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Archives of Physics Research, 2013, 4 (2):97-102
(http://scholarsresearchlibrary.com/archive.html)

Scholars Research Library
ISSN : 0976-0970
CODEN (USA): APRRC7

Cadmium sulfide doped films with different materials by chemical bath deposition process

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ABSTRACT

Thin films were prepared on a well cleaned glass substrate by economically simple chemical bath deposition (CBD) technique at 70 ± 5°C. In this paper, reports that the most important semiconductors materials from II – IV groups cadmium sulfide (CdS) thin films doped with different materials at same concentration. Copper (Cu), aluminum (Al), silver (Ag) and zinc (Zn) are the selected dopent materials. This paper presents the analysis of structural, optical and surface properties of the doped CdS thin films by X-ray diffractometer (XRD), UV-Vis-NIR spectrophotometer and scanning electron microscope (SEM) respectively. XRD studies showed all the doped CdS thin films exhibits amorphous in nature. Optical spectra of CdS thin films exhibit high transmittance in the visible region and high absorbance near Ultra-Violet (UV) range and surface smoothness is improved. Possible applications of the doped CdS thin films are also discussed.

Keywords: Thin films, CBD, XRD, SEM and Optical properties etc.

INTRODUCTION

The chemical bath deposition method is an economically simple method for the preparation of thin films suitable for scientific studies and for many applications in technology and industry [1-5].

Nowadays, II – IV group semiconductor thin films have attracted considerable attention from the research community because of their wide range of application in the fabrication of solar cells and other opto-electronic devices. Especially nanostructure based CdS materials have attracted importance due to its largest absorbance value, with a wide direct bandgap of 2.42 eV at room temperature. Here, the detailed analysis of CdS doped with different materials like, Cu, Al, Ag and Zn are prepared as thin films onto a well cleaned glass substrate by CBD method. The fabricated films structural, optical and surface properties are analyzed.

MATERIALS AND METHODS

2. Experimental works

2.1 Synthesis of precursor materials

Aqueous solutions of ammonium hydroxide (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.

2.2 Synthesis of dopent precursor materials

Aqueous solutions of ammonium hydroxide (15 mL) and triethanolamine (TEA) (15 mL) were added to dopent materials (Cu, Al, 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 continually.

2.3 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. Substrate was immerged into the suspension and samples were rinsed in running water and analyzed.

The experimental steps are given below [6].

- 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. $Cd^{n+} + S^{n-} + Cu^{n+}$ → CuCdS particles
b. $Cd^{n+} + S^{n-} + Al^{n+}$ → AlCdS particles
c. $Cd^{n+} + S^{n-} + Ag^{n+}$ → AgCdS particles
d. $Cd^{n+} + S^{n-} + Zn^{n+}$ → ZnCdS particles

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

2.4 Characterization

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

RESULTS AND DISCUSSION

3.1 Structural analysis

The X-ray diffraction pattern of doped (Cu, Al, Ag and Zn) CdS thin films are shown in the Fig.1. Form the figure, there is no sharp peaks which indicate the samples are in amorphous nature.

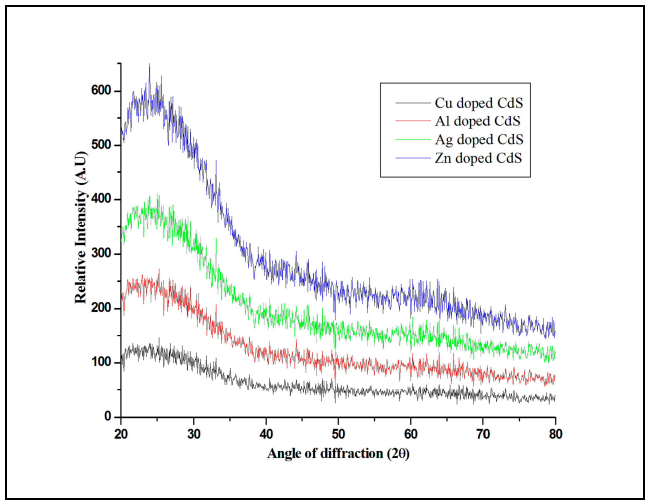

Fig. 1. XRD patterns of doped CdS films, Black, red, green and blue lines are representing Cu, Al, Ag and Zn doped CdS thin films respectively.

3.2 Optical analysis

Absorption and transmittance spectrum of thin films in the wavelength range 200 - 1000 nm are shown in the Figs. 2 (a & b).The absorbance near infrared domain (300 nm) is very low with high transmittance at the same regions. Cu and Zn doped CdS films are having increasing transmittance value when compared with other samples in the visible region and also all the samples are having increasing transmittance value in the wavelength range from blue to red region. Fig. 2(a) shows that the absorbance edges are blue shifted with respect to the bulk CdS indicating quantum confinement effect in nanoparticles [7]. 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 [8].

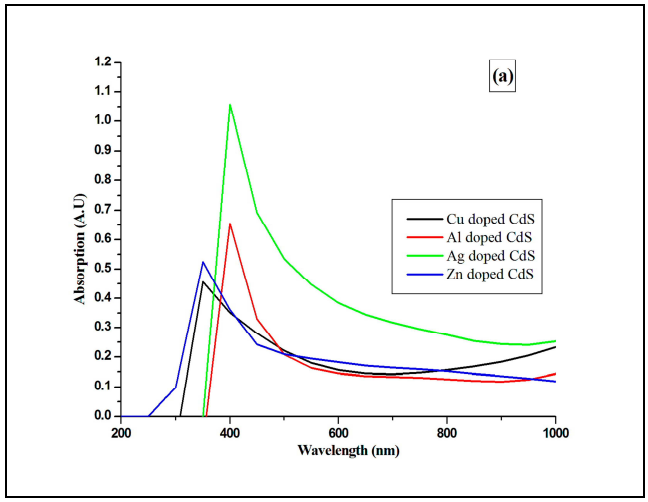

Fig. 2(a). Absorption spectrum of CdS films in the wavelength range 200 - 1000 nm. Black, red, green and blue lines are representing Cu, Al, Ag and Zn doped CdS thin films respectively.

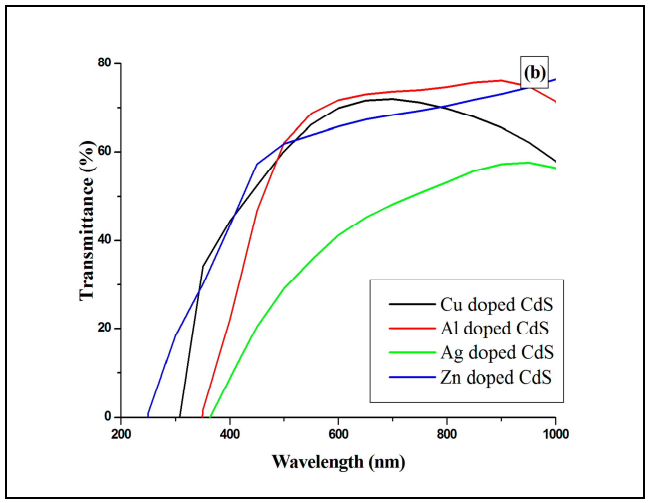

Fig. 2(b). Transmittance spectrum of CdS films in the wavelength range 200 - 1000 nm. Black, red, green and blue lines are representing Cu, Al, Ag and Zn doped CdS thin films respectively.

3.3 Reflectance

Reflectance (R) of thin films was calculated from the equation [9].

$$R = 1 - \frac{\sqrt{T}}{\exp(-\alpha t)}$$

where T is the transmittance and α is the absorption coefficient

Fig. 3. Show that the reflectance spectrum for doped (Cu, Al, Ag and Zn) CdS thin films. It is observed that the Cu and Zn doped CdS thin films exhibit very least reflectance for almost negative value comparing all other samples. From the Fig. 2(b) & 3, films exhibit highly transmittance value from 60 to 90 % and almost negative reflectance value. This property makes these films a good candidate as a transparent window layer in solar cells [10].

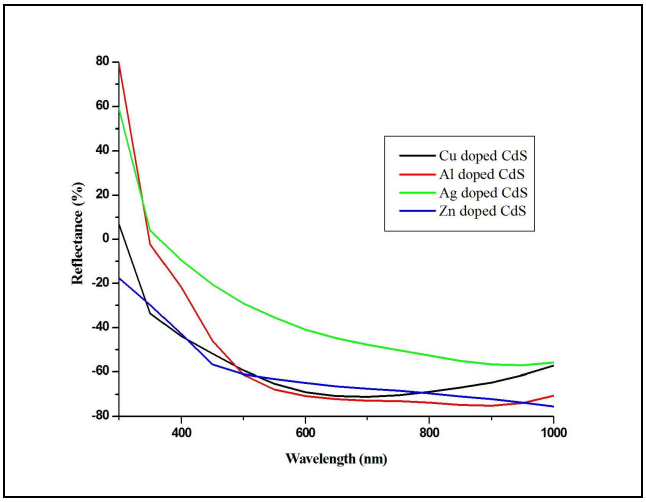

Fig. 3. Reflectance spectrum of CdS films in the wavelength range 300 - 1000 nm. Black, red, green and blue lines are representing Cu, Al, Ag and Zn doped CdS thin films respectively.

3.4 Surface analysis

Fig. 4(a, b c & d) shows that the surface morphology of Cu, Al, Ag and Zn doped CdS thin films as deposited by chemical bath deposition method at the bath temperature maintained at 70 ± 5^{o}C. Surface morphological studies of the Cu, Al, 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 Cu, Ag, Zn and Al doped films indicate the surface smoothness of the films are increased as doped as respectively and the average grains sizes are found to be in nanometer range from 153 to 308 nm. Depending upon the dopent materials the grain sizes are improved. The grain sizes for Cu, Al, Zn and Ag are 153 nm, 227 nm, 285 nm and 308 nm respectively.

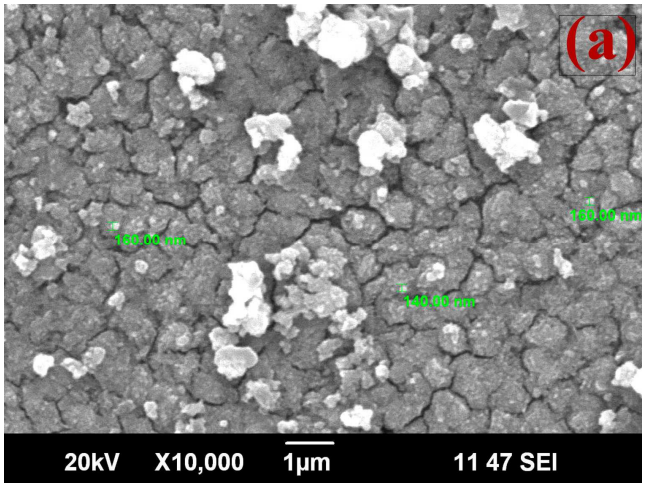

Fig. 4(a). SEM microscopes Image for Cu:CdS thin films.

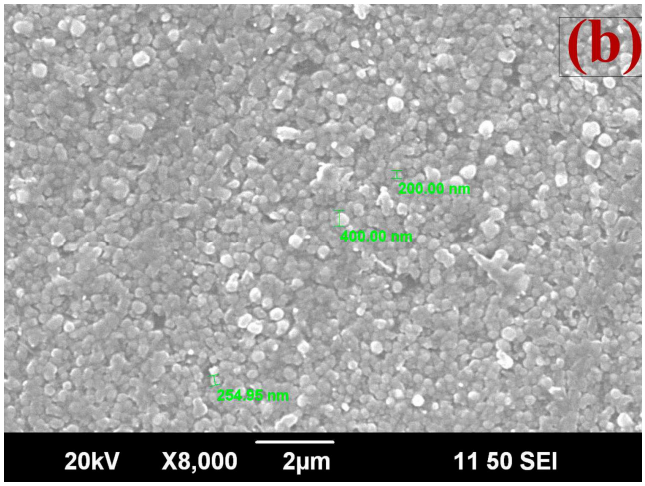

Fig. 4(b). SEM microscopes Image for Al:CdS thin films.

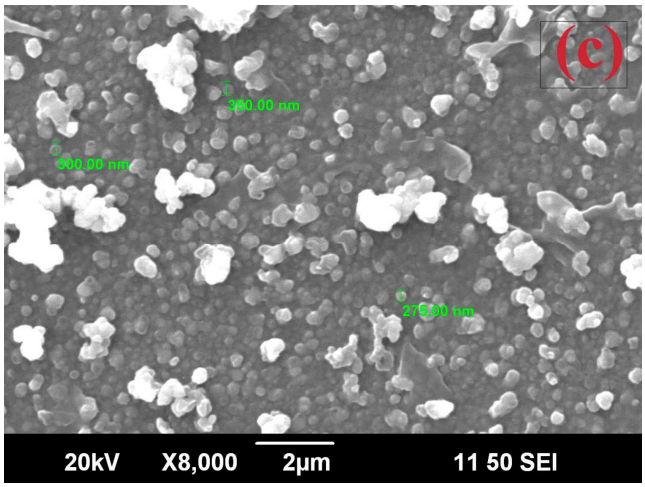

Fig. 4(c). SEM microscopes Image for Ag:CdS thin films.

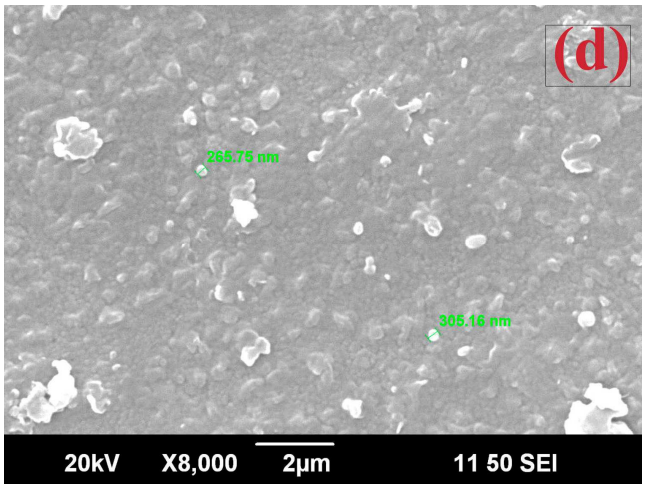

Fig. 4(d). SEM microscopes Image for Zn:CdS thin films.

CONCLUSION

Cu, Al, Ag and Zn doped CdS thin films are successfully deposited on a glass substrate by CBD technique. The structural, optical and surface smoothness properties of the films were investigated.

- All doped CdS thin films exhibits amorphous in nature.

- Cu and Zn doped CdS films are having highest transmittance and almost negative reflectance value, when compared with other samples in visible region.
- Films surface smoothness and grain sizes were improved and the grain size of the doped CdS films are 153nm, 227nm, 285nm and 308nm for Cu, Al, Zn and Ag dopent respectively.
- This property makes these films a good candidate as a transparent window layer in solar cells.

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