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TEMPERATURE DEPENDENT I-V CHARACTERISTICS OF Ag/p-$Sn_{0.2}Se_{0.8}$ THIN FILM SCHOTTKY BARRIER DIODE

***K.K. Patel*[1], *M. Patel*[2], *K.D. Patel*[2], *G.K. Solanki*[2], *V.M. Pathak*[2], *R. Srivastava*[2]**

[1] Smt. S. M. Panchal Science College,
Talod, 383215, Gujarat, India
E-mail: karm1962@gmail.com

[2] Patel University,
Vallabh Vidyanagar, 388120, Gujarat, India

Ag/p-$Sn_{0.2}Se_{0.8}$ Schottky barrier diodes have been fabricated and characterized by the current-voltage (I-V) technique as a function of temperature in the range of 303 *K to* 403 *K. The forward bias characteristics have been analyzed on the basis of thermionic emission (TE) theory and the characteristic parameters of Schottky barrier diode such as barrier height, ideality factor and series resistance have been determined. The conventional Richardson plot was drawn and the value of Richardson constant was determined using the intersection of $Ln(I_0/T^2)$ vs* 1000/*T. It is found to be around* 15 *$Acm^{-2}K^{-2}$ which is closer to the reported value for* SnSe.

Keywords: *SCHOTTKY DIODE, I-V CHARACTERISTICS, BARRIER HEIGHT, IDEALITY FACTOR, RICHARDSON PLOT.*

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1. INTRODUCTION

IV-VI group semiconductors can be categorized into rhombohedral, cubic and orthorhombic compounds. Tin selenide belongs to these group of compounds and has the layered orthorhombic structure [1, 2]. It has attracted considerable attention because of their important specific properties in the area of optoelectronics [3], holographic recording [4-6] and electronic switching [7-8]. Moreover SnSe is a semiconductor possessing a band gap of about 1 eV and has a potential for an efficient solar cell material [3, 9].

Metal-semiconductor structures are important research tools in the characterization of semiconducting materials and fabrication of such type of structures plays an important role in the realization of some useful devices [10]. Extraction of device parameters, measured only at room temperature, dose not provide enough information regarding conduction mechanism and the nature of barrier formation at the M-S interface. The characteristics measured over a wide temperature range provide the more satisfactory information for understanding the different aspects of conduction mechanisms [11]. There have been many reports on study of I-V characteristics and barrier parameters in case of semiconductors in bulk form but as per our knowledge no report could be found for such study in case of materials having off stoichiometric proportion.

In present study, we report the forward bias I-V characteristics of Ag/p-$Sn_{0.2}Se_{0.8}$ Schottky barrier diode in the high temperature range of 303 K to 403 K and evaluation of barrier parameters.

2. EXPERIMENTAL

To fabricate thin film Ag/p-$Sn_{0.2}Se_{0.8}$ Schottky barrier diodes on non conductive glass substrates, the substrates were first cleaned by ultrasonic vibrations followed by thorough washing with detergent and acetone. Silver film of 6000 Å was deposited on glass substrate by thermal evaporation. Silver coated substrates were heated at 150 °C for providing better adhesion of subsequent films. Using proper mask $Sn_{0.2}Se_{0.8}$ films of thickness 10000 Å and 0.175 cm^2 area were deposited by flash evaporation on the silver coated substrates at room temperature. Here flash evaporation technique has been used to maintain the stoichiometric proportion. For this purpose $Sn_{0.2}Se_{0.8}$ charge in powder form was prepared by reacting highly pure Sn (99.9+), Se (99.9+) powder taken in required proportion heated at proper temperature in evacuated and sealed quartz ampoule. The chemical composition of deposited $Sn_{0.2}Se_{0.8}$ thin films was confirmed by EDAX analysis. Ohmic contacts on $Sn_{0.2}Se_{0.8}$ films were obtained by depositing indium films of 10000 Å. All these depositions were carried out in a residual pressure of 10^{-6} torr. External contacts from In and Ag were taken using adhesive and conducting silver paste (Elteck-1228C) through copper wires.

The I-V measurements were performed in the temperature range 303 K to 403 K using specially designed sample holder with inbuilt heater and semiconductor characterization system- Keithley 4200 under dark conditions.

3. RESULTS AND DISCUSSION

The obtained I-V plots of fabricated Schottky diode are shown in fig. 1a. These show that the fabricated diodes exhibit good rectification nature with rectification ratio of 464 at ± 2 V.

According to TE theory I-V relationship of a Schottky barrier diode is given by [12]

$$I = I_0 \exp(\frac{qV}{nkT})[1 - \exp(-\frac{qV}{kT})] \quad (1)$$

where

$$I_0 = AA^*T^2 \exp[-\frac{q\phi_{b0}}{kT}] \quad (2)$$

Here I_0 is the saturation current, V is the forward-bias voltage, k is Boltzmann constant, q is electronic charge, A is the diode area, T is absolute temperature, A^* is the effective Richardson constant having the value 18 cm^{-2}K^{-2} for SnSe [13]. The zero-bias barrier height (ϕ_{b0}) and ideality factor (?) from equation (1) can be written as

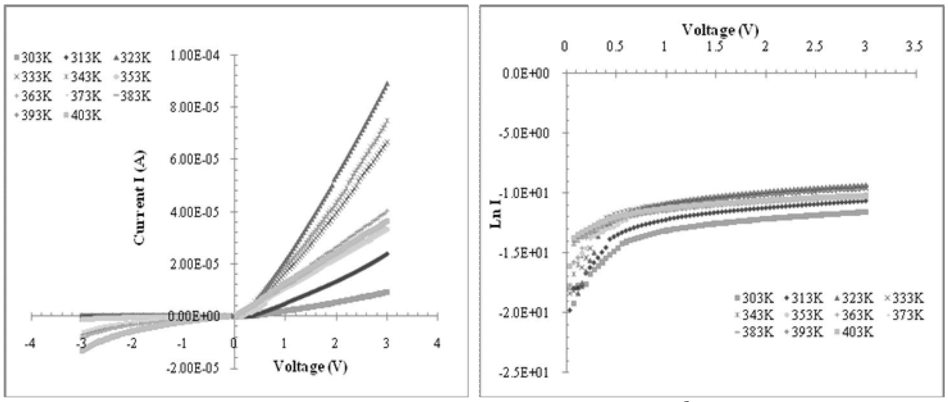
$$\phi_{bo} = \frac{kT}{q}\ln(\frac{AA^*T^2}{I_0}) \quad (4)$$

$$n = \frac{q}{kT}\frac{dV}{d(\ln I)}$$

The flat band barrier height can be calculated using the following equation

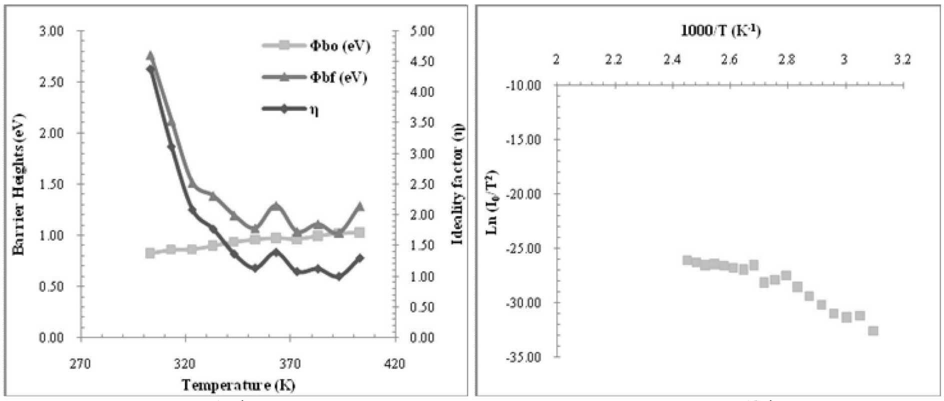
$$\phi_{bf} = n\phi_{b0} - (n-1)\frac{kT}{q}\ln[\frac{N_V}{N_A}] \quad (5)$$

where N_v and N_A are effective density of states in valance band and carrier concentration. The values of ϕ, ϕ_{b0} and ϕ_{bf} were determined from the intercept and slope of the ln I-V plot (Fig. 1b) for forward bias. These values of ϕ_{b0}, ϕ and ϕ_{bf} obtained from equation (3), (4) and (5) have been plotted as a function of temperature in Fig. 2a.



a *b*

Fig. 1 *– I-V Characteristics of Ag/p-$Sn_{0.2}Se_{0.8}$ SBD (a), and Ln I vs V plot for Ag/p-$Sn_{0.2}Se_{0.8}$ SBD (b)*



(a) *(b)*

Fig. 2 *– Variation of barrier heights and ideality factor with Temperature (a) Conventional Richardson plot (b)*

It is seen from here that in flat band barrier height and ideality factor decrease sharply in the initial part of 303-330 K and after that they found to become constant. At the same time the value of zero bias barrier height increases slowly with temperature attaining a value around 1.0 eV (Fig. 2a). Since current transport across the MS interface is a temperature activated process, electrons at low temperatures are able to surmount the lower barriers and therefore current transport will be dominated by current flowing through patches of the lower Schottky barrier heights (SBH) accounting for the larger ideality factor for observed values [14]. As the temperature increases, more and more electrons are likely to have sufficient energy to surmount even larger barriers. As a result, the dominant barrier height will increase with the temperature and bias voltage.

Equation (2) can be rearranged as

$$\ln[\frac{I_0}{T^2}] = \ln(AA^*) - \frac{q\phi_\partial}{kT} \quad (6)$$

It is known as the Richardson equation. Based on this equation a plot of ln (I_0/T^2) vs. $1000/T$ were drawn (fig. 2b). The plot should be a straight line. The value of Richardson constant obtained from this plot is around 15 $Acm^{-2}K^{-2}$, this can be compared to18 $Acm^{-2}K^{-2}$ for SnSe. The deviation in Richardson plot may be due to high ideality factor, high series resistance (47 kΩ to 467 kΩ) and deviation in composition from SnSe.

4. CONCLUSION

Ag/p-$Sn_{0.2}Se_{0.8}$ Schottky diodes have been fabricated and studied in the temperature range of 303 K – 403 K for their I-V characteristics. These characteristics show good rectification ratio at RT (464 at ± 2 V). The zero bias barrier height increases while the flat band barrier height and ideality factor decreases with the temperaure. The value of Richardson constant as determined from the Richardson plot without considering the contributions due to inhomogeneous barrier, is found to be around 15 $Acm^{-2}K^{-2}$.

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