J. Environ. Nanotechnol.
Volume 2, No.2 34-37 pp.
ISSN (Print) : 2279-0748
ISSN (Online) : 2319-5541
doi : 10.13074/jent.2013.06.132011

Silver and Zinc Doped Chalcogenide (CdS) films by Chemical Bath Deposition Process

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Received: 11.04.2013 Revised: 26.05.2013 Accepted: 20.06.2013

Abstract

Doped cadmium sulfide (CdS) thin films were prepared by chemical bath deposition (CBD) technique at 70 ± 5°C. Silver (Ag) and zinc (Zn) are the dopent materials. This paper presents the analysis of optical, structural and surface properties of the CdS thin films by UV-Vis-NIR Spectrophotometer, X-ray Diffractometer (XRD) and scanning electron microscope (SEM) respectively. Optical spectra of CdS Thin films exhibit high transmittance in the visible region and high absorbance near Ultra-Violet (UV) range. XRD studies showed all the doped CdS thin films exhibits amorphous in nature. Possible alications of the doped CdS thin films are also discussed.

Keywords :*Cadmium sulfide; Coer; Silver; Aluminum; Zinc etc.*

1. INTRODUCTION

Thin films can be deposited over large in any predetermined shape and structure. Some of the factors which determine the physical, electrical and optical properties of a film are the following via, rate of deposition, substrate temperature, environmental conditions, residual gas pressure in the system, purity of the material to be deposited, inclusion of foreign matter in the deposit, inhomogeniety of the film, structural and compositional variations of the film in localized or wider areas etc. some of which have been actually observed surface states of a film also play a dominant role in modifying electrical and other properties (Khomane , 2010 , Hankare et al. 2009, Karimi et al. 2009, Chaudhari et al.2008, Khallaf et al. 2008, Devi, et al. 2007, Purkayastha et al. 2007, Roy et al. 2006, Visoly-Fisher et al. 2003, Herrero et al. 2000 and Bayer et al. 2000).

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Nowadays nanostructure based CdS materials have attracted importance due to its largest absorbance value, with a wide direct bandgap of 2.42 eV at the room temperature. Here, the detailed analysis of CdS doped with different materials like Ag and Zn are prepared as thin films onto a well cleaned glass substrate by CBD method. The absorption and emission properties are analyzed and also crystallite properties of CdS have been explained.

2. EXPERIMENTAL SECTIONS

2.1 Synthesis of precursor materials

Both the aqueous solutions ammonia (15 mL) and triethanolamine TEA (15 mL) were added to 0.5 N of cadmium precursor dissolved in 25 mL of distilled water and this aqueous solution bath temperature is maintained under 75°C and also the dopent materials, Ag and Zn aqueous solutions are added under the same conditions as mentioned above and ammonia solution was added to control the pH value of the solutions. 30 ml of synthesized

suspension was introduced into another 50 mL glass beaker and stirred.

2.1.1 Sulfulrization

0.5 N of sulfide precursor was dissolved into 15 mL of distilled water and this aqueous solution was added to suspension of synthesized as mentioned above. Yellow films were synthesized after continuous stirring. Samples are rinsed in running water and analyzed.

2.1.2 Fabrication of thin films

Synthesized materials were well dispersed in binder solution and a well cleaned glass substrate was died in it. After this treatment, the thin films were well washed with running water and dried in room atmosphere and analyzed. The experimental steps are written below (Saikia et al. 2010).

Cadmium +TEA + NH_4OH '! $[Cd(TEA)]^{n+}$ + $[Cd(NH_3)_n]^{n+}$

$(NH_2)_2CS + 2OH^-$ '! $S^{n-} + CH_2N_2 + 2H_2O$

$[Cd(TEA)]^{n+} + [Cd(NH_3)_n]^{n+}$ '! $Cd^{n+} + 4NH_3$

a. $Cd^{n+} + S^{n-} + Ag^{n+}$ '! AgCdS

b. $Cd^{n+} + S^{n-} + Zn^{n+}$ '! ZnCdS

The samples are characterized by UV-Vis-NIR, XRD and SEM studies.

2.2 Characterization

Absorbance and transmittance spectra of the thin films were calculated as a function of incident photon wavelength at normal incidence at room temperature using a UV-Vis-NIR spectrophotometer. The crystallite properties were measured by XRD and the surface morphology was carried out using SEM attached to it.

3. RESULTS AND DISCUSSION

3.1 Optical analysis

Transmittance spectra of thin films in the wavelength range 200 - 1000 nm are shown in the Fig. 1 (b). The absorbance near infrared domain (300 nm) is very low with high transmittance at the same regions. Ag and Zn doped CdS films are having increasing transmittance value when compared with other samples in the visible region. And all the samples are having increasing transmittance value in the wavelength range from blue to red region. Fig. 1 shows that the absorbance edges are blue shifted with respect to the bulk CdS indicating quantum confinement effect in nanoparticles (Moutinho et al. 1996).

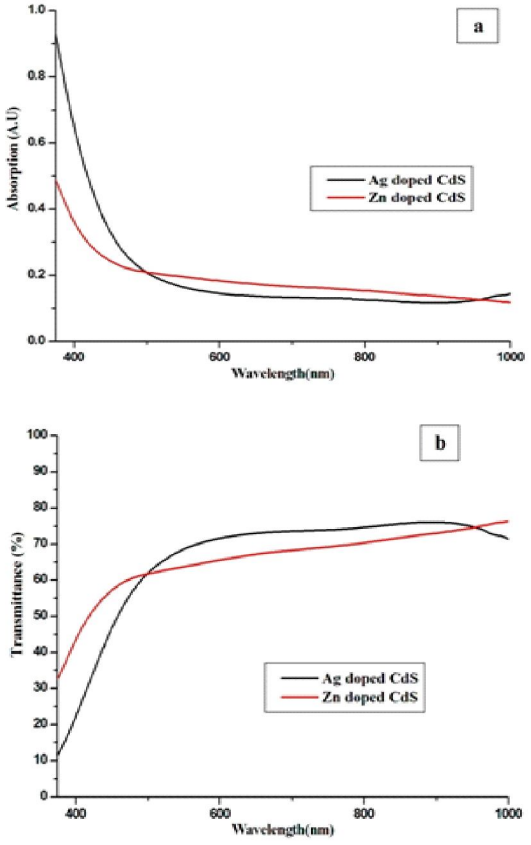

Fig. 1(a): shows that the absorbance spectra of thin films in the wavelength range 200 - 1000 nm (b) shows that the transmittance spectra of CdS films in the wavelength range 200 - 1000 nm. Black and red lines are representing Ag and Zn doped CdS thin films respectively.

High transmittance (~ 60 – 90 %) and low absorbance near infrared region (~500 – 1000 nm), thus making the film suitable for optoelectronic devices for instance window layer on solar cells (Sahay et al. 2007).

3.1.1 Extinction coefficient

The rise and fall in the extinction coefficient is directly related to the absorption of light. This conforms to the relation:

$$k = \frac{\alpha\lambda}{4\pi}$$

Variations of extinction coefficient (k) as a function of photon energy (hν) are shown in the figure.2

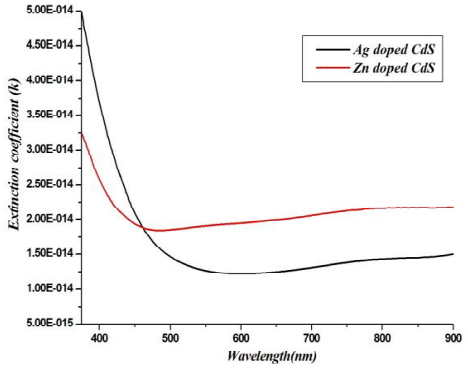

Fig. 2: Extinction coefficient versus Wavelength for the CdS thin films

3.2 Structural analysis

The X-ray Diffraction pattern of doped (Ag and Zn) CdS thin films are shown in the Fig.3. The graph plotted in the range 20° - 70° is due mainly to the amorphous glass substrate. The planes (002), (200), (110) and (004) show that Ag: CdS films are in polycrystalline crystal structure [11]. And the planes (110), (110), (002) and (004) show that Zn: CdS films are in polycrystalline crystal structure (Dura´n et al. 1997).

3.3 Surface analysis

Fig. 4 (a) & (b), shows that the surface morphology of Ag and Zn doped CdS thin films as deposited by chemical bath deposition method at the bath temperature maintained at 70 ± 5°C. Surface morphological studies of the Ag and Zn doped CdS films have been carried out using scanning electron micrographs. Comparison of the SEM images clearly shows that the thin films are uniformly distributed grains over the entire surface of the substance.

The grain sizes for Zn and Ag are 285 nm and 308 nm respectively. Depending upon the dopent materials Zn and Ag the surface smoothness and grain size are improved respectively as doped.

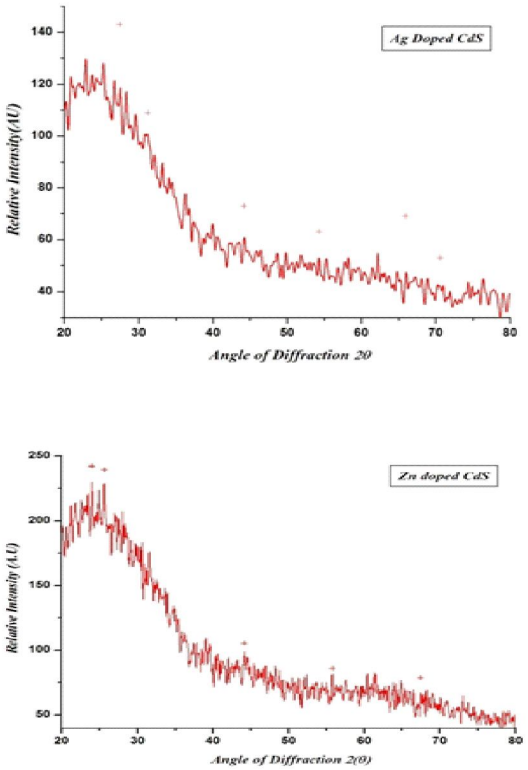

Fig. 3: Shows that the XRD patterns for Ag and Zn doped CdS thin films respectively

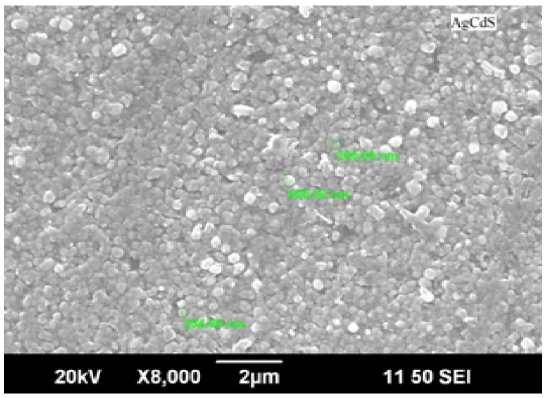

Fig. 4(a) shows that the SEM microscopes Image for Ag doped CdS thin films.

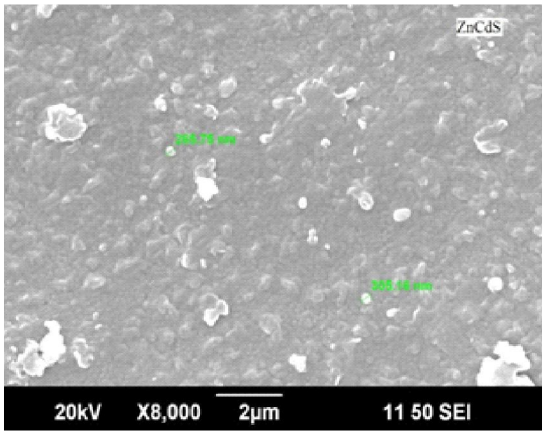

Fig. 4(b) shows that the SEM microscopes Image for Zn doped CdS thin films.

4. CONCLUSIONS

Doped CdS thin films are successfully deposited by chemical bath deposition technique, optical, structural and surface smoothness properties were investigated. Ag doped CdS films are having highest transmittance value (60 – 80%) in visible region than Zn. Since doped (Ag and Zn) CdS thin films which are in polycrystalline phase, film surface smoothness and grain sizes were improved. The grain sizes for Zn and Ag are 285 nm and 308 nm respectively. Comparing dopent materials, Zn doped CdS thin films are used as a transparent conductive buffer layers in an optoelectronic device due to its highest transmittance value.

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