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CdZnO coated film: A material for photovoltaic applications

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ABSTRACT

The present study reports structural and optical parameters of wide band gap oxide thick film prepared by screen-printing followed by sintering route. Characterization of the samples was carried out with UV-spectroscopy, XRD, SEM, and Photoluminous study. The XRD and SEM studies reveal that the film deposited is polycrystalline, double phase, and porous with unsymmetrical grain distributions. Optical diffused reflection spectroscopy and Pl measurements give optical band gap of 2.87 eV and near band edge emission at 430 nm.

Introduction

Cadmium oxide (CdO) with band gap (E_g ~2.3 eV), low resistivity and optical transmittance in the visible region of the solar spectrum [1]. In comparison to Zinc oxide (ZnO) having band gap (E_g ~3.36 eV) with a large exciton binding energy of ~60 meV and high resistivity [2]. Since both belongs to n-type semiconductor but it is reported that to obtain simultaneously a high transmission coefficient in the visible region and good conductivity qualities is difficult [3]. However a ternary compound which combines these properties in a controlled way may allow the optimization of the window layer, for this ratio of Cd and Zn actions becomes important for obtaining a TCO film [4]. A various techniques have been reported for the preparation of CdO-ZnO alloy films such as dual ion beam sputtering deposition [5], molecular beam epitaxy [6], sol-gel process [7,8], spray pyrolysis [9] and screen printing [10]. Among these methods, screen printing is a fast- emerging, multi-faceted method known for its uniformity, reproducibility and feasibility of producing cheap large-area films.

It was reported in literature that $Cd_{0.75}Zn_{0.25}O$ composition enhances the band gap of CdO and can be extended to green region with longer wavelength by alloying it with higher Cd. [11,12]. Therefore this study focused on the deposition of $Cd_xZn_{x-1}O$ films for X = 0.75, is promising material for potential visible light optoelectronic applications, such as violet light emitting diodes and laser diodes, photo detectors, etc [13,14].

In the present work authors synthesized the screen printed $Cd_{0.75}Zn_{0.25}O$ films and investigate the structural and optical properties of the films to employ this material for the fabrication of photovoltaic devices.

Characterization techniques used

X-ray diffraction pattern was recorded on advanced Rigaku diffractrometer in the 2θ range of 20^0–60^0 using Cu-K-X-ray radiation source. The surface morphological information was derived by using scanning electron microscope (SEM, Leo-440, UK) for recording micrographs. The optical reflection spectrum was measured on Hitachi make UV–VIS Spectrometer-3900 in the 400–700 nm range. PL spectra in 350–700 nm region have been scanned on Perkin Elmer LLS PL spectrometer at 325 nm excitation wavelength at room temperature. Taylor Hobson (Taly step UK) instrument has been used for film thickness measurement and thickness of the film is found to be ~5μm.

Preparation of $Cd_{0.75}Zn_{0.25}O$ composition for coating

The molecular weight of CdO = 128.4104. & Molecular weight of ZnO = 81.408

Hence the calculated amounts of $Cd_{0.75}$ $Zn_{0.25}O$ compositions are

Weight of CdO = 128.4104 × 0.75 = 96.3078 gm
And weight of ZnO = 81.408 × 0.25 = 20.352 gm
And weight of $CdCl_2$ = 10/100 × 116.659 = 11.67 gm

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The above calculation is very large so we reduce all the weights same preposition. All the above three were mix properly and a paste was prepared with ethylene Glycole, the paste thus prepared was screen printed on various glass substrates. The film thus prepared dried at 120 °C for 2 h than at higher temperature 500 °C for 10 min in an air atmosphere [15].

The steps involved in the preparation of $Cd_{0.75}Zn_{0.25}O$ composition thick films by screen printing method as described above are presented in the following schematic flow chart as shown if (Fig. 1) [16].

Results and discussions

Structure analysis

XRD patterns of the $Cd_{0.075}Zn_{0.25}O$ composite coated films deposited onto the glass substrate and are shown in (Fig. 2). A combination of cubic CdO and hexagonal wurtzite ZnO phases was observed. The polycrystalline CdO peaks in the patterns were identified as (1 1 1), (2 0 0), (2 2 0) and (3 1 1), while those of ZnO were indexed as (1 0 0), (0 0 2) and (1 0 1), respectively. These peaks are in agreement with the standard values of JCPDS (05-0640) for CdO [10] and JCPDS (36-1451) for ZnO [16]. The mean crystallite size (D) was evaluated according to broadening of the highest intensity peak corresponding to the (1 1 1) diffraction plane using the Debye-Scherrer formula shown in Eq. (1) [17]:

$$D = \frac{0.94\lambda}{\beta Cos\theta} \tag{1}$$

where λ, β, and θ are the X-ray wavelength (1.5418 Å), full width at half maximum (FWHM) in radians and from this formula the D was found to be 38.29 nm. The dislocation density (δ) was calculated from D using Eq. (2) [17]:

$$\delta = \frac{1}{D^2} \tag{2}$$

this was found to be $0.6821 \times 10^{-3}\,(nm)^{-2}$ and the Strain present in the film calculated from Eq. (3) is found to be 094.51×10^{-5} [13]:

$$\varepsilon = \frac{\beta \cos\theta}{4} \tag{3}$$

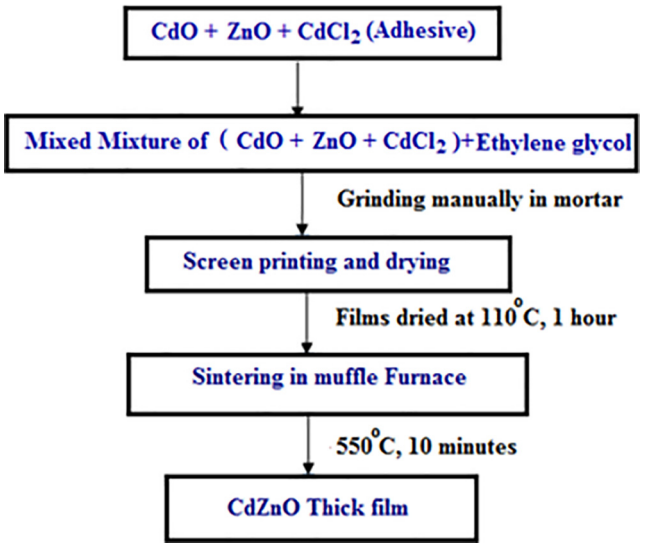

Fig. 1. Screen Printing procedure diagram.

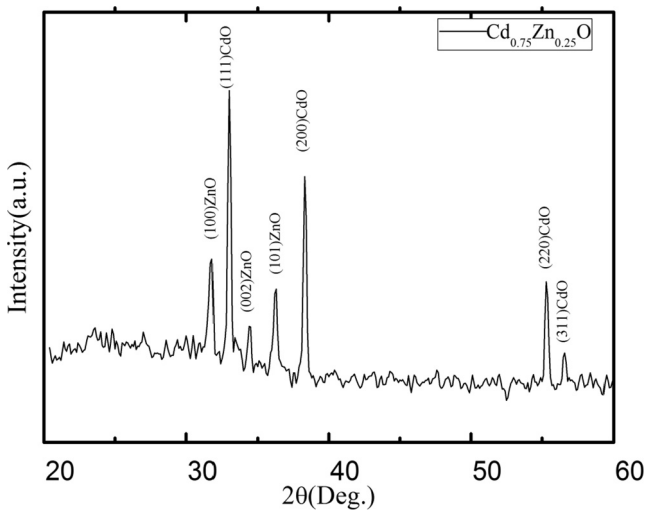

Fig. 2. XRD of $Cd_{0.75}Zn_{0.25}O$ thick film.

This lower value for δ implied that our films had very few lattice defects and good crystalline qualities and these values are in good agreement [18].

Scanning electron microscopy (SEM) analysis

The surface morphology of $Cd_{0.075}Zn_{0.25}O$ composite coated films were studied by scanning electron microscopy (SEM). The presence of some residual, intragranular porosity and agglomeration of grains at some region are shown in the (Fig. 3). The hexagonal and cubic tipped rods confirm the co-existence of ZnO Wurtzite and CdO cuboidal morphologies respectively with dominating Zn-doped CdO structure, hence such structures are useful for sensing and semiconducting devices.

Optical properties

UV–vis Diffused reflectance (UV-DR) and photoluminescence (PL) studies, performed at room temperature (RT), have been employed to know the optical properties of the $Cd_{0.075}Zn_{0.25}O$ composite. Diffuse reflectance spectra of the sample are shown in

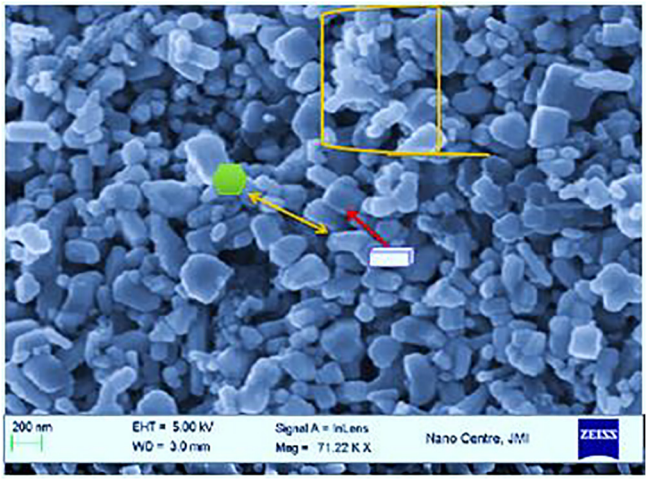

Fig. 3. SEM image of $Cd_{0.75}Zn_{0.25}O$ thick film.