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Preparation and Characterization of n-CdS Thin Films and Its Schottky Barrier

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Abstract: Cadmium sulphide (CdS), a member of group II-VI semiconductors is one of the promising materials from its applications point of view. The present investigations are about the preparation, structural and optical characterization of CdS thin films and their use as Schottky diode with Aluminum. Thin films of CdS having thickness around 700nm have been deposited by thermal evaporation. The chemical composition of the deposited CdS thin films has been made using EDAX technique. The structural characterization of this films was carried out using XRD. The structure of CdS after the deposition was found to be Cubic. Also, the lattice parameters were evaluated from the XRD data. From TEM of CdS thin films, the polycrystalline nature was confirmed. Optical characterization has been carried out using UV-VIS-IR spectroscopy. The direct as well as indirect band gaps obtained are 1.64eV and 1.48eV respectively. Schottky junctions were formed by a thermal-vapor-deposition of 500nm Al films on pre-coated CdS glass substrates. Diode parameters, such as the zero bias barrier height $\phi b0$, the flat band barrier height ϕbf and the ideality factorη, were calculated using thermionic emission theory at room temperature.

1. Introduction:

In recent years, much attention has been shown to semiconducting II-VI compounds because of their interesting optoelectronic properties and applications. Cadmium sulphide is an important member of this group. It has an indirect band gap of approximately 1.49eV at room temperature which makes it an interesting material for various applications. The CdS thin films have been extensively studied for structural [1,] optical [2] and optoelectronic [3, 4] properties. The heterojunction devices have also been investigated for understanding the charge transport mechanism [5]. In this paper studies on thermally evaporated CdS thin films, characterized by XRD, TEM, UV-VIS- IR techniques and used for making Al/CdS Schottky barrier diode have been presented.

2. Experiment:

CdS thin films of 700nm were deposited on chemically and ultrasonically cleaned glass substrates using thermal evaporation under vaccum of 10-6 torr at 400K. The chemical, structural and optical characterizations were made using the standard EDAX, XRD, TEM and UV-VIS-NIR spectroscopy. In order to obtain the schottky barrier structure Al films of 500nm were deposited through suitable metal mask (1cm2) on CdS films and its I-V characteristics were measured using Keithly 4200 SCS.

3. Results and Discussion:

3.1 EDAX

EDAX confirmed that deposition of CdS films is comprised of only Cd and S elements (Fig. 1.). Their proportion is also as expected.

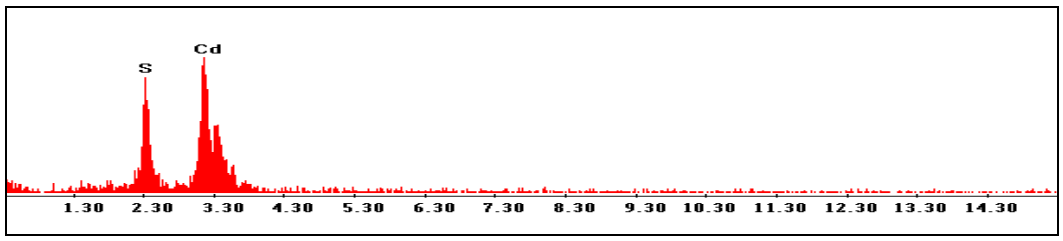

Fig. 1 EDAX spectra of 700nm CdS thin film deposited at 400K.

3.2 XRD

It can be seen from indexed XRD pattern (Fig. 2.) that the observed 'd' values and calculated values of the lattice constants 'a' are in good agreement with the standard data [6], as given in table 1.The grain size (D) was determined by the Debye-Scherrer's formula[7] and is found to be the order of 23.37nm [8].

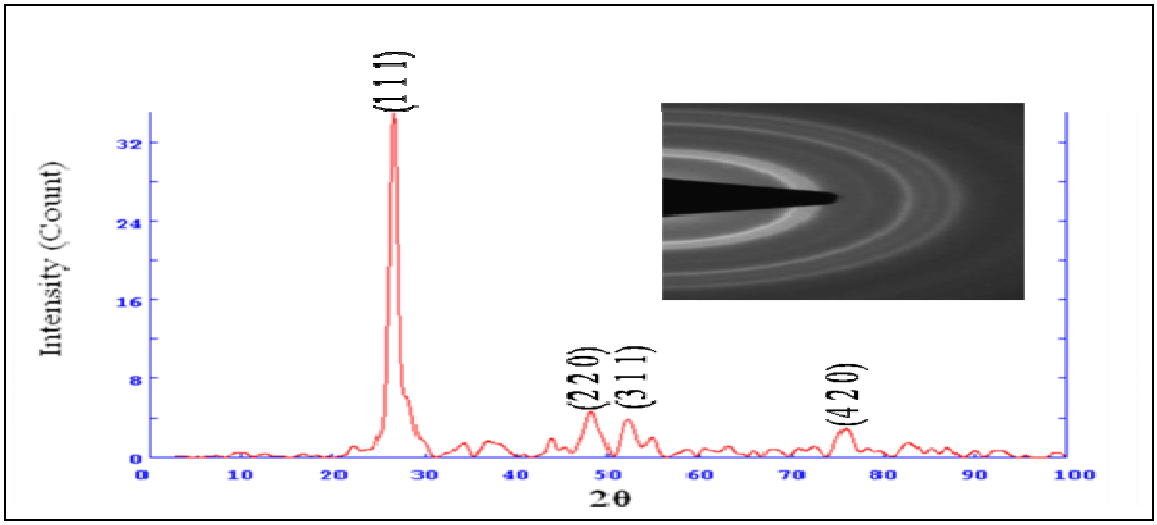

Fig. 2 XRD and ED pattern of 700nm CdS thin film deposited at 400K.

3.3 TEM

The electron diffraction pattern (inset of fig 2) shows that the deposited CdS films are polycrystalline in nature. The d values corresponding to all these rings and 'a' values have been calculated and are given in Table 1. These values are near and confirm that the deposited CdS films possess the cubic structure [9].

Table 1 Results of TEM & XRD analysis of 700nm CdS thin film deposited at 400K.

(h k l)	Observed Interplaner spacing (d) values Å		JCPDS[8] d values Å	Lattice parameter "a" Å	
	TEM	XRD		TEM	XRD
(111)	3.19	3.18	3.16	5.52	5.50
(220)	1.94	1.89	1.93	5.49	5.34
(311)	1.67	1.65	1.64	5.56	5.53
(420)	1.25	1.27	1.22	5.58	5.67

3.4 UV-VIS-NIR

The optical absorption and transmittance measurement of CdS thin films have been carried out at room temperature. The values of direct and indirect band gaps were found to be 1.64 eV and 1.48 eV respectively using plots given in Fig. 3.

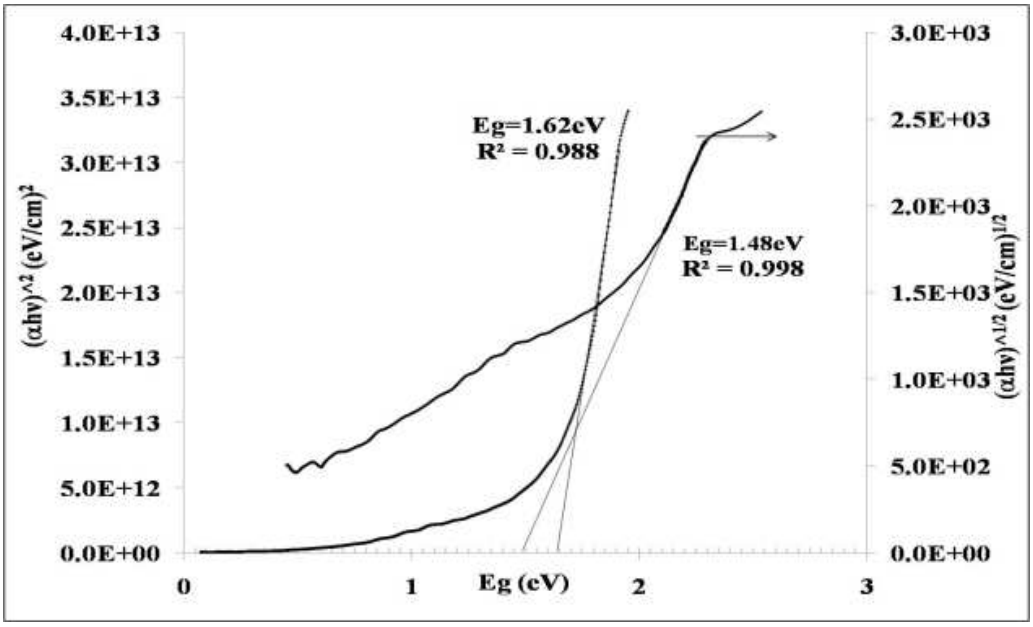

Fig.3 $(\alpha h\nu)^{r}\rightarrow(h\nu)$ Plot for 700nm CdS thin film.

3.5 Schottky barrier of Al/CdS

The I/V characteristic of Al/CdS diode is shown in fig. 4. It shows rectifying nature. Characterized by a reduced rectification ratio of 31 (V=1V) at room temperature, such behavior is likely a consequence of the unsaturated current under reverse bias [10].

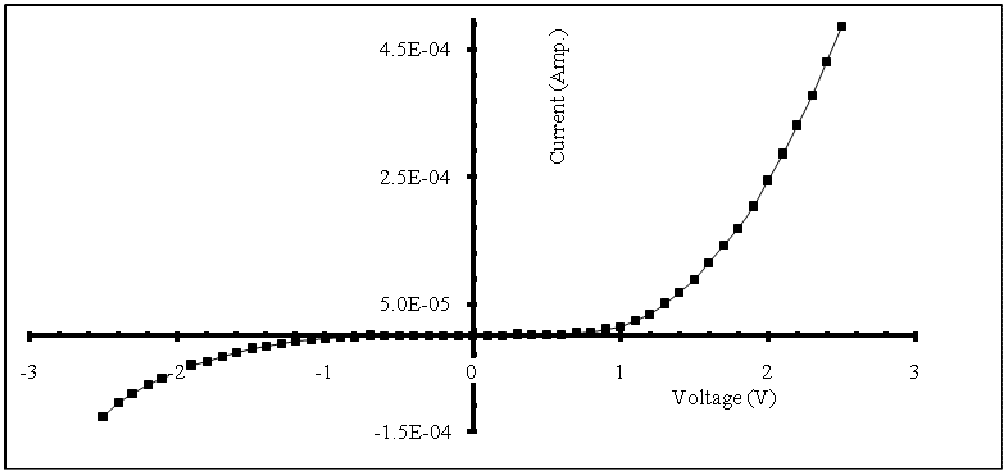

Fig. 4 I-V characteristic of Al/CdS Schottky diode.

Diode parameters, such as the zero bias barrier height $\phi b0$, the flat band barrier height ϕbf and the ideality factorη, were calculated using thermionic emission theory at room temperature and they are found to be 0.78 eV,2.92eV, 5.49 respectively.

4. Conclusion

Deposited CdS thin films were found to be poly crystalline in nature with cubic structure. The optical characterization reveals that CdS possesses both direct and indirect allowed band gaps of 1.64 eV and 1.48 eV respectively. The zero bias barrier height $\phi b0$, flat band barrier height ϕbf and ideality factorη, for Al/CdS diode were calculated using thermionic emission theory at room temperature and they are found to be 0.78 eV,2.92eV, 5.49 respectively.

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