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Fabrication and Characterizations of Cu / $CdS_{0.6}Te_{0.4}$ Thin Film Schottky Diode

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ABSTRACT

The Schottky junction of Cu/ $CdS_{0.6}Te_{0.4}$ thin films has been formed by closed spaced sublimation technique under the pressure of 2×10^{-5} torr. The XRD analysis shows that $CdS_{0.6}Te_{0.4}$ is polycrystalline in nature, having monoclinic structure. The SEM study reveals that the nano crystalline grains are uniformly distributed. The average grain size is found to be near about 117 nm. The electrical characteristics such as a current-voltages measurement of prepared Cu/ (n)-$CdS_{0.6}Te_{0.4}$ schottky junction confirms the Schottky barrier formation. The variations of current with voltage have been studied to evaluate the Schottky parameters like reverse saturation current (J_o) = 15.35×10^{-3}, diode ideality factor (η) = 1.15 and Schottky Barrier Height (ϕ_B) = 0.48 eV. The ideality factor (η) is found approximately equal to the ideality.

Key words: Cu/$CdS_{0.6}Te_{0.4}$ Schottky diode, Reverse saturation current (J_o), Diode ideality factor (η), Schottky Barrier Height (SBH).

INTRODUCTION

Metal semiconductor contact formations have drawn much attention because of its usefulness in the fabrication of various electronic devices [1]. The properties of metal semiconductor (MS) interface are mostly depending on chemical compositions and surface preparation conditions [2, 3]. Many researchers work with to understand the behaviors of MS junction. Major efforts are being prepared to arrive at additional realistic interpretation of Schottky diode parameters [4]. The two probe measurement method has been extensively used to evaluate the Schottky barrier height (SBH) and ideality factor of Schottky diode [5]. The metal semiconductor contact is one of the fundamental structures in electronic devices and application like low-voltage and high-current rectifiers [6]. MS contacts are used frequently in ICs, solar cells and various electronic devices.

In the present work the structural properties of vacuum evaporated $CdS_{0.6}Te_{0.4}$ thin film are discussed. Further Cu/ (n)-$CdS_{0.6}Te_{0.4}$ schottky diode was prepared and investigated the current transport mechanism of metal semiconductor junction.

METHODOLOGY

1. Materials

The ternary ingot of $CdS_{0.6}Te_{0.4}$ was obtained by melt quench method. The direct mixture of extremely pure (99.999%) CdS and Te with their atomic ratio were kept in an evacuated quartz ampoule. The ampoule was heated above to 1000 °K for about 12 hrs. Well mixed charges were then quenched in an ice bath. The ingot of $CdS_{0.6}Te_{0.4}$ was taken out from the ampoule and prepared fine powder for film preparation.

2. Methods

The Schottky barrier was formed by sequentially depositing ohmic contact, semiconductor layer and a metal layer onto the glass substrate by using vacuum thermal evaporation system (Hind-Hi Vac – 12A4D) under the pressure of 2×10^{-5} torr. The source to substrate distance was kept about 14 cm. The deposition rate was maintained in the range of 8-10 Å/s and growth was monitored on Digital Thickness Monitor (DTM-101) provided by Hind-Hi Vac.

2.1. Preparation of Samples

First of all, the ohmic contact was formed by depositing the Al thin film of 1000Å thickness on glass substrate. Next, a semiconductor layer of $CdS_{0.6}Te_{0.4}$ of 3000Å thickness was deposited on Al thin film. Finally, onto the semiconductor layer the Cu thin film was deposited to from schottky diode. Then the prepared sample was annealed at 100 °C. The schematic of Schottky diode is shown in fig. 1.

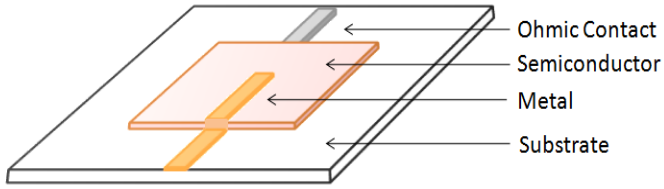

Fig. 1. Schematic of Cu/ (n)-$CdS_{0.6}Te_{0.4}$ Schottky Diode

The deposited $CdS_{0.6}Te_{0.4}$ thin film was examined under the X-Ray Diffraction to determine the crystal structure and nature of the material. The surface morphology of $CdS_{0.6}Te_{0.4}$ thin film was studied by using SEM micrographs. I-V measurements of Cu/ $CdS_{0.6}Te_{0.4}$ thin film schottky diode were carried out by using Keithley (model-2600A) under room light condition.

RESULT AND DISCUSSION

1. XRD Analysis

Fig 2 shows the XRD pattern of $CdS_{0.6}Te_{0.4}$ thin film. The sample was scanned within the 2θ range of 20° - 80°. The multiple XRD peaks reveal that $CdS_{0.6}Te_{0.4}$ thin film is polycrystalline in nature [7]. The diffraction angles 2θ peaks observed at degree 22.0°, 25.4°, 26.9°, 39.5° and 41.4° corresponds to (011), (040), (313), (012) and (-121) reflection planes respectively. According to JCPDS data the dominant peak belong to monoclinic structure. The lattice parameters a = 3.10, b = 7.51 and c = 4.76 were found.

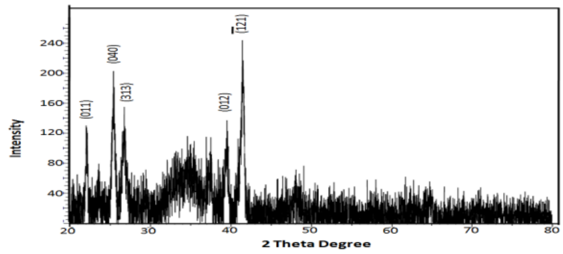

Fig. 2. XRD Pattern of $CdS_{0.6}Te_{0.4}$ Thin Films

2. SEM Analysis

Fig 3 shows the SEM photographs of the $CdS_{0.6}Te_{0.4}$ thin film. The SEM image reveals that the grown sample was homogeneous and smooth. The spherical shaped nano grains were closely packed and uniformly distributed on the substrate. The sample was free from defects like cracks or peeling off. It is also seen that the grains are made up of small particle and forms clusters [8, 9]. The average cluster size is found to be near about 117 nm.

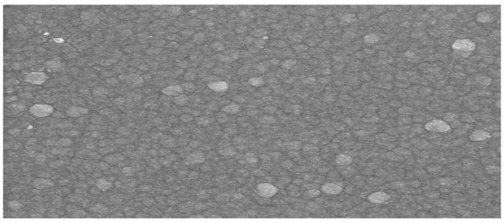

Fig. 3. SEM Image of $CdS_{0.6}Te_{0.4}$ Thin Films

3. Characteristics of Schottky diode

The current-voltage analysis is widely used to study the nature of the developmental barriers across the metal semiconductor interface. Fig 4 shows current-voltage characteristics of Cu/ (n)-$CdS_{0.6}Te_{0.4}$ Schottky diode**.** The carrier transport occurs across the barrier due to the thermionic emission obeys the relation [10, 11]:

$$I = I_0 \exp\left(\frac{qV}{\eta kT}\right)\left(1 - \exp\frac{-qV}{kT}\right)$$

Where, q is the electronic charge, V is the applied voltage, η is the diode ideality factor, k is Boltzmann's constant, T is the temperature in Kelvin and I_o is the saturation current. The ideality factor (η) of a Schottky diode can be expressed as:

$$\eta = \left(\frac{q}{kT}\right)\left(\frac{\partial V}{\partial \ln J_0}\right)$$

Where, J_o is saturation current density. Figure 5 shows the plot of voltage Vs ln (J_o) for Cu / (n)-$CdS_{0.6}Te_{0.4}$ Schottky diode.

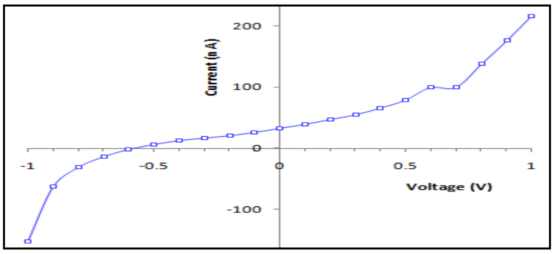

Fig. 4. I-V Characteristics of Cu/ (n)-$CdS_{0.6}Te_{0.4}$ Junction

The Schottky Barrier Height (SBH) can be formulized as:

$$\phi_B = \frac{kT}{q} \ln A^* \frac{T^2}{J_0}$$

Where, Φ_B is the Schottky barrier height, A is effective Richardson constant (8.6 $A^2/cm^2/K^2$), J_o is a saturation current density. Diode parameters for the Cu/ (n)-$CdS_{0.6}Te_{0.4}$ Schottky device are: J_o = 15.35 × 10^{-3}, η = 1.15 and ϕ_B = 0.48 eV. The high value of the ideality factor is probably due to the potential drop in the interface layer and recombination through the interface states between the metal semiconductor interfaces [10].

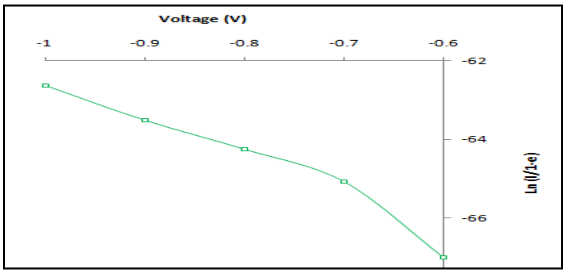

Fig. 5. Plot of Voltage Vs ln (J_o) for Cu/ (n)-$CdS_{0.6}Te_{0.4}$ Junction

CONCLUSION

The Cu / (n)- $CdS_{0.6}Te_{0.4}$ thin films Schottky barrier was formed by thermal evaporation technique. The $CdS_{0.6}Te_{0.4}$ thin film has polycrystalline nature. The SEM image reveals that the films are smooth and uniform. I-V characteristic confirms the formation of Schottky barrier at metal semiconductor interface. The forward current transport obeys the thermionic-field emission. The ideality factor has been calculated 1.15 which is approximately equal to 1.

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