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A STUDY OF SCHOTTKY BARRIER HEIGHT INHOMOGENEITY ON In/P-SILICON

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The current-voltage characteristics of In/p-Si Schottky diode measured over a temperature range of 120-360 K *have been interpreted on the basis of thermionic emission across an inhomogenous Schottky contact. The experiment shows that the apparent barrier height* ψ_{be} *increases and ideality factor decreases from* 0.26 *eV and* 6.36 *at* 120 *K to* 0.70 *eV and* 1.91 *at* 360 *K respectively. The variation of effective Schottky barrier height and ideality factor with temperature has been explained considering lateral inhomogeneties at the metal-semiconductor interface. We have also discussed whether or not the junction current has been connected themionic field emission* (*TFE*) *mechanisms.*

Keywords: *SCHOTTKY BARRIER HEIGHT, METAL-SEMICONDUCTOR INTERFACE, CURRENT-VOLTAGE CHARACTERISTICS, THERMIONIC EMISSION, IDEALITY FACTOR, LATERAL INHOMOGENETIES IN SBH.*

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1. INTRODUCTION

Metal-semiconductor (MS) contacts are significant devices of semiconductor devices. The electronic properties of Schottky barrier diodes (SBDs) are characterized by its Schottky barrier heights (SBHs) and ideality factor [1]. The barrier height of Schottky contact is defined, as the potential difference between the metal Fermi-level and the top/bottom level of the conduction/ valance band edges for n/p type semiconductor. Even after investigations spreading over more than a century, Schottky devices still elude a clear understanding of the mechanisms and their exact contribution in the overall observed barrier heights. It is known that observed barrier heights are a result of band line up and accompanying charge transfer across the interface. As a result barrier height should correspond to that predicted by Mott Schottky model [2]. This model is more likely to hold for Schottky devices where the contact between metal and semiconductor are intimate, laterally homogenous and abrupt in nature, because the nature of Schottky diodes and the evaluated parameters carry the important of the causes which are responsible for difference between real and ideal devices, with no defects and localized states near the interface. However, such contacts are not often found in experimentally, fabricated Schottky devices. As results observed barrier heights show variation from the predictions Mott-Schottky model [3]. The observed scatter in experimental observed barrier heights lead to the preposition that charge transfers and band alignment in such devices are complex and are likely to be influenced by (a) intrinsic surface states and metal induced gap states (MIGS) (b) a combination of MIGS and interface defects [4, 5].

Such characteristics are then used for extraction and evaluation of the parameters characterizing behavior. The electrical behavior of Schottky devices like that of other device characterized primarily by the I-V characteristics taken only at room temperature has been found to be insufficient information about the cause of such differences. Therefore, it is imperative to determine such characteristics over a large span of temperature.

In this paper, we present our results on In/p - Si Schottky diodes and analyze then to show that observed behavior of these devices is differing from ideal behavior due to interfacial oxide layer, high density of interface states and inhomogenetics.

Indications to interface states with interface layer [6, 7, 8]

(a) Reverse characteristics depend on V_R^+
(b) Temperature and bias dependent barrier heights
(c) Arhenius plot, Richardson plots and T_o effect.

2. RESLTS AND DISCUSSIONS

It may be noted that the nature is in general is rectifying. The observed I-V-T characteristics of the fabricate In/p - Si is shown in Fig. 1.

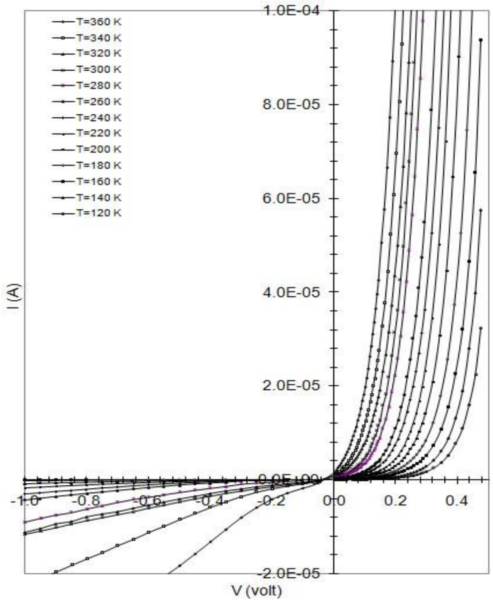

Fig. 1 – I-V characteristics for In/p-Si Schottky diode

It is known that these raw characteristics contain influence of parasitic series and shunt resistances. Therefore these raw characteristics were corrected for such parasitic resistance and one such corrected curve along with uncorrected one at 360 K is shown inset in the Fig. 2. Only corrected ln I-V curves at different temperature is shown in Fig. 2.

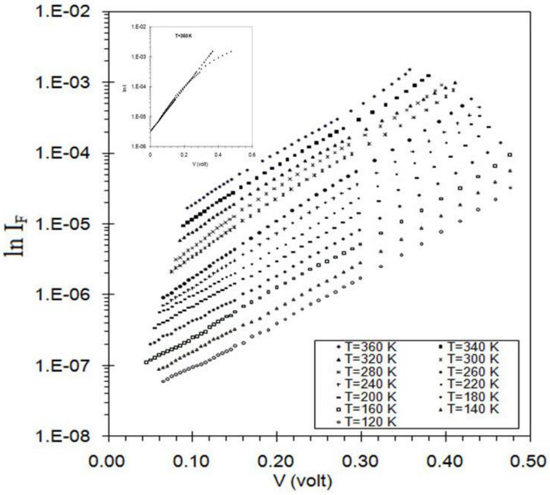

Fig. 2 *– Forward ln I-V at V > 3kT / 2 characteristics for In/p-Si Schottky diode*

Using this corrected I-V at different temperature, ideality factor n and zero bias barrier height φ_{be} were calculated assuming thermionic emission as the charge transport mechanisms. It is seen these are temperature dependent as shown in Fig. 3. Further, it is also seen that even corrected I-V-T curves do not show linearity over a large bias range indicating the ideality factor and barrier height are bias dependent also [9].

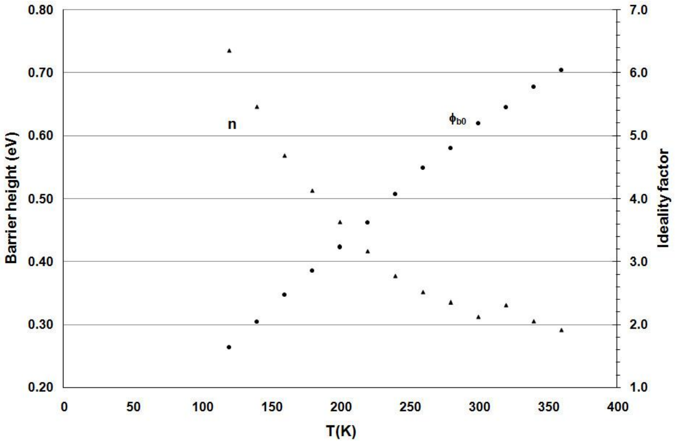

Fig. 3 *– Variation of evaluated values of barrier height and ideality factor with temperature for In/p-Si Schottky diode*

It has been referred that these kinds of deviation in behavior of Schottky diode may arise from

(1) Multiplicity of operative charge transport mechanisms [10, 11]
(2) Interfacial layer and interface states [12]
(3) Lateral inhogenities at the interface [13, 14, 15]
(4) Variation in donor concentration near surface or field dependence of permittivity [16].

Besides the discrepancy of barrier height at lower temperature, commonly shown by all the diodes, it also point towards some additional contributing factors other than the pure thermionic emission process which may get dominated at low temperatures. Looking to the possibility of TFE as being effective in lower temperature regions characterize energy E_{oo} was evaluated from plot nKT / q versus KT / q and it is seen that these characteristic energy is 0.06 eV. It may be noted that high characteristic energy TFE transport at low temperatures has been reported by many workers [13, 17, 18, 19].

3. CONCLUSIONS

In/p-Si Schottky diode is fabricated by thermally evaporated indium deposited on chemically etched silicon in a clean vacuum environment. The temperature dependence of Schottky barrier height and ideality factor can be explained as due to lateral inhomogeneties. The high characteristics energy TFE transport at low temperatures that E_{oo} obtained from experimental I-V characteristics is much higher than theoretically estimated one.

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