Chapter V

Summary and Conclusions

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SUMMARY AND CONCLUSIONS

Thin film science has wide applications in many fields of science and technology which is consisted of material science, surface science and applied physics. The rapid progress in the thin film micro and nano materials has given birth to a whole new technology of junction devices and integrated circuits of monoliths and hybrid types. The search for new thin film materials appropriate to many applications is of particular importance. Features such as the electronic structure, mobility and the characteristic optical absorption are frequently those that determine material stability. The properties of thin film materials are ultimately connected with the method of their fabrication. Hence, the search for new materials also implies the exploration of fabrication process. In order to reduce the cost and have the quick access to the physico-chemical properties of the materials, a relatively simple and quick deposition method is preferred.

Cadmium oxide with direct band gap of 2.5 eV has attracted wide attention because of its possible applications in gas sensors. Cadmium oxide is a promising candidate for development of short wavelength optical devices as well as for applications in optics and optoelectronics such as transparent conducting electrodes for flat panel displays and solar cells

Literature survey shows that the cadmium oxide thin films are polycrystalline, transparent, good conductive, and have good luminescent spectra. Incorporation of aluminium reduces the resistivity. Doping induces enhancement in conductivity, carrier concentration, figure of merit, optical transparency and band gap so it has wide applications such as solar cells, optoelectronic devices, heat mirrors, transducers, photo detectors, transparent conductive oxide, UV light emitters etc.

The present study is an attempt to prepare undoped, and Aluminium doped cadmium oxide thin films by using spray pyrolysis method. Spray pyrolysis is well suited for preparation of above thin films, because it is easy to use, economical, safe and ease of adding various doping materials etc. The studies are made on preparation and physico-chemical characterization of aluminium doped cadmium oxide thin films prepared from aqueous media by spray pyrolysis techniques The present work is divided into five phases.

Chapter I is introductory in nature. A brief literature survey on CdO and Al:CdO is given which is followed by the scope of present work. The theoretical background of various characterization techniques such as X-ray diffraction, scanning electron microscopy (SEM), Energy dispersive analysis by x-ray (EDAX), optical absorption, transport properties viz. electrical resistivity, etc, is outlined in **chapter II.**

Chapter III opens with the introduction of the simplest thin film deposition technique "spray pyrolysis". The preparation of CdO thin films in aqueous and non aqueous media with cadmium acetate as a precursor by spray pyrolysis technique is explained. This chapter also deals with detailed description of mechanism of thin film formation and its characterization. The effect of preparative parameters such as substrate temperature, concentration and quantity of spraying solution are optimized to get film quality; in terms of crystallinity, resistivity etc.

The films have been characterized by the following techniques:

1) Thickness measurement

2) X-ray diffraction

3) Scanning electron microscopy (SEM)

4) Optical absorption and transmission

5) Electrical resistivity

Thickness is calculated for all preparative parameters by using gravimetric weight difference method. X-ray diffraction patterns of cadmium oxide films deposited at optimized temperature and optimized concentration with different quantity of spraying solution. All the peaks in the pattern correspond to polycrystalline cubic structure of cadmium oxide; peaks are indexed on the basis of JCPDS card number 03-065-2908. The lattice parameter value '*a*' for cubic structure, calculated for the deposited films are found to be in good agreement with the reported values. The diffractograms show characteristics CdO orientations along the preferred direction (200). The presence of other peaks such as (111), (220), (311), (222), and (400) have also been detected but with substantially lower intensities .The absence of impurity peaks suggests the high purity of the nanocrystallites. The average crystallite size is found to be 16.4 nm.

The micrograph (SEM) reveals that the substrate is well covered with large number of fine grains and film surface is uniform, porous with compact growth.

The optical band gap has increased from 2.12 to 2.5 eV with quantity of spraying solution. The transmittance of the order of 60% is measured at 550 nm for the typical film. So it has potential applications in opto-electronic devices. Electrical resistivity measurements were carried out using the van der pauw method. The minimum resistivity of cadmium oxide films is obtained by optimizing substrate temperature, concentration of solution and quantity of spraying solution. Resistivity decreases with increase in temperature and suggest the semiconducting behavior of CdO films.

In **Chapter IV**, emphasis is given on characterization of Al:CdO thin films. The effect of preparative parameters on the crystallinity of the films has been discussed.

The films have been characterized by the following techniques:

1) Thickness measurement

2) X-ray diffraction

3) Scanning electron microscopy (SEM)

4) Optical absorption and transmission

5) Electrical resistivity

Thickness of aluminium doped cadmium oxide thin films are calculated using weight difference method. It shows significant change with doping percentage of aluminium. X-ray diffraction patterns which have shown an increase of peak intensity corresponding to (200) crystal plane with increase in aluminium concentration. These XRD patterns do not show the presence of any aluminum compound in the films, which indicates the absence of an impurity phase in the films.

The range of the crystallite size is of the order of 15-20 nm. The texture coefficient along (200) crystal plane increases with dopant concentration. The highest TC (200) for 1.30 at.% aluminium doping is 3.22. The micrograph shows the existence of well-crystallized grains, having a faceted cap like structure. From EDAX study we concluded that the structure of our material is stoichiometric.

The optical absorption studies were carried out in the wavelength range of 350-850 nm. The variation of optical density with wavelength shows that the optical absorption coefficient is a function of photon energy. The optical band gap slightly increased from 1.6 to 2.15 eV with aluminium doping concentration from zero to 5 at%. The transmittance of the order of 60% is measured at 550 nm for the typical film. So it has potential applications in opto-electronic devices.

Electrical resistivity measurements were carried out using the van der pauw technique. The minimum resistivity of aluminium doped cadmium oxide thin films is obtained for 1.3 at% of aluminium doping.

Good quality cadmium oxide and aluminium doped cadmium oxide thin films were deposited using the spray pyrolysis method. The influences of aluminium doping concentration on the electrical, structural and optical properties of films have been systematically studied. The present films have a high transmittance and low resistivity, together with a smooth surface, as required for most contacts in optoelectronic applications, such as liquid crystal displays.

We interested to study in the future about the energy band diagrams for the Al doped films, the exact composition of dopants using photoelectron X-ray spectroscopy, luminescence properties. These films would be used for applications of gas sensing and solar cells.