International Journal for Multidisciplinary Research
International Conference on Multidisciplinary Research & Studies 2023
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Effect of Indium Doping on Structural Properties of Spray Pyrolysed Cadmium Oxide Thin Films

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Abstract

Pure films of cadmium oxide and indium-doped cadmium oxide films were deposited using a spray pyrolysis technique. The deposited films were structurally characterised using the X-ray diffraction method. The structural studies revealed that films are polycrystalline in nature with a cubic lattice. The decrease in particle size from 42 nm to 34 nm was observed as dopant was introduced. For pure CdO thin films, the band gap energy obtained was of the order of 2.58 eV, and it decreased to 2.32 eV with the addition of dopant.

Key Words: Nanostructured; Thin films; Spray pyrolysis; Structural properties.

Introduction

Optoelectronic device characteristics have been improved by scientists and researchers. TCOs, which are used for making LEDs, LCDs, flat panel displays, smart windows, and spintronics, are an important component of these devices. TCOs are group II–VI semiconductors, and because of their distinct characteristics and simple structure, this field of study is developing. One of the significant transparent conducting oxide nanomaterials is cadmium oxide (CdO). Additionally, CdO nanoparticles have a significant impact on a variety of applications, including gas sensors, heat mirrors, phototransistors, solar cells, and thin-film resistors [1–6]. Researchers have used a variety of methods to deposit pure CdO and doped CdO films on various substrates; Renu Kumari et al. [7] used the sol-gel-derived screen-printing process to deposit gadolinium-doped CdO film. Undoped and Mn-doped CdO photodiodes were prepared using the sol-gel method by Dugan et al. [8]. Thambidurai et al. [9] had successfully synthesised Ga-doped CdO nanocrystalline thin films by the sol–gel spin coating method and reported the structural and optical properties of the deposited film. Gupta et al. [10] used a quartz substrate to deposit thin films of indium-doped cadmium oxide using the pulsed laser and studied their physical properties. Saha et al. [11] synthesised cadmium oxide thin films using radio-frequency magnetron sputtering with varying aluminium doping concentrations. Kabir et al. [12] sprayed-deposited CdO and investigated the effects of Ga doping on the physical properties of thin films. We used spray pyrolysis at 573 K to deposit CdO and indium-doped CdO thin films onto a hot glass substrate in this study.

Experimental Details

The process for parameter optimization is discussed elsewhere [13]. An optimised temperature for depositing the films by the spray pyrolysis method was found to be 573 K. Non-conducting glass substrates were used to deposit pure and doped CdO films using a precursor solution containing cadmium chloride ($CdCl_2$) and indium (III) chloride ($InCl_3$). $InCl_3$ was dissolved in double-distilled water and hydrochloric acid (HCL) in a 1:1 volume ratio. To achieve doping, indium chloride ($InCl_3$) with a concentration of 3 wt% was mixed with the above-prepared solution. The spray rate was adjusted to 4 mL/min, while the distance between the nozzle and the glass substrate was adjusted to 30 cm.

Structural Analysis

The XRD pattern for the pure and doped films deposited at 573K was shown in the figure below (Fig.1).

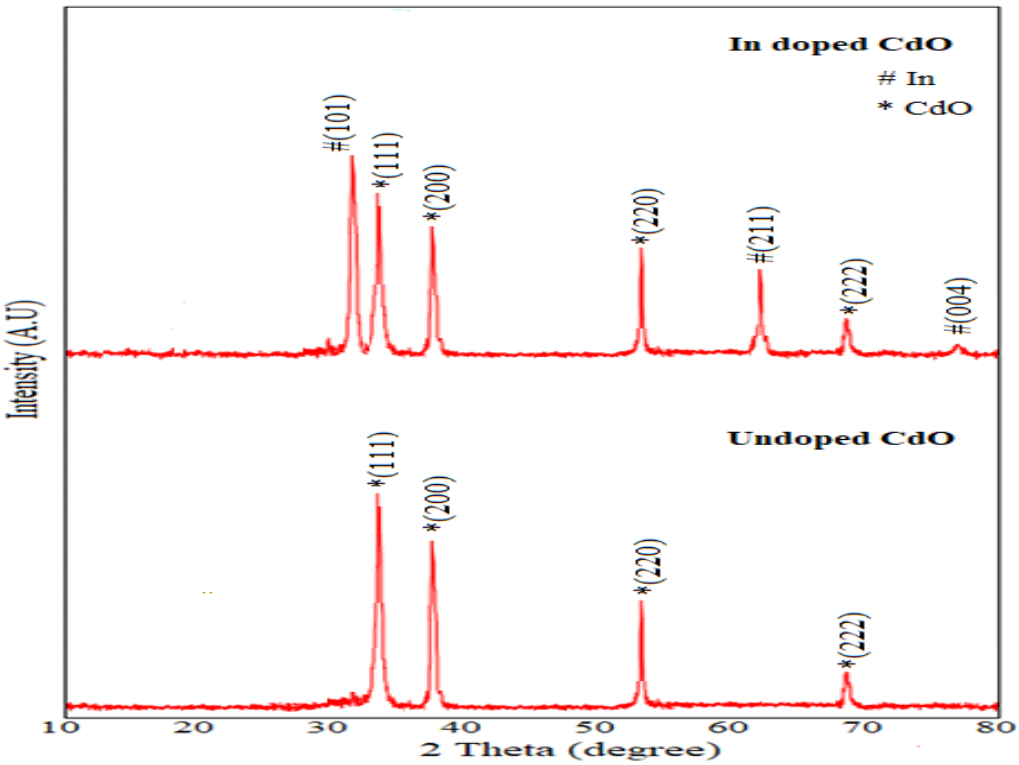

Figure 1: XRD patterns of the pure and indium doped cadmium oxide thin films

The strong diffraction peaks of the CdO deposition were observed at 33.568°, 38.203°, 54.899° and 69.310°, which correspond to the (1 1 1), (2 0 0), (2 2 0) and (2 2 2). They have preferred orientation along (111) plane with cubic lattice, while the diffraction peaks of the dopant also appear at 32.965°, 63.034° and 77.044° which correspond to the (101), (211) and (004) corresponding to hexagonal phase and having preferred orientation along (101). It was also observed that the peaks height gets decreased with indium doping, which might be due the change in electron density or might be due to point defects.

Table 1: Comparison of observed and standard XRD data of Pure CdO films (JCPDS card 05-0640) and indium doped CdO films (JCPDS card 05-0642)

Film	Observed data		Standard data		h k l	phase
	2θ (deg.)	d(Å)	2θ (deg.)	d(Å)		
Pure CdO Films	33.568	2.680	33.002	2.712	1 1 1	Cubic
	38.203	2.489	38.286	2.349	2 0 0	Cubic
	54.899	1.773	55.260	1.661	2 2 0	Cubic
	69.310	1.318	69.290	1.355	2 2 2	Cubic
In Doped CdO Films	32.782	2.818	32.965	2.715	1 0 1	Hexagonal
	33.568	2.680	33.002	2.712	1 1 1	Cubic
	38.203	2.489	38.286	2.349	2 0 0	Cubic
	54.899	1.773	55.260	1.661	2 2 0	Cubic
	64.124	1.139	63.034	1.395	2 1 1	Hexagonal
	69.310	1.318	69.290	1.355	2 2 2	Cubic
	77.201	1.021	77.044	1.236	0 4 4	Hexagonal

Conclusion

Spray pyrolysis technique was utilized to deposit pure CdO and indium-doped CdO thin films. The structural properties of prepared pure and doped thin films of cadmium oxide were investigated using X-ray diffraction. The X-ray diffraction study reveals that the structural properties of prepared pure and doped thin film samples were affected by the addition of indium as a dopant. It was observed that the films were polycrystalline in nature with a cubic lattice.

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