Study of Cu- ZnSe Thin Film Schottky Barrier Junctions

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Abstract: The samples were prepared on glass substrates by sequential thermal evaporation process at a base pressure of 10^{-5} torr. Schottky barrier junctions of Al-doped n-type Zinc selenide (ZnSe) thin films have been fabricated with Cu on glass substrates. The current-voltage characteristics of Cu- (n) ZnSe/Al junctions show non-linear behavior with rectifying characteristics. From the current-voltage characteristics, the parameters such as ideality factor, saturation current density and barrier height were measured. The rectifying nature of I-V Characteristics with soft reverse current of the fabricated structures indicated the existence of barrier between the films of Cu and (n) ZnSe .Both types of junctions were found to possess a high ideality factor. The barrier height of the junction was found in the range of 0.804 to 0.809 eV. It is seen that heat treatment of the device slight lowers the diode ideality factor and increases the barrier heights.

***Keywords*:** Thermal evaporation, Barrier height, Diode ideality factor, Schottky barrier.

I.INTRODUCTION:

Zinc Selenide (ZnSe), a direct gap II-VI semiconductor with band gap energy of 2.67 eV, has long been found as promising material for optoelectronic devices such as LED, thin film transistor, blue laser diode etc [1-3]. Because of its large band gap, ZnSe has been used as window layer for the fabrication of photovoltaic solar cells. A variety of methods for preparation of ZnSe films have been reported by different authors like Chemical vapor deposition, Electro deposition, photochemical deposition, Chemical bath deposition (CBD), Pulsed laser deposition and thermal evaporation [4 - 11]. Although many investigations on the formation of Schottky barriers with single crystal bulk ZnSe using different metals have been carried out [12,13, 14], little attention has been given to Schottky barriers formed with polycrystalline ZnSe thin films. Thin-film Schottky barriers are attractive for photo detectors and thin-film solar cells due to their easy fabrication. Thermal evaporation is also cost effective and suitable for large area deposition. In the present work, (n)ZnSe thin-film Schottky barrier junctions with Cu barrier metal have been prepared by thermal evaporation. The prepared devices were also subjected to a short heat treatment. Studies of various junction parameters of these Schottky barrier junctions, measured before and after heat treatment, are reported in this paper.

II.EXPERIMENTAL:

The samples were prepared on glass substrates by sequential thermal evaporation process at a base pressure of 10^{-5}torr. First, the ohmic contacts formed from two parallel strips of aluminum each of width 0.2cm and length 2cm, were thermally deposited over glass slides from an electrically heated tungsten spiral and thickness was kept 2000 Å. Above these Al-doped ZnSe films of area 1.5×1.5 cm^2 were thermally deposited by thermal evaporation of ZnSe ingot from electrically heated molybdenum boat. The thickness was kept 2000 Å with the deposition rate of 5-10 Å / sec. Al made ZnSe films n-type. At the time of deposition, the substrate temperature was maintained at 303K. After deposition the films were annealed in vacuum at 453K for 60 minutes. Finally, for the barrier metal, two Cu electrodes (each of width 0.2 cm) were vacuum deposited over the Al-doped ZnSe films using suitable masks to form Cu-(n) ZnSe/Al structures of junction area 0.04 cm^2 each. Thus, 4 junctions of equal area (0.04 cm^2) were obtained on the same substrate. The Schottky barriers were formed between Cu and (n) ZnSe films, Al is for ohmic contact. A schematic diagram of a device structure having 4 Cu-(n) ZnSe Schottky barrier junctions on a single substrate has been shown in Fig.1.
A Keithey system electrometer (Model 2400) was used to measure the I-V characteristic of Schottky diode.

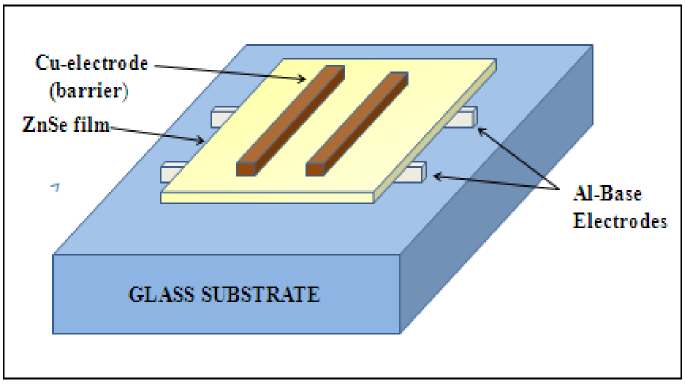

Fig.1: Schematic Diagram of Cu-(n) ZnSe Schottky diode

III.RESULTS AND DISCUSSION:

3.1 Current-Voltage characteristics

The current-voltage characteristics of Cu- (n) ZnSe/Al junctions show non-linear behavior with rectifying characteristics as shown in Fig. 6.2. The thickness of the semiconducting layers was of the order of 2000 Å. The material parameters of these semiconducting layers deposited on the separate glass substrate have been evaluated independently. Resistivity and carrier concentrations have been determined from four probe resistivity and Hall set up. All these measurements were carried out at room temperature.

The I-V Characteristics of Cu-(n)ZnSe-Al structures as-prepared and after the short heat treatment are shown in Fig.2. The rectifying nature of I-V Characteristics with soft reverse current of the fabricated structures indicated the existence of barrier between the films of Cu and (n) ZnSe. The reverse current does not saturate and shows some bias dependence of the barrier height. The current density I of a diode of saturation current density I_0 and diode ideality factor n, are related by [15],

$$I = I_0\, e^{(qV/nkT)} [1-e^{-qV/kT}]$$

The ideality factor (n) and the saturation current density (I_0) of different junctions, as-prepared and annealed were calculated from the slopes and intercepts of the respective **ln[*I*/(1-*e*$^{-qV/kT}$)] vs*V*** plots (Fig.3) and are tabulated in Table 1. The Schottky barrier height (SBH) has been calculated using the following relation and shown in Table 1.

$$\Phi_B = KT/q \ln A^*T^2/I_o$$

Where,

Φ_B- Schottky barrier height
A* - effective Richardson constant
($A= 41\ A^2/cm^2/K^2$)
K - Boltzmann constant
T - Temperature
I_0- Saturation current density
q - Electronic charge

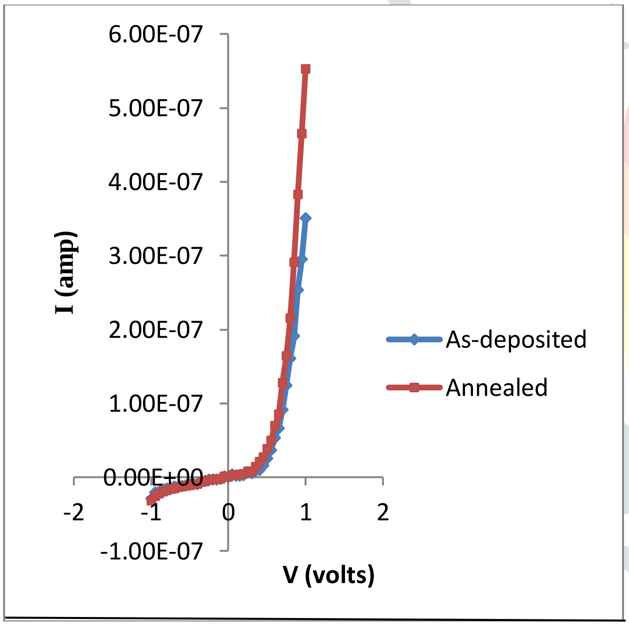

Fig.2: I-V Plots at room temperature

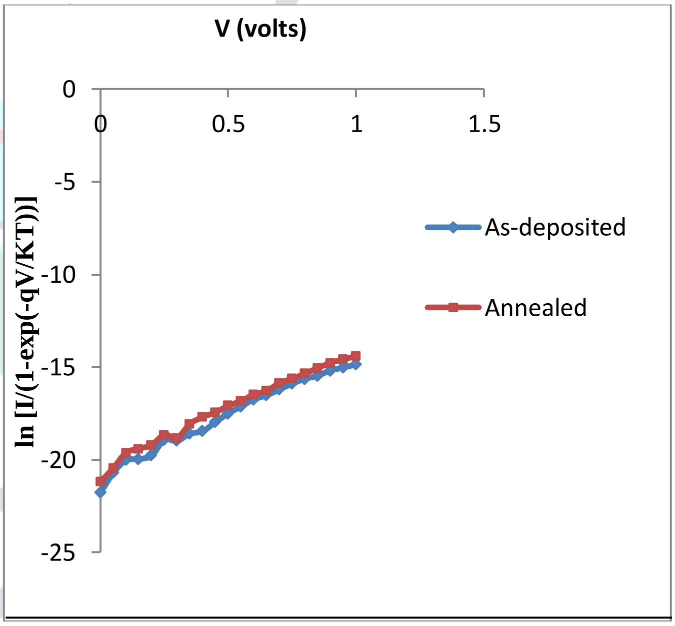

Fig.3: ln[I/(1-e-qv/kT)] verses V

Table1: Junction parameters of as prepared (U) and annealed (A) Cu-(n)ZnSe Schottky barriers

Barrier metal	Ideality factor n		Saturation current density Io (nA.cm^{-2})		Barrier height Φ_B (eV)	
	U	A	U	A	U	A
Cu	5.99	5.90	20.95	20.49	0.804	0.809

The barrier heights of the Cu-(n)ZnSe junctions were found in the range of 0.804 to 0.809 eV. The barrier heights have been observed to slightly increase on annealing the junction. From the study it is found that the *I-V* characteristics of Cu-(n)ZnSe Schottky barrier junctions are of rectifying in nature. The diode ideality factor for as-prepared junction has been found to be 5.99 which were found to reduce to 5.90 on heat treatment of the device. The barrier heights measured from the values of I_o at room temperature for Cu-(n)ZnSe junction and is found to be 0.804eV, while the barrier height of the same junction after heat treatment were found to be 0.809eV.This is in good agreement with the values reported earlier[16, 17].However, higher barrier heights of 1.65eV and 1.2eVfor single crystal ZnSe with Au and Ni, respectively, have been reported by other workers [18, 19]. From the table it is seen that heat treatment of the device slight lowers the diode ideality factor and increases the barrier heights. The reverse saturation current density of the annealed devices was found less than the unannealed devices. The diode ideality factor was found to be greater than unity and have been slightly lowered on heat treatment of the structures. The presence of an interfacial layer, image-force lowering, and carrier recombination due to surface states or defect levels are some of the main reasons for the ideality factor being greater than unity. In polycrystalline semiconductor thin films, the constitute atoms at the grain boundary are disordered and hence, there are large numbers of defects due to incomplete atomic bonding (dangling bond).This may result in the existence of surface states [20].In our case ,the barrier heights have been found to be less dependent on the work function of the barrier metals. These may be due to the effect of surface states of the semiconductors [21].Similar behavior was observed in Schottky barriers of other II-VI semiconductors including ZnSe [22].

IV.CONCLUSIONS:

The rectifying nature of the I-V characteristics of the junction indicates the existence of barriers at the junction. The presence of an interfacial layer, surface states, and various defects are found to affect the *I–V* characteristics. Heat treatment of the devices reduces the defects of the film and also makes more intimate contacts between the electrodes and semiconductor by thermally removing the insulating layer. Therefore the diode ideality factor of structures has been found to be lowered on heat treatment. The barrier heights measured from I-V characteristics and it is found to be 0.804 eV. The reverse saturation current density of the annealed devices was found less than the unannealed devices.

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