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SYNTHESIS AND CHARACTERIZATION OF Al DOPED CdS THIN FILMS GROWN BY CHEMICAL BATH DEPOSITION METHOD AND ITS APPLICATION TO REMOVE DYE BY PHOTOCATALYTIC TREATMENT

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Alluminium doped cadmium sulphide thin films were prepared by chemical bath method on glass substrate at different temperature ranging from 80 ^{0}C to 140^{0}C in 20 ^{0}C steps using aqueous solution of cadmium sulphide and thiourea salts. We used Alluminium sulphate as the dopant. strucutural characterization was carried out by X-ray Diffraction (XRD) Scanning Electron Microscopy(SEM).The Al-doped CdS thin films were used to remove methylene blue dye from an aqueous solution in presence of UV light.

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Keywords: CdS thin films, Doping, Chemical bath deposition, Methylene blue, XRD, SEM

1. Introduction

In situ doping with group III elements has been widely used to decrease the dark resistivity of CdS thin films grown by chemical bath deposition methods [1,2].The need to such doping is attributed to the fact that chemical bath deposition CdS thin film are highly stoichiometric [3, 4]. The group III elements such as Alluminium, Indium and Gallium are the most suitable approach to tackle this problem where the need for post deposition treatment such as ion implantation is being eliminated. Several different techniques are known for CdS thin film preparation such as the method of spray pyrolysis [5-7], evaporation [8], Close space elimination [9], Sputtering [10], Electrolysis, MBE, Screen printing and chemical deposition etc. The chemical deposition method is one of the least expensive method with respect to expenditure of energy and chemicals and convenient for large area deposition on a variety of of substrate .Several metals have been utilized to dope CdS thin film such as Hg[12,13], In[14], Cu[15,16], Ag[17,18] etc. Gallium in situ doping of CdS using chemical bath deposition is being reported. The same investigation methodology used in Al/B doping work [19-21]. The ion exchange method of CdS thin film in $AgNO_3$ aqueous solution has been previously used to produce Ag_2S thin films[22, 23].

In present work Al was doped in CdS thin film and its application to removal of dye from an aqueous solution .The results of experimental were good approach.

2. Experimental

Glass substrate was previously cleaned by 24 hr immersion in chromosulphuric acid and rinsed wit acetone and double distilled water. The deposition solution contains 20ml 0.2M $CdCl_2$, 20ml 7M NH_4OH , 5ml 2.5M NH_4Cl ,40ml 1M $(NH_2)_2CS$ all filled up to 200ml with distilled water in 200ml beaker. All the chemicals were analytical grade. Alluminium doping was carried

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out by adding the appropriate amount from 0.004M $Al_2(SO_4)_3$ to the main solution.The alkalinity of of this solution was pH 10.8. The deposition temperature was kept constant at 85^0C. After deposition of substrate all films were annealed at 300 ^{0}C in furnace for 1 hr.

Six to eight glass substrate were arranged inside .The process of CdS commences at solution temperature 85 ^{0}C. The deposition completed after some 25-30 minutes. Transferent and homogenous orange to yellow colored thin films obtained at the end of deposition process.

0.05M stock solution of methylene blue dye was prepared in double distilled water.The photocatalytic activity of Al doped CdS thin films were carried out at room temperature. In 100 ml dye solution of desired concentration irradiated to mercury lamp (PHILIPS-400 Watt) having light intensity 37.4 measured by Illuminance meter (AGRONIC-Electronics LX-101). To ensure the dipping of thin film in aqueous solution of methylene blue. At specific time intervals (10 min.) thin film substrate was withdrawn and analyzed by UV –Visible double beam spectrophotometer (Systronics-2203) at λmax 665 nm.

3. Results and discussion

SEM Analysis

The SEM images of the Al doped CdS thin film thermally at room temperature 300 ^{0}C during 30 minutes are shown in Fig.1.SEM images show that Al doping did not have significant effect on the morphology of CdS thin film. Both doped and undoped thin films are smooth, continous and uniform with some coverage by scattered crystalline overgrowth that appear to have slightly higher density for Al doped film. These are most probably aggregates due to colloid at particles formed in solution and then removal of methylene blue dye by prepared thin film.

The optical transmittance spectra of all Al doped films grown at different [Al]/ [Cd] ratios. Adding higher concentration of Al_2 $(SO_4)_3$ resulted in homogenous reaction that quickly dominated the deposition process and affected the quality of doped CdS thin films. It should be noted that a ratio of zero was assigned to undoped film (purely CdS). As shown all films exhibit a high transmittance that exceeds 80% inter visible region of the spectrum and exceeds 90% right before the absorption edge. A red shift in the absorption edge towards lower band gap is noticed in all Al doped CdS thin films.

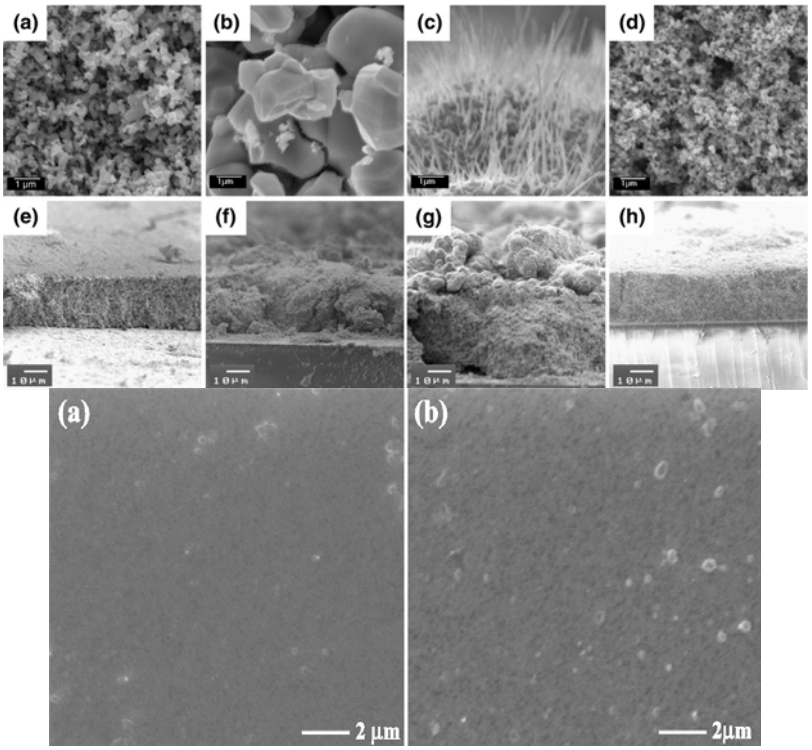
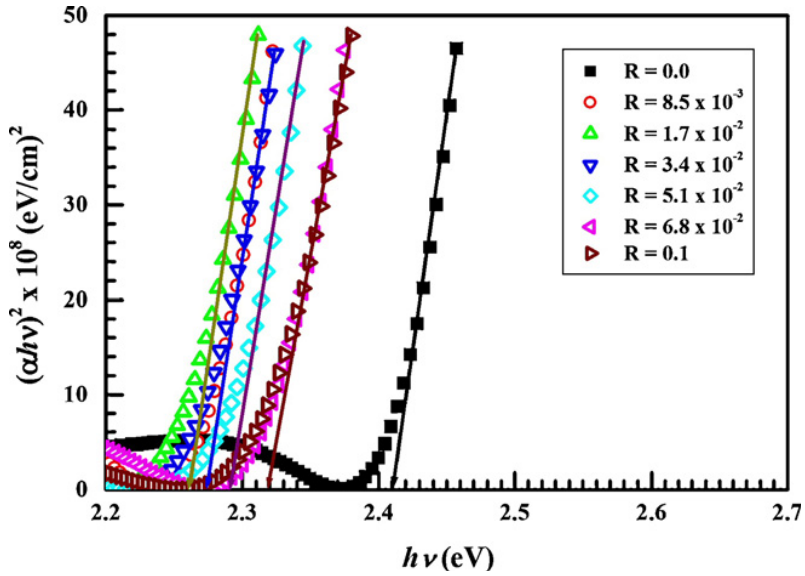


Fig.1 SEM images of Al doped CdS thin films

Fig.3 shows band gap dependence on Al /Cd ratio.The band gap doped films decreases to minimum to 2.2 ev at the ratio of 0.011 then increases and finally saturates at 2.32 eV, as the Al /Cd ratio exceeds at 0.05.



The optical transmittance spectra is as shown in Fig.3

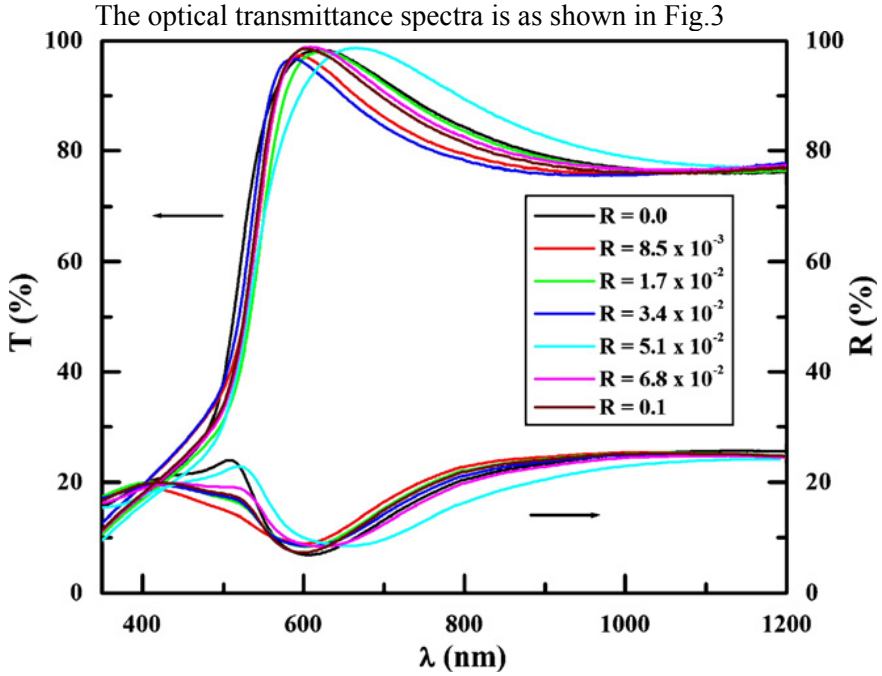


Fig.4 shows XRD pattern of Al – doped films and undoped Cds thin films. Only one peak is detected, which is their cubic Cds is a metastable phase, while hexagonal CdS is the stable phase while hexagonal CdS is the stable phase at room temperature.

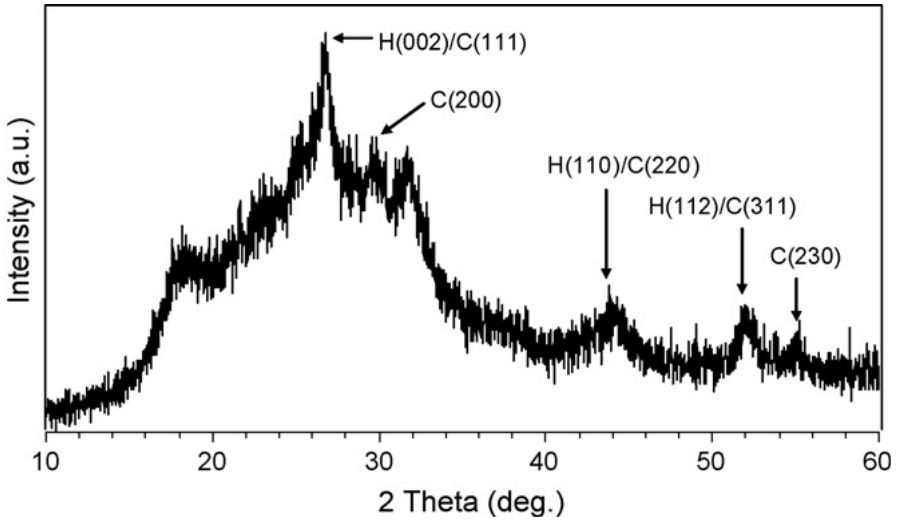


Fig. 4. XRD pattern of Al – doped films Cds thin films

The photocatalytic activity studies of the Al doped CdS thin films were carried out at different temperature. The film catalyst was immersed in a quartz cell containing 3.5 ml of an aqueous solution at 0.05M ppm of methylene blue. The methylene blue solution was irradiated in a photocatalytic reactor with mercury lamp (PHILIPS-400 Watt) with an intensity 37.4 mW/cm^2. The reaction rate was followed by taking samples every 15 min. and analyzing them by UV–Visible double beam spectrophotometer (Systronics model - 2203).The concentration of methylene blue was calculated from the absorption band at 665 nm by means of methylene blue. The percentage removal by Al doped CdS thin films of methylene blue is shown in table 1.

Table1: Removal of methylene blue by prepared thin films is shown as

Al doped CdS thin films (time)	% R
30	2.6
60	7.6
90	12.5
120	23.1
150	35.4

4. Conclusion

This communication demonstrates that nanocrystalline Al doped CdS thin films have been synthesized successfully using chemical deposition method at different temperature. The films are mechanically stable. The choice of the non heat resistance substrate such as glass substrate which should be beneficial for for photocatalytic applications. The XRD and SEM results indicates the composites film are amorphous. The Al doped CdS thin films present photocatalytic activity in the decomposition of methylene blue. The photodecomposition grade still low and is probably due to thickness of the films.

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References

[1] T. Chu, S. S. Chu, N.Schultz, C.Wang, C.Wu, J. Electrochem.Soc.,**139**, 2443 (1992).
[2] J. Lee, Thin Solid Films, **451-452** ,170 (2004).
[3] H. Khallaf, I. Oladeji, L.Chow, Thin Solid Films **516** ,5967 (2008).
[4] H. Khallaf, I.Oladeji, G, Chai, L.Chow,Thin Solid Films **516**, 7306 (2008).
[5] H.L.Kwook, W.C.siu, Thin Solid Films **61**, 249 (1979).
[6] H.L.Kwook, J.Phys.D. **13**, 1911 (1980).
[7] Y.Y.Ma, R.H.Bube, J. Electrochem.Soc.: Solid State Sci.Technol. **124** (9) 1430 (1977).
[8] A.Kunioka, Y.Sakai, Solid State Electron. **8**, 961 (1965).
[9] T.L.Chu, S.S.Chu,J.Brittet,al., IEEE Eelectron Device Lett. **13**(5) 303 (1992).
[10] F.A.Abouelfotouh, R. Al. Awadi , M. M. Abd-Elnaby, Thin Solid Films **60**, 55 (1979).
[11] R.Krup, A.Wrezesinska,Acta Phys.Polonica A **53** ,675 (1978).
[12] M.T.S.Nair,P.K.Nair,R.A.Zingaro,E.A.Mayers,J. Appl.Phys.,**75**(3) 1557 (1994).
[13] M.Skyllas-Kazaandcos, J.F.McCann,R.Arruzza,Appl.Surf.Sci. **22-23**,1091 (1985).
[14] T.Hayashi, T,Nishikura,T,Suzuki, Y.Ema, J.Appl.Phys., **64**, 3542 (1988).
[15] M.K.Karanjai,D.Dasgupta,J.Phys.D, **21**,1769 (1988).
[16] P.J.Sebastian, M.Ocampo, J.Appl.Phys. **77** ,4548 (1995).
[17] J.Krustok, P.E.Kukk, Mater.Sci.,**15**(3) ,43 (1989).
[18] J.Krustok, J.Maddason,M.Altosaar, P.Kukk,J.Phys.Chem.Solids,**51**(9), 1013 (1990).
[19] H.Khallaf,G.Chai, O.Lupan,L.Chow,S.Park, A.Schulte,J.Phys.D,:Appl.Phys. **41**, 185304 (2008).
[20] L.Sillen, A.Martell, Stability constants of metal ion complexes.Burnington House, London, 1964.
[21] H. Khallaf,G. Chai, O.Lupan,L.Chow,S.Park, A.Schulte, Phys.Status Solidi A, doi:10-1002/pssa ,24290, 2008.
[22] C. D.Lokhane,V.V.Bhad, S.S. Dhumure,J.Phys.D,25315, 1992.
[23] C. D.Lokhande, K.M.Gadave, Mater.Chem.Phys. **36** ,119 (1993).