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"STUDIES ON GAS SENSITIVITY OF CADMIUM SULPHIDE (CdS) THIN FILMS".

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Abstract:

Nanocrystalline semiconducting Cadmium Sulphide (CdS) thin films were deposited on glass substrate by relatively simple, quick and cost effective chemical bath route. The deposition kinetics played important role to get good quality nanocrystalline films with uniform thickness. By optimizing preparative parameters uniform film have been obtained. The characterization of as deposited thin films was carried out for the structural, compositional, surface morphological, and gas sensing properties using X-ray diffraction (XRD), Scanning electron microscopy (SEM) and Gas sensing static unit.

Gas sensing responses of the nanocrystalline CdS thin films were measured by exposing as deposited film to different gases like carbon dioxide (CO_2), Hydrogen sulphide (H_2S) and Chlorine (Cl_2). It was found that the CdS thin film sensors exhibited a high sensitivity and good selectivity to Chlorine (Cl_2) gas at 500 ppm and CdS thin film can be used as a new type of gas sensing material.

Keywords: Thin films, Cadmium Sulphide, Nanocrystalline, *gas sensing, selectivity*.

1. Introduction

Nanocrystalline Cadmium Sulphide (CdS) belongs to I-IV group compound of semiconducting material. Its band gap varies between 1.2 to 2.5 eV. The CdS thin films have wide range of well perspective applications such as field effect transistors, light emmiting diodes, photocatalysis and biological sensors [1-2] optical coding optical data storage and sensing [3,4], nonlinear integregated optical device [5]. In recent years there has been growing interest in developing techniques for preparing semiconductor nanoparticles and thin films because the properties in nano form differ significantly from those of their bulk counter parts [6,7]. Therefore much effort has been made to control the size, morphology and crystallinity of CdS thin film. For the deposition of CdS thin films both gas phase and liquid phase methods have been used. Gas phase deposition method includes vacuum evaporation, flash evaporation, activated reactive

evaporation(ARE),sputtering and chemical vapor deposition(CVD) whereas liquid phase include, electrodeposition [8], electroless deposition, successive ionic layer adsorption and reaction (SILAR) [9,10], chemical bath deposition(CBD) [11-14]. Among them, chemical bath deposition (CBD) is well known as a low temperature aqueous technique for depositing large area of semiconductor thin films. It is very simple, cost effective and also capable in growing nanocrystals, microcrystal and epitaxial structure under various growth condition.

Preciously we have reported the synthesis of CdS thin films by different route [15]. In present investigation CdS thin films have been deposited using chemical bath deposition method in alkaline bath. The structural, compositional, surface morphological and optical properties of the as deposited CdS thin films were studied.

2. Experimental details

The deposition was carried out by using Corning glass slides (25mm X 75mm X 1mm) as substrate which were initially boiled in concentrated chromic acid for 30 min. rinsed in acetone, deionised water and finally ultrasonically cleaned. All analytical grade (A.R) reagents were used as it is without further purification for the deposition of CdS thin films.Aqueous solution of 0.1M Cadmium sulphate, 0.1M thiourea and complexing agent Liq. Ammonia and C_2H_5OH was used. Initially 20ml of CdSO4 solution , 2.5 ml liq. ammonia and 1ml C_2H_5OH was placed in 50 ml beaker, after stirring for several minutes solution becomes dark purple and homogeneous under continuous stirring , 15 ml ml thiourea solution was introduced then cleaned glass substrate were vertically immersed into the prepared bath at room temperature. Preparative parameters are optimized for best quality CdS film.

3. Characterization Techniques

The structural characterization of the films was carried out using Philips (PW-3710) X-ray diffractometer with CuKα radiation (α= 1.5404^{o}A) in 2θ range from 20^0-80^0. The surface morphological study of ZnS films was carried out by scanning electron microscopy using a Model JOEL, JSM 6360 A. Gas sensing performance was measured by homemade static gas sensing unit.

4. Result and discussion

4.1 Structural studies

X-ray diffraction patterns of the film were recorded on Model Bruker D8 advance AXS X-ray diffractometer with scanning angles in the range 20 – 80 degree using CuK_α radiation (λ=1.5406 Å).

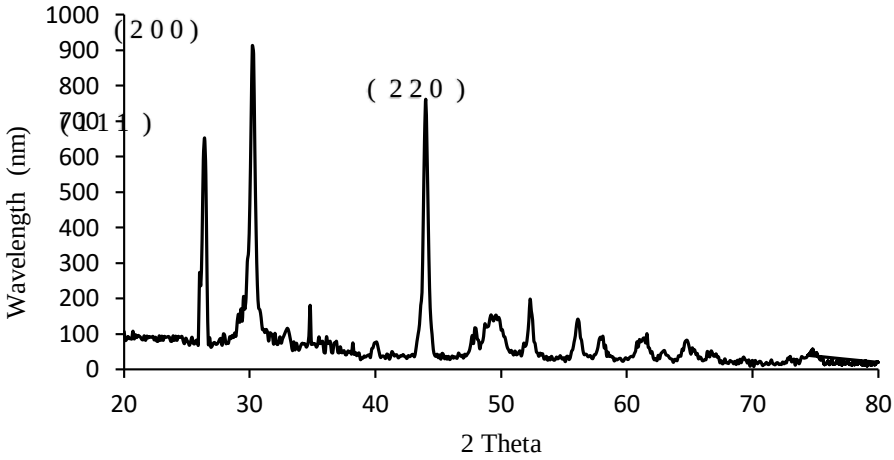

Fig. 1 : X-ray diffraction pattern of as-deposited CdS thin films For different thicknesses on glass substrate at room temperature.

Fig.1 shows X-ray diffraction pattern of as-deposited CdS thin film on glass substrate by chemical bath deposition method. In the present diffraction pattern of XRD, four dominant peaks at 26.5°, 30.7°, 44.0° and 52.1° corresponding to the (111), (2 0 0) and (2 2 0) planes of CdS are seen with cubic crystal structure [14]. An average value of the crystallite size can be obtained by applying the Debye-Scherrer's equation, $D = 0.9\lambda/\beta\cos\theta$ where, λ=1.5406 Å for CuKα, β is the full width at half maximum (FWHM) of the peak and θ is the diffraction/Bragg's angle. The sample as-deposited CdS resulted in an average crystallite size of approximately 90 nm.

4.2 Surface morphological studies

Scanning electron microscopy (SEM) is a versatile technique for studying microstructure of thin films. The CdS thin film with 250 nm thickness was used to study the surface morphology using a scanning electron microscopy.

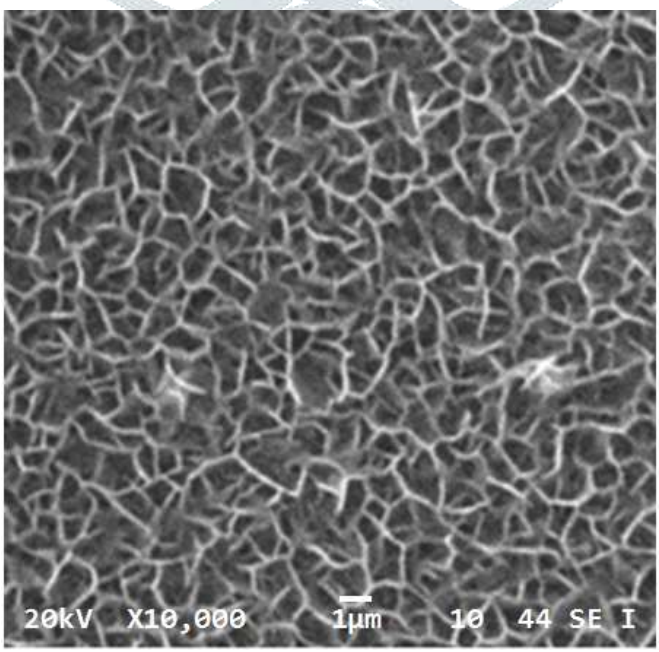

Fig. 2: The surface morphology of as-deposited CdS on glass substrate at room temperature by scanning electron microscopy studies.

Fig. 2 shows a scanning electron microscope of CdS thin film at X 10000 magnification the scale bar length is 1µm the average grain size of CdS thin films is 120nm which was estimated using Cotrells methods [18]. The as-deposited film shows net like nanostructure with symmetry in shape. The film surface looks smooth and uniform. It was observed that the film was uniform Yellowish and well substrate covered.

4.3. Sensing Performance

4.3.1. Measurement of Gas response, Selectivity

The gas-sensing properties of CdS thin films to different gases Carbon dioxide (CO_2), Hydrogen Sulphide (H_2S) and chlorine (Cl_2) were studied. Sensitivity (S) or Gas response is measured as the ratio of change in resistance of the sensor on exposure of the target gas to the original resistance in air medium using relation

$$\text{Sensitivity S (\%)} = \frac{Ra - Rg}{Ra} \text{ x } 100 \qquad \text{.....(1)}$$

Where *Ra* is the stabilized resistance of sensor in air medium and *Rg* is the resistance in the presence of target gas and selectivity or specificity is measured, as the ability of a sensor to respond to certain gas in the presence of more gases.

Fig. 3 depicts the variation gas responses as function of operating temperature of nanocrystalline CdS thin films for different gases with 500 ppm concentration.

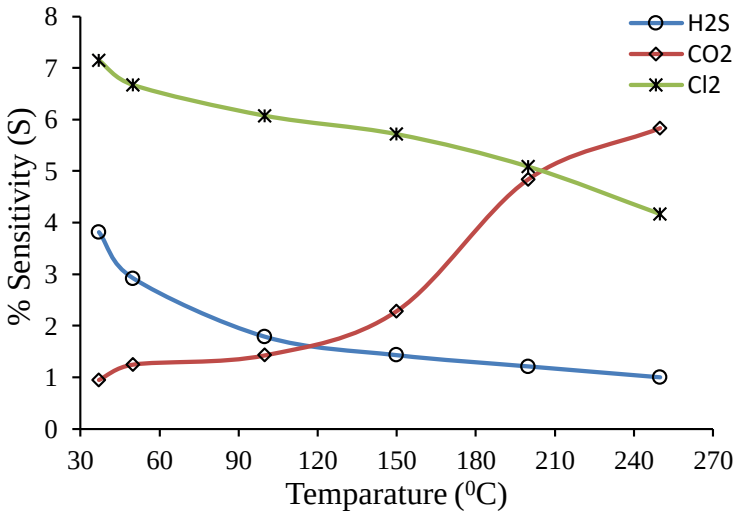

Fig. 3: Variation of gas response as function of operating temperature.

From **Fig. 4** it is observed that nanocrystalline CdS thin film sensor shows high sensitivity at room temperature for H_2S gas. The sensitivity for Cl_2 increase with increase in temperature but in case of CO_2 the behavior of thin film sensor is completely reverse. .

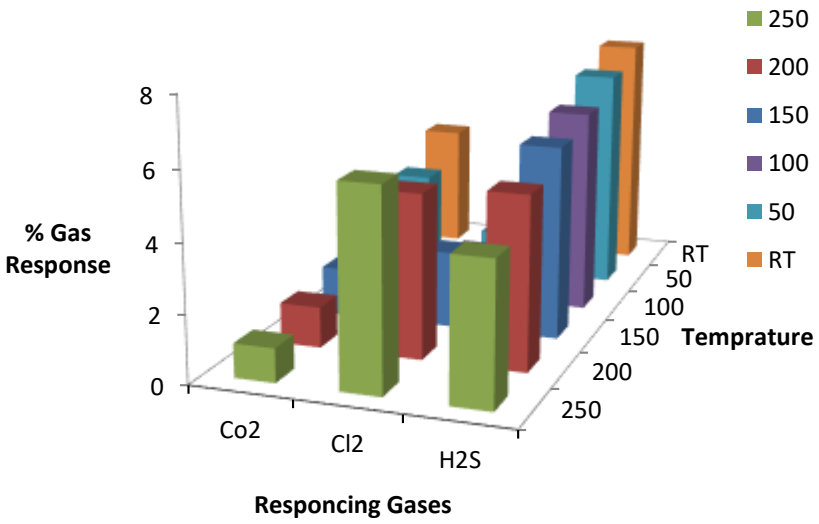

Fig. 4: Variation of gas response with operating temperature for CdS thin film gas sensor for different gases.

4.3. 2 Selectivity for Cl_2 Against Various Gases

The gas response of nanocrystalline CdS thin film sensor was tested for H_2S Cl_2 , and CO_2.

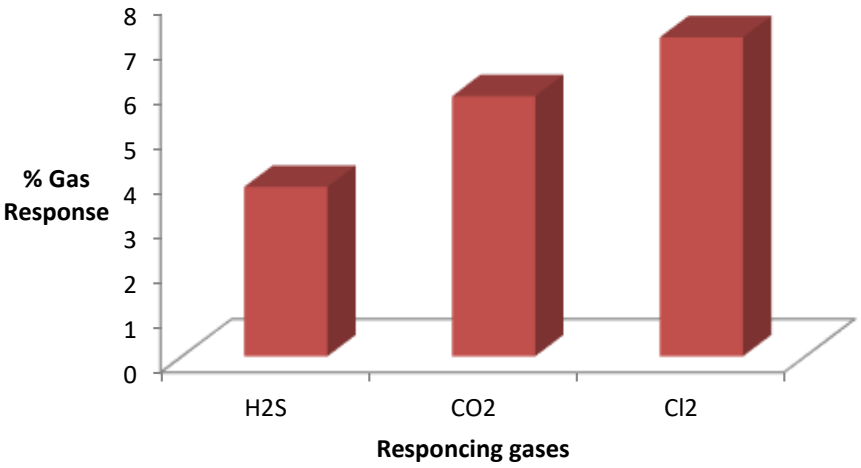

Fig. 5 Selectivity of CdS thin films for various gases at 500 ppm gas concentration .

It is observed from **Fig. 5** that the nanocrystalline **CdS** sensor gives maximum response to **Cl_2** gas at room temperature. The nanocrystalline **CdS** thin film sensor showed highest selectivity for **Cl_2** among all other tested gases.

Conclusion

The XRD study of as deposited nanocrystalline CdS thin films by CBD route on glass substrate showed the cubic structure partical size 90nm. The SEM micrograph reveals that substrate is well covered and average grain size is 120 nm. The investigated gas sensing responce of CdS thin film for Carbon dioxide (CO_2), Hydrogen Sulphide (H_2S) and chlorine (Cl_2). The CdS thin film sensor shows fast response and a good recovery times . The results demonstrated that nanocrystalline CdS thin film can be used as a new type of gas sensing material which has a high sensitivity and good selectivity to chlorine (Cl_2) gas at 500 ppm.

References :-

1. A. P. Alivisators. *Science* 271. (1996) p.933-937.

2. D. I. klevin, R. Roth, A. K. I.Lim, A. P. Alivisators. *Nature* 389. (1997) p.699-701.

3. K. C. Sarma, R. K. bordolo, M. Sarma, J. N. Gangurly. *J.Instrum.Soc.India*.31 (2001) 216.

4. G.Cao. *Imperical college Press*.349(2004).

5. K. Senthil, D. Magalraj, S. K. Narayandas. *Appl. Surf.Sci*. 169-170.

6. A. Henglein. *Chem.Rev*.89.(1989) p.1861-1873.

7. A. fukuka, Y. Sakamoto, S. Guan, S. Ingaki, N. Sugimoto, Y. Fukushima, K. Hirahara, S. Lijima, M. KIkawa. *J.Amer.Chem.Soc*.123(2001) p. 3373-3374.

8. B. M. Basol, E. S. Tseng, D. S. Lo. *US. Patent* 4,548(1985) 681.

9. Y. F. Nicolaue, M. Dupuy, *J. Elctrochem.Soc* 137(1990)2915.

10.Y.F.Nicolaue, *Appl. Surf. Sci*. 22-23 (1985) 1061.

11. S.S.Kale, U.S.Jadhav, C.D.Lokhande, *Ind J.Pure Appl phys* 34(1996) 324

12. A.Mondal, T.K.chaudhary,P.Pramanik, *Sol Energy Matter* 7(1983) 431.

13. M. S. Shinde and R. S. Patil* *"International Sciences Press", International Journal of Material Science and Electronics Research (IJMSER),* (ISSN: 0976-6111) Vol.2 No.1-2 Jan.-Dec.2011, 17-24.

14. YA Kalandaragh, MB Muradov, RK Mammedov, A Khodayari *Journal of crystal growth* 305 (1),(2007) 175-180

15. U. M. Jadhav, M. S. Shinde, S. N. Patel and R.S. Patil *NISCAIR's , Indian Journal of Pure and Applied Physics* (ISSN: 0019-5596)*(Vol. 52) January (2014) 39-43.*

16. A.cottrell, *Intorduction to Mettallurgy* ,Arnold, Londan, (1975) P.173