Study of Chemically Deposited Nanocrystalline $Cd_{1-X}ni_xs$ Thin Films

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ABSTRACT

Nickel doped cadmium sulfide ($Cd_{1-x}Ni_xS$) thin films were prepared by a simple and inexpensive chemical bath deposition (CBD) technique. $Cd_{1-x}Ni_xS$ thin films have been deposited on commercial glass substrate for various nickel concentration (x= 0, 0.3, 0.5. 0.7, 1) at 70±2°C. The effect of nickel content (x value) on structural, morphological and optical properties have been studied. The as-deposited $Cd_{1-x}Ni_xS$ thin films were characterized using X-ray diffractometer (X-PERT PRO), SEM and UV-VIS spectrophotometer. The obtained film shows good crystallinity with hexagonal structure. The average grain size estimated is 4.22nm. The values of energy bandgap obtained are between 2.48 eV and 2.82 eV for varying Ni content between x= 0 to 1 respectively. The other optical properties were under consideration.

Keywords: CdNiS, chemical bath deposition, thin films.

INTRODUCTION

Cadmium nickel sulfides $Cd_{1-x}Ni_xS$ have properties in between CdS and NiS. Addition of Ni to the most widely used CdS buffer layer material enhances the electronic and optical properties of optoelectronic devices. The CdNiS thin film band structure has energy gap between CdS and NiS. From the analysis, due to its high bandgap these films were found to possess favorable properties for solar and industrial applications such as antireflection coating in the solar collectors [1-2], solar control coatings, warming coatings as well as solar absorber layer of a solar cell[3]. Keeping these aspects in view, more attention is being given in producing good quality CdNiS thin films for comprehensive structural, optical studies and their various applications. A number of film deposition methods such as spray pyrolysis, sputtering, electro deposition, vacuum evaporation, chemical vapour deposition and chemical bath deposition (CBD) have been used for preparing II-VI compounds.[4-6]. In this study, we were prepared the $Cd_{1-x}Ni_xS$ thin films for varying Ni content by simple CBD technique. The effects of Ni content on structural, morphological and some optical properties have been investigated.

METHODOLOGY

The $Cd_{1-x}Ni_xS$ thin films were prepared by CBD technique on commercial glass slide for various nickel concentration (x= 0, 0.3, 0.5, 0.7, 1). The starting materials used were $CdCl_2$ (1M) as a Cd^{2+} ion source, $NiCl_2$ (x= 0, 0.3, 0.5, 0.7, 1M) as Ni^{2+} ion source, thiourea (1M) as an S^{2-} ion source. An alkaline solution of ammonia was used to adjust pH of the reaction mixture. All the chemicals used were of Analytical Reagent grade. The process involving a controllable chemical reaction at a low rate, by adjusting the pH value and temperature of the working solution allows maintaining the stoichiometry constant for any ratio of anions and cations. The experimental arrangement consists of a special substrate holder which is attached to a motor having a constant speed of 60 r.p.m. The temperature of chemical bath was adjusted with a hot plate and temperature controller (72±2°C), while magnetic stirrer is applied to promote ion-by-ion heterogeneous growth on the substrate. The $Cd_{1-x}Ni_xS$ samples were prepared on carefully cleaned glass substrates. Cleaning of substrate is important in deposition of thin films, cleaning steps and growth procedure is reported elsewhere [7]. As-deposited thin films were rinsed with distilled water and allowed to dry in air.

The grown films were characterized by (XPERT-PRO) X-ray diffractometer using Cu-Kα radiation with wavelength, 1.5418Å for the study of crystallographic structure. The thickness of thin film was measured by the weight difference method at room temperature. The average grain size in the deposited films was obtained from a Debye-Scherrer formula. Surface morphology was examined by JEOL model JSM-6400 scanning electron microscope (SEM). Optical properties were measured at room temperature by using Perklin-Elmer UV-VIS lambda-35 spectrometer in the wavelength range 300-1100nm.

RESULT AND DISCUSSION

Structural & Morphological properties:

Fig. 1 shows the XRD pattern of $Cd_{1-x}Ni_xS$ films for Ni content x=0.5, A comparison of the peak position (2θ values) of the JCPDS XRD spectra data suggests that the as-deposited films have hexagonal structure. The 2θ value of 24.54° (d = 3.6179 Å) and 28.72° (d = 3.0998 Å) correspond to the diffraction lines produced by (100) and (101) planes respectively.[9] The grain sizes (g) has been estimated from the XRD pattern using Debye-Scherrer's relation, [7-11]

$$g = K\lambda / \beta \cos\theta \qquad \dots (1)$$

Where, K = constant taken to be 0.94, λ = wavelength of X-ray used (1.542Å), β = FWHM of the peak and θ = Bragg's angle. The calculated average grain size of the film is about 4.22 nm.

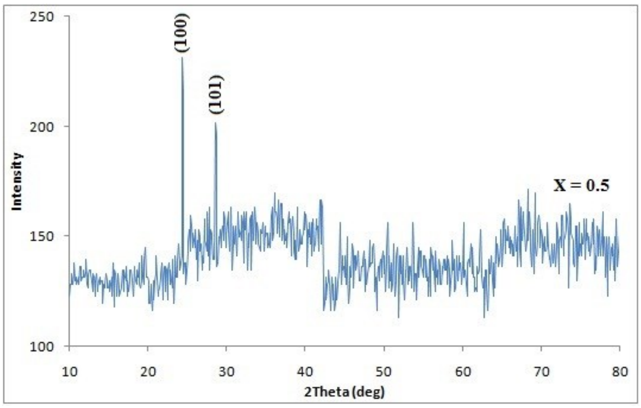

Fig. 1. XRD pattern of $Cd_{1-x}Ni_xS$ films for x= 0.5

The SEM micrograph shows smoother and more uniform films (as shown in fig. 2). It is observed that the grain size obtained from XRD and SEM matches

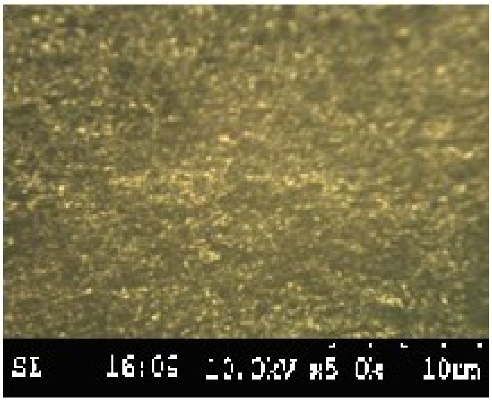

Fig. 2. SEM of $Cd_{1-x}Ni_xS$ films at x=0.5

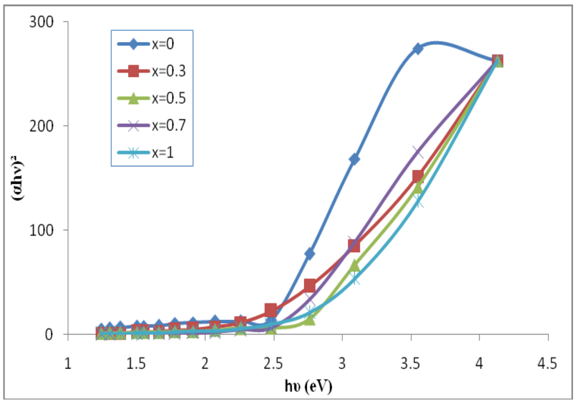

Fig. 3. Plot of $(\alpha h\nu)^2$ vs $h\nu$ for all $Cd_{1-x}Ni_xS$ thin films.

well. The band gap energy was determined from absorbance data by plotting $(\alpha h\nu)^2$ versus $h\nu$ and then extrapolating the straight line portion to the energy axis at α =0 (as shown in fig. 3). The band gap energy Eg obtained for each Ni content is different. For higher Ni content (x=1) the band gap is 2.75 eV and for lower Ni content (x=0) it is 2.48 eV. The band gap of other films is intermediate.

CONCLUSION

$Cd_{1-x}Ni_xS$ nano-crystalline thin films have been grown successfully onto glass substrates using modified CBD technique. The structural, morphological and optical energy bandgap characteristics have been studied. The structural analysis indicates that the grown film has hexagonal crystalline structure with the average grain size of 4.22nm. The band gap energy obtained is in between 2.48eV and 2.72eV. The wider bandgap makes the films suitable for optoelectronic devices, for instance window layers in solar cells as well as suitable for coating in solar collector plates as an anti reflection films.

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Conflicts of interest: The authors stated that no conflicts of interest.

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