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***Research Article***

# ELECTRICAL BEHAVIOUR OF CADMIUM OXIDE THIN FILMS DEPOSITED BY CHEMICAL SPRAY PYROLYSIS METHOD

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## ABSTRACT
Nanostructured cadmium oxide (CdO) thin films were deposited onto glass substrates by using chemical spray pyrolysis technique at 673K. The optical band gap of the as deposited CdO thin films was found to be of the order of 2.62 eV. The films are polycrystalline in nature with cubic phase and are preferentially oriented along (111) direction. The electrical resistivity of the films is of the order of $10^{-4}\Omega$cm. The thermo-emf measurement confirms n-type conductivity of cadmium oxide thin films.

***Keywords:*** *Thin Films, Nanostructures, Electrical Properties, n-Type Conductivity*

## 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 (Lewis and Paine, 2000; Kim *et al.*, 1999; Selvan *et al.*, 2006; Anandan, 2008). CdO is one such semiconducting materials having wide range of applications as transparent conducting oxide (TCO), solar cells, smart windows, optical communications, flat panel display, phototransistors etc.,. The CdO based materials could be widely used in high performance solar cells which contain a large amount of Cd. It has n-type semiconducting property with a rock-salt crystal structure (FCC) and an optical band gap lies between 2.2-2.7 eV (Ortega *et al.*, 2000). It is well know that the electrical properties of CdO films can be improved by the movement of interstitial cadmium atoms and oxygen vacancies. The electrical conductivity and optical transparency of CdO thin films depend on the nature, number, atomic arrangements of metal cations, morphology and on the presence of intrinsic or intentionally produced defects (Flores-Mendoza *et al.*, 2013). Lokhande *et al.*, (2004) obtained a low resistivity value of $10^{-6}$ Ω cm for the CdO films fabricated by spray pyrolysis technique at 400°C.

## MAERIALS AMD METHODS
The chemical technique of spray pyrolysis which is simple to handle, economically viable is used for several decades in glass industry and in solar cell production to deposit electrically conducting electrodes. It is a very simple and relatively cost-effective method for preparing films of any desired composition under controlled conditions, involving the spraying of a solution containing a soluble salt of the cation of interest onto a heated substrate. The solution of cadmium acetate dihydrate, 2-methoxy ethanol and monoethanolamine was used to deposit the films. Finally, 30mL of as prepared solution was sprayed onto pre heated cleaned glass substrates at 673K by using compressed dry air as a carrier gas to get faint yellow transparent CdO thin films. The substrate was placed perpendicular to the spray nozzle. The spray solution was sprayed on the heated glass substrates at a spray rate of 6mL/min and then cooled down to room temperature in the electric furnace. The experimental setup of advanced spray pyrolysis technique and its other details have been reported elsewhere (Ubale and Ibrahim, 2015). During the course of spray, other parameters viz. nozzle to substrate distance, spray rate, air pressure and hot plate core temperature were essentially kept the same.

## RESULTS AND DISCUSSION

### *Electrical Studies*

The electrical properties of the deposited film dependents on various parameters such as film composition, thickness, substrate temperature and deposition rate. In the present work silver paste was used to make ohmic contacts to CdO thin films. The nature of CdO/Ag contacts were checked up to 30 V using two-probe method by plotting I-V characteristics (Figure 1). The variation of electrical resistivity (ρ) with temperature was studied in the range 303K to 483 K.

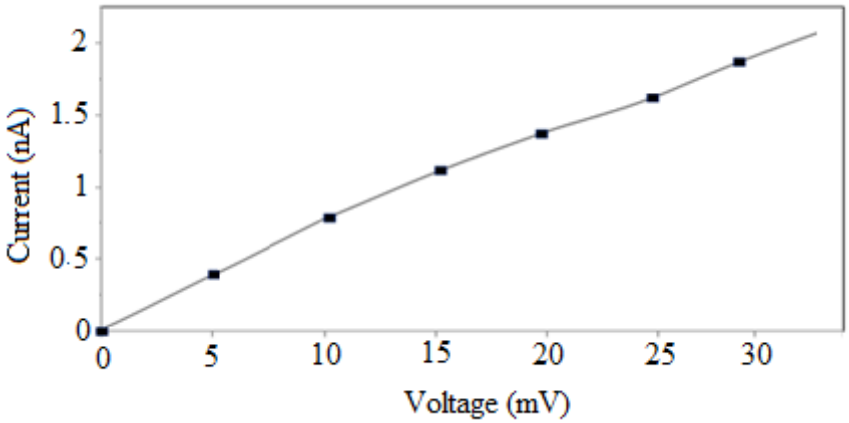


**Figure 1: I-V Characteristic of CdO Thin Films**

The electrical resistance was found to be of the order of $10^{-4}\Omega$cm. The conductivity of the film samples increases with increase in temperature indicating the semiconducting nature.

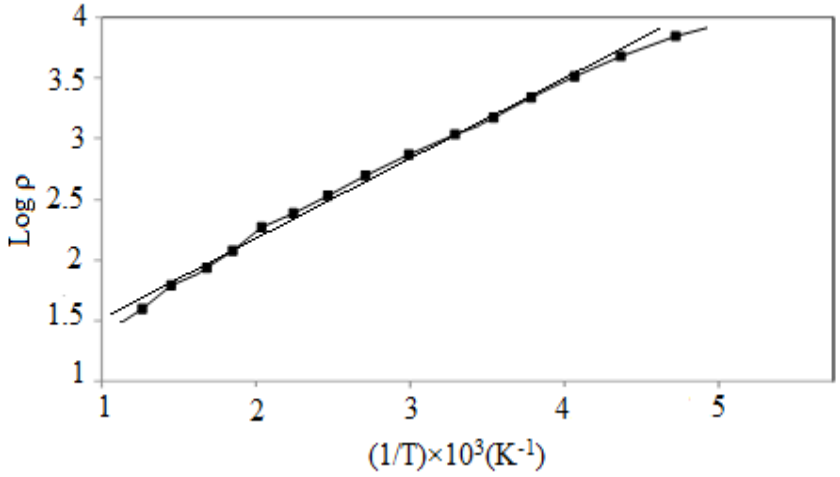


**Figure 2: Variation of Log of Resistivity with 1/T for CdO Films**

The variation of log (ρ) with reciprocal of temperature (1/T) for CdO thin film is shown in figure 2. The dependence of resistivity on temperature is almost linear indicating the presence of only one type of conduction mechanism in the film.

The thermal activation energy was calculated using the relation,

$$\rho = \rho_0 \exp^{(E_0/KT)} \quad (1)$$

Where, ρ is resistivity at temperature T, $\rho_0$ is a constant; K is Boltzmann constant.

The activation energy ($E_0$) was calculated from the resistivity plots and was found to be 0.021 eV.

***Thermo-emf Measurement***

The type of conductivity exhibited by as deposited CdO thin films is determined by thermoelectric power (TEP) measurement. When temperature gradient is applied across a semiconductor thin film, then charge carrier transfer takes place from hot to cold end which gives thermal voltage. The thermo-emf generated across CdO thin film is proportional to the temperature difference across it (figure 3).

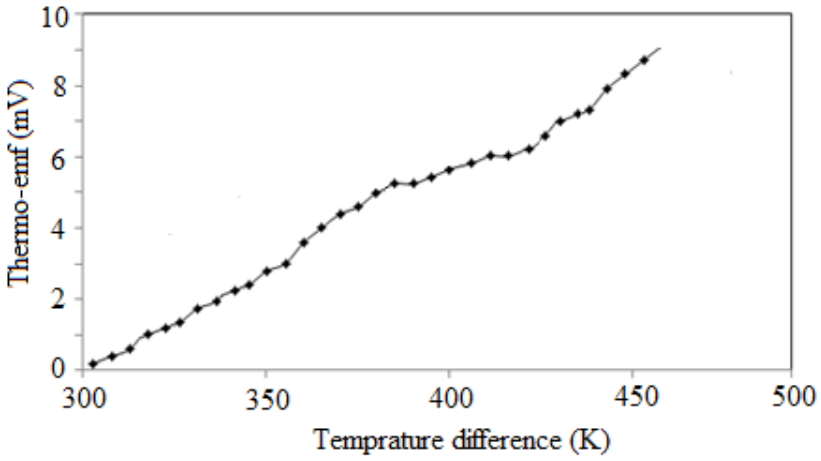


**Figure 3: Variation of Thermo emf (mV) with Temperature Difference for CdO Thin Films**

The sign of thermo-emf generated gives the information of the dominant charge carriers inside the semiconductor. In the present investigation CdO films deposited by spray pyrolysis technique are of n-type. The thermo-emf increases exponentially with applied temperature difference which may be because of increased charge carrier concentration and its mobility.

***Conclusion***

CdO thin films were deposited onto glass substrates at 673K. The electrical behaviour of the as-deposited thin films was investigated. The films were polycrystalline in nature with cubic crystal structure with a preferential orientation along the (1 1 1) plane and has band gap of the order of 2.62eV. Electrical studies showed that the film exhibit resistivity of 2.17 x $10^{-4}$ ohm-cm. The thermo-emf measurement confirms n-type conductivity of Cadmium oxide thin films.

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