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Study Of Current Voltage Characteristics Of Schottky Diode Using Numerical Method

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Abstract- We can generate current-voltage characteristics of inhomogeneous schottky diodes. This can be done by using analytical solved equation for total current through all the elementary diodes. We can do this work by numerical integration over the entire barrier height range. These current-voltage characteristics with different features can be achieved by simulation method. It shows apparently that the achievement of analysis of inhomogeneous Schottky contacts is not consistent. In this work, we analyze the achievement of modeling of inhomogeneous Schottky contacts. In order to do so, the nature of each elementary diode Schottky contact is investigated to make the approach for current-voltage characteristics.

Keywords: Schottky diode, numerical integration, current-voltage

1 INTRODUCTION

Metal-semiconductor Schottky diode is an essential part of virtually all semiconductor electronic and optoelectronic devices. The important aspect of metal semiconductor junction is the process, which determines the flow of charge carriers over the barrier from the semiconductor to metal and vice versa. The barrier height of Schottky diodes controls the electronic transport across MS interfaces and is therefore of vital importance to the successful operation of any semiconductor device. Analysis of current voltage characteristics of the Schottky barrier diodes measured at room temperature only does not give detailed information about the conduction process and the nature of barrier formed at metal-semiconductor interface. It neglects many possible effects that cause non-ideality in the diode I-V characteristics and leads to reduction the barrier height. The Diode parameters derived from the experimental data shows the abnormal temperature dependence, which cannot be understood on the basis of existing current transport theories. The variation of barrier heights in Schottky diodes is considered to explain the anomalous behaviour. The variation of barrier heights is described mainly by distribution function and it has widely accepted to correlate the experimental data [1, 2, 3, 4, 5, 6-7]. The ballistic electron emission microscopy studies have also supported the existence of barrier heights in Schottky diodes [8, 9]. Simulation performed to see the effect of such in homogeneities in barrier heights and leads to same temperature dependence of diode parameters as observed from the experimental current-voltage characteristics [10, 11].

The distribution function of BH's is still being invoked to explain the temperature dependence of barrier parameters derived from the experimental current-voltage and capacitance-voltage measurements [12, 13, 14, 15, 16-17] on various metal semiconductor contacts.

2 MAIN OBJECTIVES

The current-voltage characteristics of inhomogeneous Schottky diodes can be generated either using analytically solved equation for total current through all the elementary diodes or by numerical integration over the entire barrier height range. The simulation performed using these two approaches yields current-voltage characteristics with different features. It apparently indicates that the two approaches of analysis of inhomogeneous Schottky contacts are inconsistent. In this paper approaches of modelling of inhomogeneous Schottky contacts are analyzed and compared and is investigated to make the approach yield similar current-voltage characteristics.

3 RESULTS AND DISCUSSION

Simulation of I-V data of inhomogeneous Schottky diodes performed at various temperatures for diode area, $A_d = 7.87x10^{-7} m^2$, corresponding to 1 mm diameter metal dot, effective Richardson constant $A^{**}= 1.12x10^6$ $Am^{-2}K^{-2}$(for n-type Silicon), $\overline{\emptyset}$=0.8V, σ = 0.08V and Rs = 20Ω .In these simulations the value of a is assumed to be about 10% of the mean $\overline{\emptyset}$ which is generally observed in the experimentally fabricated Schottky barrier diodes showing of BHs, in metal-semiconductor contacts [18, 19, 20, 21, 22, 23, 24]. Another reason for taking hight a is that the effect of barrier in homogeneities on device characteristics can be seen much prominently. The In (I)-V plots obtained by analytical approach are shown in figure 1 (solid lines).

The intersecting behaviour of these plots at very low this already discussed [25]. The currents are also generated by numerical approach performing numerical integration of equation using Simpson's one third rule, over same BH range 0-1.6 V (0 to 2$\overline{\emptyset}$)in steps of 0.005 V and the corresponding ln(I)-V plots thus obtained are also shown in figure1 (dashed lines) at various *T*. It is evident from figure.1 that the curves obtained by two approaches do not coincide over entire bias range. Also the curves obtained by numerical integration (dotted lines), do not intersect unlike the curves generated by using analytical equation (solid lines) do. In contrast the integrated curve shifts downward without intersecting each other over entire bias range with decreasing *T*.

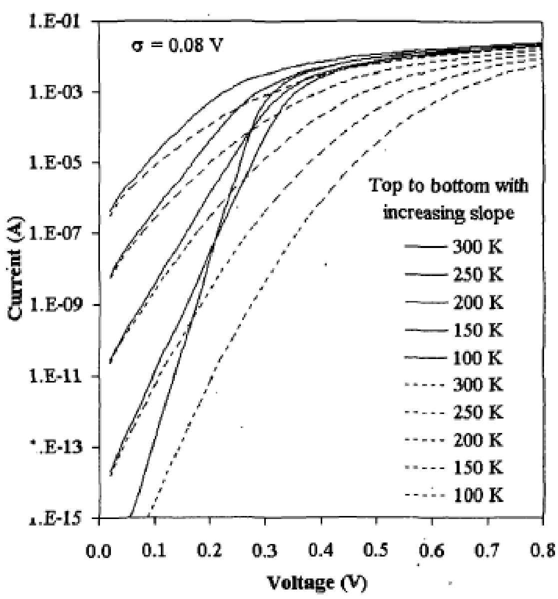

Figure-1 Simulated I-V curves generated by, (i) using analytical equation for Gaussian distribution of barrier heights (solid) and (ii) numerical integration (dotted) are curved over entire bias range unlike the other curves (solid) which exhibit straight portion up to a bias beyond which current saturation due to the series resistance occurs and it tends to become a horizontal straight line at higher bias. However, both types of curves originate from same current at zero bias and converge to each other asymptotically at high forward bias. Thus, the modified equation solved analytically for Gaussian distribution of BHs and data obtained from equation by numerical integration yields slightly different results indicating thereby that the two approaches of BHs distribution are not fully consistent.

Another difference between the two is that the ln(I)-F plots obtained by numerical integration (dotted) are curved over entire bias range unlike the other curves (solid) which exhibit straight portion up to a bias beyond which current saturation due to the series resistance occurs and it tends to become a horizontal straight line at higher bias. However, both types of curves originate from same current at zero bias and converge to each other asymptotically at high forward bias.

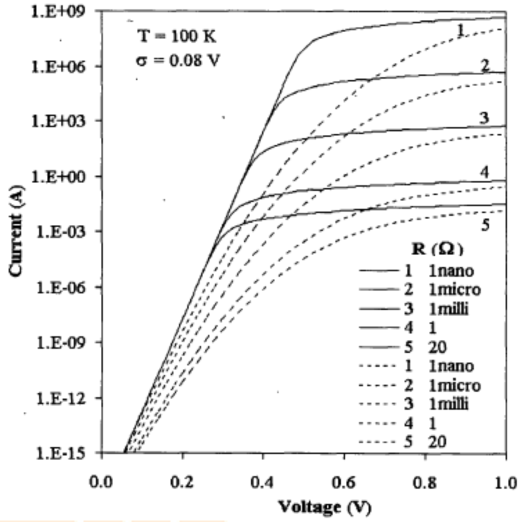

Figure-2. Simulated I-V curves generated by, (i) using analytical equation for barrier heights (solid) and (ii) numerical integration (dotted), for various series resistances.

The ln(I)-V curves obtained by the two approaches coincides only at very low bias that too for high T and low σ and the mismatch between the two increases with decreasing T and increasing σ. The difference in the results obtained from approaches appears to be due to a constant series resistance (say 2Ω here) considered for calculating current through each elementary barrier in the distribution. The series Rs affects the current through each elementary barrier in the distribution, which when added using Simpson's 1/3rd rule after multiplying by probability distribution function $\rho(\emptyset)$, yields curved ln(I)-V F plot. On the other hand equation considers inhomogeneous Schottky contact as a homogeneous barrier of single apparent BH at any temperature, thus

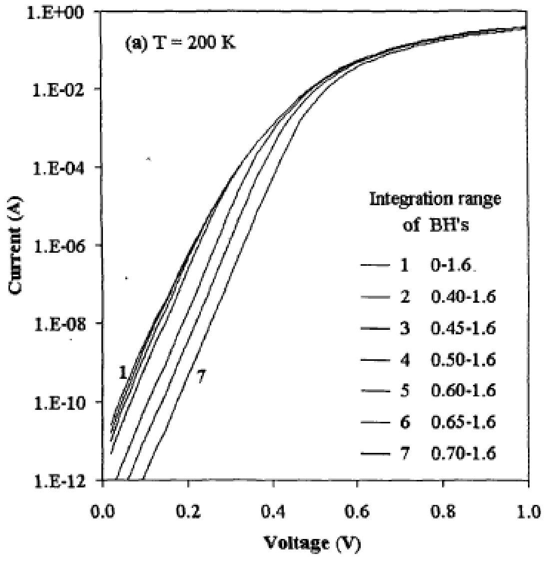

Figure-3 The I(n)-V curves obtained by numerical integration over different barrier height ranges, excluding low BH's, at temperature 200 K.

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