

# Optical properties of spray deposited Al doped CdO thin films

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## Manuscript Details

Available online on <http://www.irjse.in>  
ISSN: 2322-0015

Editor: Dr. Arvind Chavhan

### Cite this article as:

Munde Bhaskar S. Optical properties of spray deposited Al doped CdO thin films, *Int. Res. Journal of Science & Engineering*, 2018; Special Issue A5: 81-83.

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## ABSTRACT

The objective of this work is to study the influence of Al doping on optical properties of the CdO thin films prepared by spray pyrolysis technique. The optical band gap value decreased from 2.51 to 2.32 eV with increasing the Al doping. Aluminum nitrate was used as a dopant.

**Keywords:** Thin films; X-ray diffraction; Cadmium oxide; spray pyrolysis; Optical properties.

## INTRODUCTION

Transparent conducting metal oxide semiconductor materials have attracted much attention owing to their potential applications in flat panel display, smart windows, light emitting diodes, heat reflectors, electronic, photovoltaic devices and solar cells [1-4]. Its high electrical conductivity and high optical transmittance in the visible region of the solar spectrum along with a moderate refractive index make it useful for various applications such as transparent electrodes, phototransistors, photodiodes, gas sensors, etc. [5-6]. CdO is an n-type semiconductor with a rock-salt crystal structure (FCC) and possesses a direct band gap of 2.2 eV [7]. Besides, the CdO will be attractive in the field of optoelectronic devices by making heterostructures with ZnO which has band gap energy of 3.3 eV. CdO thin films have been prepared by various techniques such as sol-gel, DC magnetron sputtering, radio-frequency sputtering, spray pyrolysis, pulsed laser deposition, chemical vapor deposition, and chemical bath deposition [8-15].

## METHODOLOGY

All the chemical reagents used in the experiments were obtained from commercial sources as guaranteed-grade reagents and used without further purification. The amorphous glass substrates supplied by Blue Star Mumbai, were used to deposit the CdO thin films. Before the deposition of CdO thin films, glass slides were cleaned with detergent and distilled water, then boiled in chromic acid (0.5 M) for 25 min, then slides washed with double distilled water and further ultrasonically cleaned for 15 min. Finally the substrates were degreased in AR grade acetone and used for deposition.

### Thin film preparation

CdO films were prepared on preheated glass substrate using a spray pyrolysis technique. Spray pyrolysis is basically a chemical process, which consists of a solution that is sprayed onto a hot substrate held at high temperature, where the solution reacts to form the desired thin film. The spraying solution was prepared by mixing the appropriate volumes of 0.5 M cadmium sulphate ( $\text{CdSO}_4$ ) and distilled water. The CdO films were deposited at substrate temperatures of 300 °C.

### Characterization of thin films

A UV-vis spectrophotometer (SHIMADZU UV-1700) was used to record the optical absorption spectra of the samples in the wavelength range 400-1050 nm.

## RESULTS AND DISCUSSIONS

### Optical properties

The optical transmission spectra of spray deposited CdO films conducted at room temperature, in the wavelength range from 400 nm to 1050 nm is depicted in Fig. 1. All the transmission spectra of these films indicate sharp absorption edge and high optical transparency in visible range suggesting good quality of the films. It can be observed from Fig. 1 that the transmission values of the films are at short wavelengths ( $\leq 520$  nm) and high at longer wavelengths. This is related to the energy of incident light, when energies of photons are smaller than the band gap of CdO film. They are insufficient for excitation of electrons from valance band to conduction band [16].

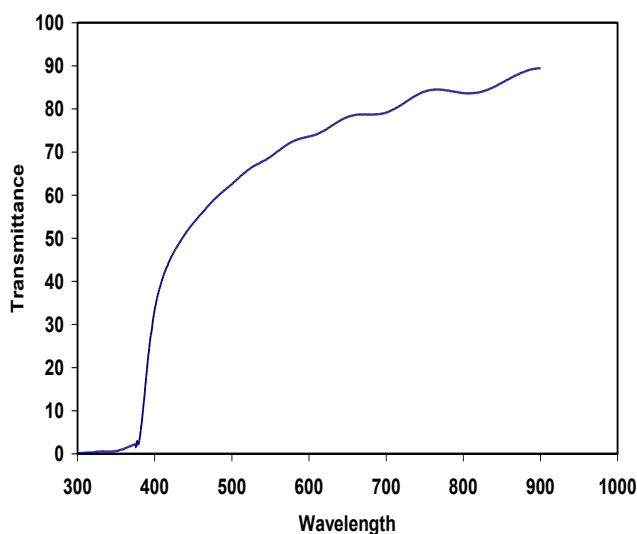


Fig. 1 Transmittance of CdO thin film

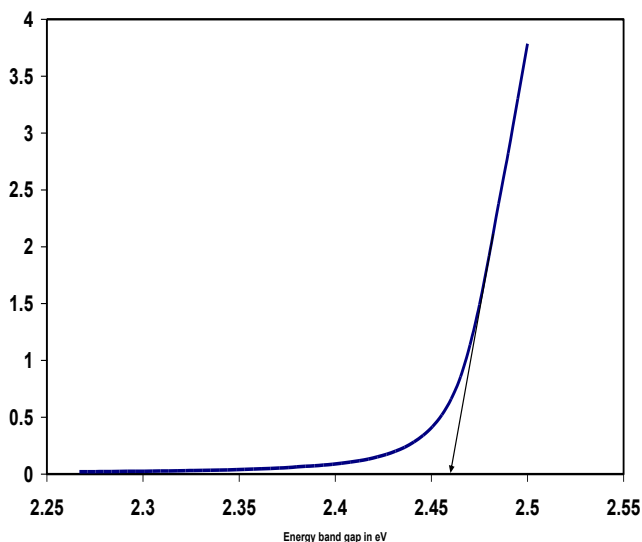


Fig. 2 Energy band gap of Al:CdO (2%) thin film.

The optical band gaps for the sprayed CdO thin films are calculated on the basis of the optical spectral absorption using the following well-known relation [17]

$$\alpha h\nu = A(h\nu - E_g)^n \quad (6)$$

where A is constant,  $E_g$  is the separation between valance band and conduction band, n is constant equal to 1 for direct band gap semiconductors and 4 for indirect band gap materials. In the present investigation the optical absorption coefficient is of the order of  $10^4 \text{ cm}^{-1}$ , supporting the direct transition of the material [18-19]. The variation of  $(\alpha h\nu)^2$  vs.  $h\nu$  is linear and shown in Fig. 2, which means that the mode of transition in these films is of direct nature. The extrapolation of these curves to energy axis for zero absorption coefficient value gives the optical band gap energy. With increase in Al doping energy band gap decreased from 2.51 eV to 2.32 eV. The decrease in band gap energy with increase in film thickness and dopants is commonly observed phenomenon in semiconducting thin films [20-22].

## CONCLUSION

In this study, the influence of Al doping on optical properties of CdO thin films grown on amorphous glass substrates by spray pyrolysis was investigated. The optical absorption coefficient is of the order of  $10^4 \text{ cm}^{-1}$ . With increase in Al doping energy band gap decreased from 2.51 eV to 2.32 eV.

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