Schottky diode at low bias was investigated by theoretical computation with the aid of computer machine. Visual Basic language programming was written for the existing current density model. The results of simulation in this work revealed that the Bethe *et al.* current density model for n-type gallium nitride Schottky diode represents the exact current-temperature stability noticed for n-GaN Schottky diode by other workers but later failed at the very high temperature above 700K.

(Keywords: band gap, current density, current-temperature stability, n-GaN, Schottky diode)

INTRODUCTION

Recently, research on the wide band gap semiconductors such as GaN and AlGaN became very popular for their application on various devices. The unique properties of n-GaN Schottky diodes (i.e., metal-GaN junction diodes) such as high thermal stability (2, 6) and wide energy band gap compared to that of existing materials such as silicon (Si) and gallium arsenide (GaAs), the performance of n-GaN has been investigated.

Schottky diode possesses two unique features compared to an ordinary p-n. It has electrons as majority carriers on both sides of the junction, so it is a uni-polar device. Also, there is no depletion layer or stored charges since no holes are available in metal. n-GaN Schottky diodes have been discovered to possess high thermal stability, which offer many advantages required for solar cell devices and advanced microwave communication systems (8).

The different thermal effect with different doping concentration levels result in various behavior in I-V curves of n-GaN (1, 4). At low doping, the thermal effect is small but at high doping there is decrease in mobility with the forward bias accompanied with enhanced ionization process. Current density for n-GaN Schottky diode at low bias for existing current density was investigated.

Based on the theory and experimental facts about n-GaN Schottky diode, this study tries to know whether the existing current density model can represent the exact current-temperature stability noticed by other workers. Group III-nitride semiconductors such as GaN, InN, AlN and their ternary and quaternary compounds are promising candidates for high-power high frequency applications.

In this study, Bethe *et al* current density model for n-GaN Schottky diode represents the exact current-temperature stability noticed by other workers but later failed at the very high temperature above 700K.

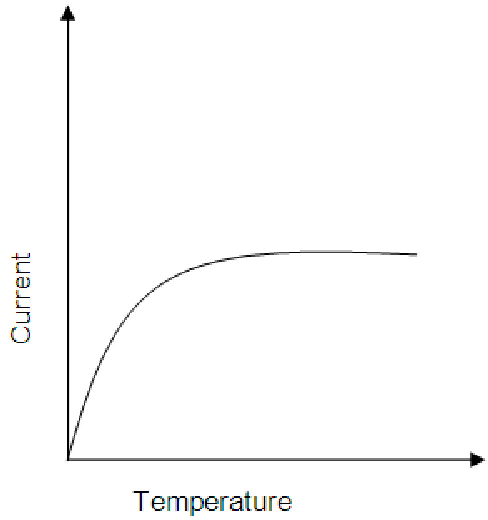

Figure 1: Current-Temperature Stability Noticed for n-GaN Schottky Diode.

CURRENT DENSITY FOR SCHOTTKY DIODE

Current density for Schottky diode is the current per square meter. The conductivity in a Schottky diode is due to the drift of electrons. The number of electrons present must be put into consideration and at the same time the surface area of the Schottky diode is very important and must be considered. Due to constant supply of electrons from the voltage source the electrons will move from the semiconductor towards the metal. Also the electron in the metal will be attracted by the positive terminal of the voltage source. Therefore, there will be a constant flow of current. The rate of flow of current depends on the number of electrons involved.

If the n-type semiconductor is small and electrons from the source are too many, there will be congestion of electrons in the material. As a result of this the electron will start to collide with one another which will eventually slow down the movement of electrons. Therefore, the rate of flow of current in the Schottky diode will be very slow.

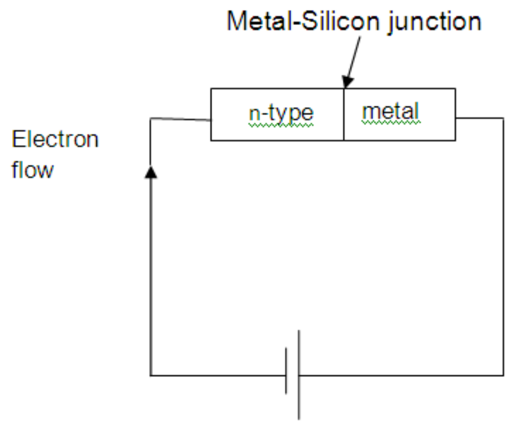

Figure 2: Schematic Metal-GaN Junction Diode.

METHOD OF STUDY

Current density for the model was carried out by method of simulation using a computer program (i.e., visual basic). Temperature ranges between 300K and 800K with a step of 1.

The existing current density model for n-GaN considered:

The Bethe, Crowell and Sze model for Schottky diodes:

$$I = AT^2 \, e^{\left[\frac{-qQ}{kT}\right]} e^{\left[\frac{qV}{nkT}\right]-1} \qquad \textbf{(1)}$$

Where:
A = Richardson constant ($Acm^{-2}k^{-2}$)
T = Finite temperature (Kelvin)
q = Electronic charge (C)
k = Boltzmann's constant (J/K)
Q = Barrier height (eV)
n = Ideality factor (which is "1")
V = Applied voltage (volts)

$$Q = \frac{1}{3}\left[3.503 + \frac{(5.08e^{-4}) \times T^2}{T-996}\right] \qquad \textbf{(2)}$$

RESULTS

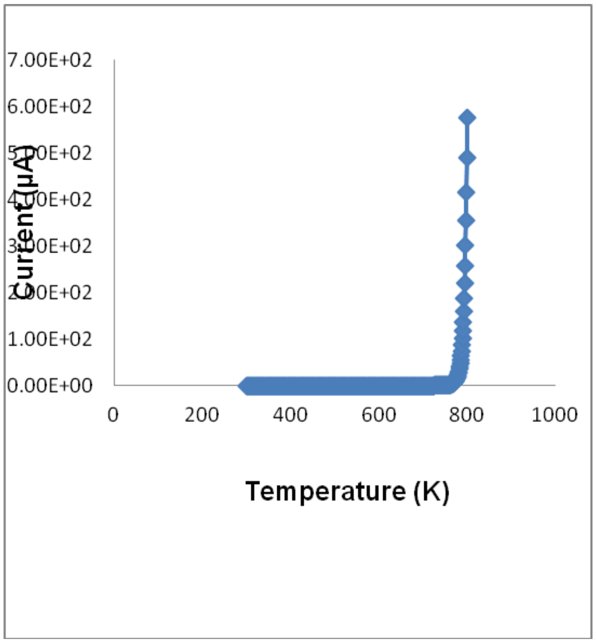

Figure 3: Graph of Current (μA) against Temperature (K) for the Bethe, Crowell, and Sze Model (T = 300K – 800K).

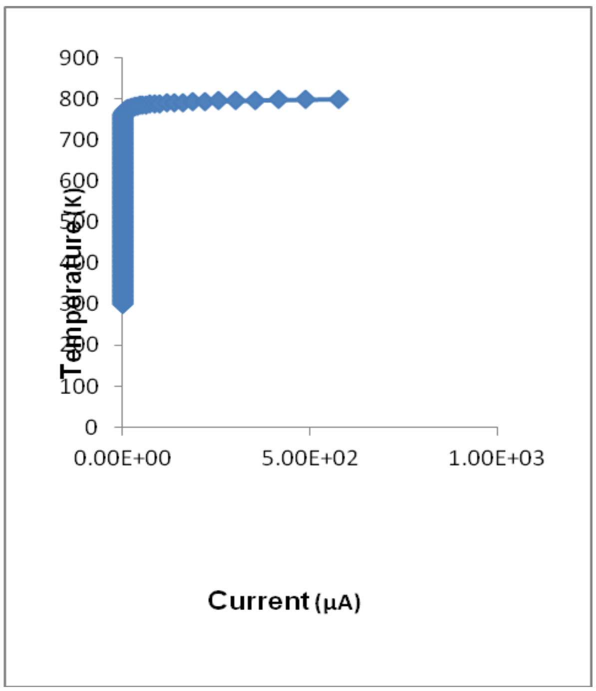

Figure 4: Graph of Temperature (K) against Current (μA) for the Bethe, Crowell, and Sze Model (T = 300K – 800K).

CONCLUSION

The results of simulation in this work revealed that the Bethe *et al.* current density model for n-type Galliun Nitride Schottky diode represents the exact current –temperature stability noticed for n-GaN Schottky diode by other workers but later failed at the very high temperature above 700K.

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