DEPOSITION OF L-PROLINE DOPED CADMIUM OXIDE THIN FILM BY CHEMICAL SPRAY PYROLYSIS METHOD

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ABSTRACT

L-proline doped CdO thin films were prepared by the JNS pyrolysis technique. The prepared samples are characterized by UV-Vis, SEM, EDS, XRD and FTIR analysis. SEM analyses showed the well-structured particles orientation with defined grain boundaries. The EDX analysis showed the presence of metal ions in the films without any impurities. From UV spectral analyses, confirms that the L-proline doped cadmium oxide thin films are promising semiconductor materials processing superior optical and electrical properties required for optoelectronic applications.

Keywords: *SEM; EDS; XRD; FTIR and UV.*

1. INTRODUCTION

Transparent conducting oxides such as cadmium oxide, zinc oxide, indium oxide, tin oxide find wide applications in optoelectronic devices, gas sensors and phototransistors [1–4]. In particular, cadmium oxide (CdO) is a promising material for solar cell applications due to its high electrical conductivity and high optical transmittance in the visible region of solar spectrum [5]. CdO is an n-type semiconducting material with the band gap energy of 2.16 eV at room temperature. Therefore, CdO is used as a window layer in heterojunction solar cell [6,7]. The conductivity, mobility and carrier concentration of CdO thin film are based on the creation of cadmium interstitial and/or oxygen vacancies that can be controlled by doping CdO with different metal ions or varying the physical parameters such as, work function, electron affinity and film thickness of the film. Several techniques have been used to deposit CdO thin films such as chemical vapor deposition [8], sputtering [6], chemical bath deposition [9], sol–gel [10], SILAR [11,12], thermal evaporation [13], layer by layer assembly [14] and spray pyrolysis [15–18]. Owing to simplicity and inexpensiveness, the spray pyrolysis is a better chemical method for the preparation of thin films with larger area coating and it provides an easy way to dope the elements in the required ratio proportion through the precursor solution [19]. In this work, we report on the deposition of l-proline doped CdO films using spray pyrolysis technique.

2. EXPERIMENTAL PROCEDURE

2.1. SUBSTRATE CLEANING PROCESS

A clean substrate is pre-requisite for the formation of any film. It is necessary to remove contaminants without damage to the substrate. The procedure for cleaning the glass substrates includes the following steps.

i. The substrates were first treated with sodium hydroxide. This alkaline agent dissolves fatty material by saponification and menders them wet. After chemical Treatment the substrates are washed by hand using a cotton pad and a solution of detergent. The substrates are then rinsed with distilled water.

ii. Solvent cleaning is employed to dissolve contaminants. Solvent such as acetone, isopropyl alcohol, chloroform etc are used. The cleaning takes place when solvent vapor condense on the substrate using ultrasonic cleaner. This is accompanied by placing the substrate in isopropyl alcohol for 30 minutes.

iii. Heating the substrate may remove the volatile impurities. The temperature must be chosen according to the melting point. The substrates were dried by heating in hot plate or oven.

2.2. CHEMICAL SPRAY PYROLYSIS TECHNIQUE USING JET NEBULIZER

The Spray pyrolysis technique is a simple technology in which an ionic solution containing the constituent elements of a compound in the form of soluble salts is sprayedonto over heated substrates using a stream of clean, dry air. The atomization of the chemical solution into a spray of fine droplets is effected by the spray nozzle, with the help of compressed air as carrier gas. In this process, the spray rate the size of the sprayed particles and the spray pattern are strongly influenced by the geometry of the spray nozzle used. This method is low cost and simple handling. The ability to produce good films depends on proper choice of various processes involved in this technique.

These include the substrate nature, spray-nozzle diameter, nozzle-substrate distance, substrate temperature (Ts) during film deposition and solution concentration (α). In the present work spray coating technique has been employed using **JET NEBULIZER** for coating ofCuO thin films at various substrate temperature. The deposition process was carried out using spray apparatus such as oven, Air compressor, spray gun etc. The spray parameters are optimized to fabricate the thin film of thickness ranging from nanometers to micrometers on a substrate. The schematic diagram of JNSP technique is shown below in figure 1.

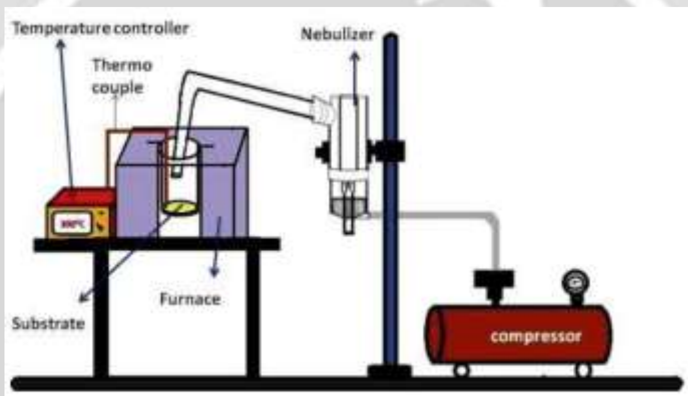


Figure 1. Schematic Diagram of Nebulizer Spray Pyrolysis (NSP) Technique.

2.3. SAMPLE PREPARATION

L-proline doped cadmium oxide thin films are deposited on glass substrates using L-proline acid and cadmium chloride as a chemical precursor. The substrates are cleaned using hydrochloric acid, sodium hydroxide, isopropyl alcohol and then rinsed with deionized water. 0.1 M of cadmium chloride and L-proline is dissolved in 50 ml of deionized water stirred for 30 minutes in equal mole ratio. The prepared solution is deposited on glass substrates using jet nebulizer. The compressed air is used as carrier gas. Nozzle-substrate distance is fixed at 5 cm. The substrate temperature stented in 600^0C. The aerosol formed from nozzle undergoes successive pyrolysis due to temperature gradient and successivepyrolysis results into decomposition of aerosol at substrate and leads to film formation. The chemical reaction of overall deposition process is assumed as follows,

$$C_5H_9NO_2 + Cd\,Cl_2 \rightarrow CdO\,(C_5H_9NO_2)$$

The prepared samples are characterized by UV-Vis, SEM, EDS, XRD and FTIR.

3. CHARACTERIZATION TECHNIQUES

3.1. FT-IR Analysis of L-Proline Doped Cadmium Oxide Thin Film:

A presence of molecules and their vibrational wave assignments are identified for L-proline doped CdO Thin Film using Fourier Transform Infrared Spectrophotometer IR Tracer 100. Figure 2, identifies that the observed wave assignments are belongs to the prepared sample L-proline doped CdO Thin Film.

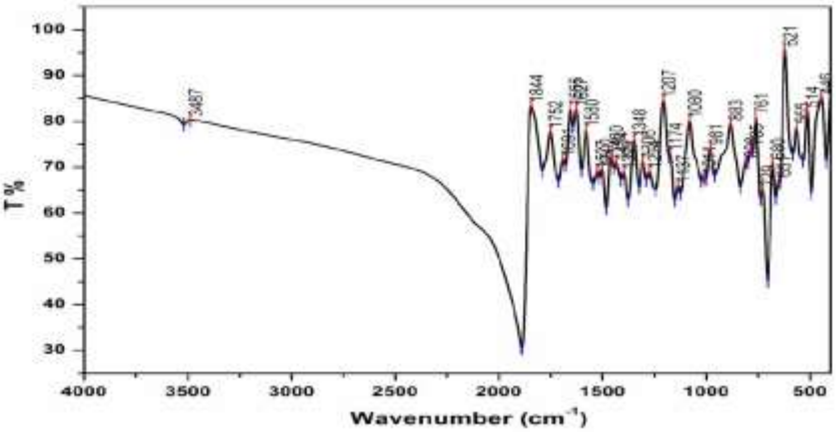


Figure 2. FT-IR Spectrum of L-proline doped CdO Thin Film

3.2. UV spectral analysis of L-proline doped CdO Thin Film

Absorbance and transmittance spectra of L-proline doped CdO thin films were recorded in the wavelength range 300–1100 nm and are shown in Figure 3(a) and 3(b). The average optical transmittance is about 60% for the films prepared with higher precursor concentration of cadmium. The optical transmittance of CdO film decreases with increasing concentration, which may be due to the change in the particle size as well as film thickness.

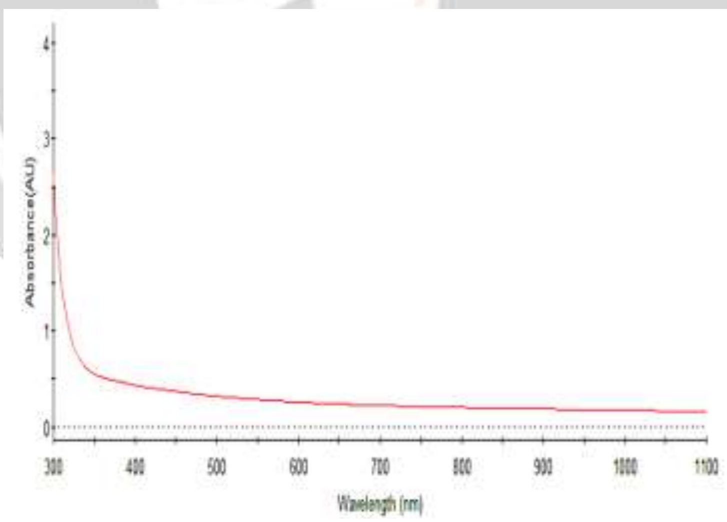


Figure 3(a). UV-Absorbance Spectrum of L-proline doped CdO Thin Film

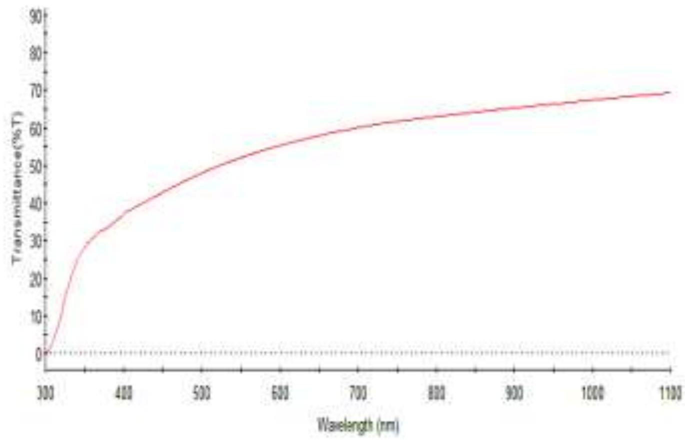
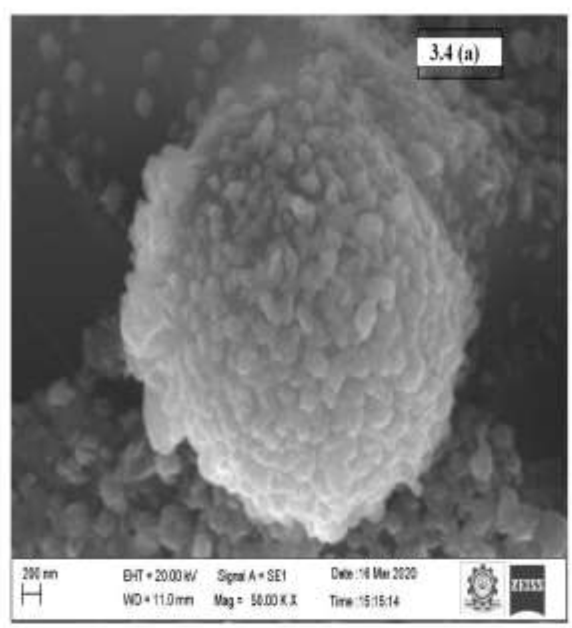
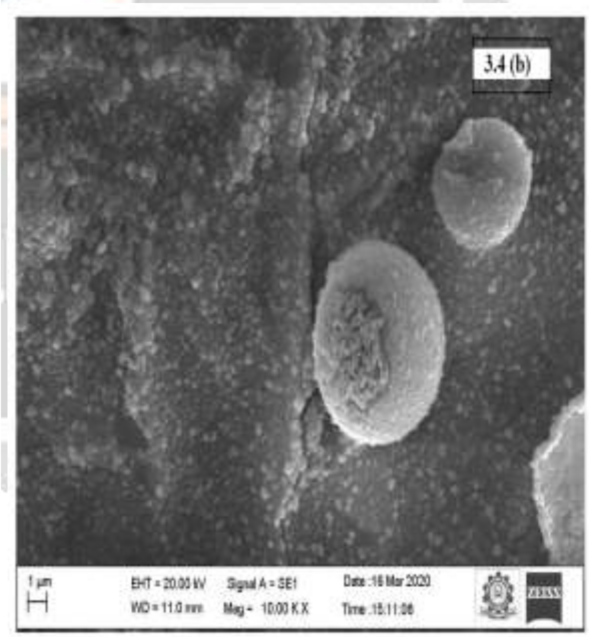


Figure 3(b). UV Transmittance Spectrum of L-proline doped CdO Thin Film

3.3. Scanning Electron Microscope Analysis of L-Proline doped CdO Thin Film.

The SEM analysis was carried out for l-proline doped cadmium oxide thin film using Scanning Electron Microscope EVO18 (CARL ZEISS) instrument. The different magnification ranges are analyzed for the L-proline doped CdO thin film. From the observed thin film surface micro-graphs, we confirms that the developed L-proline doped CdO thin film are deposited as Coal like micro-structural arrangements. The magnification SEM image are observed as 1µm, 2 µm, 200 nm and 300 nm as shown in Figure 4(a) to 4(g).





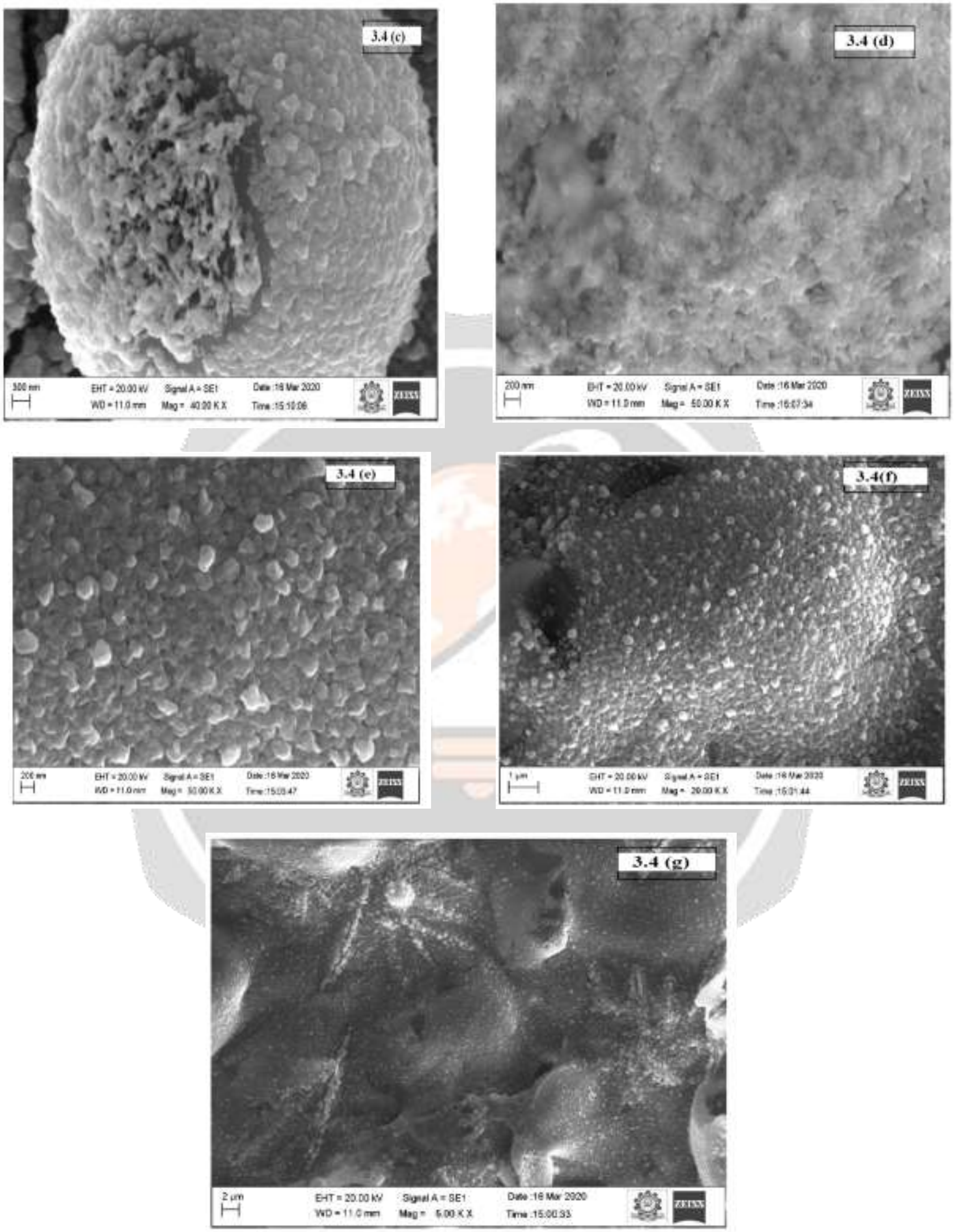
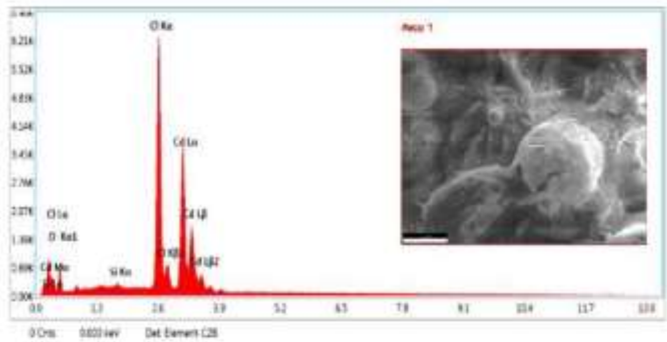


Figure 4. SEM images of L-proline doped CdO Thin Film

3.4. EDAX Analysis of L-Proline doped CdO Thin Film.

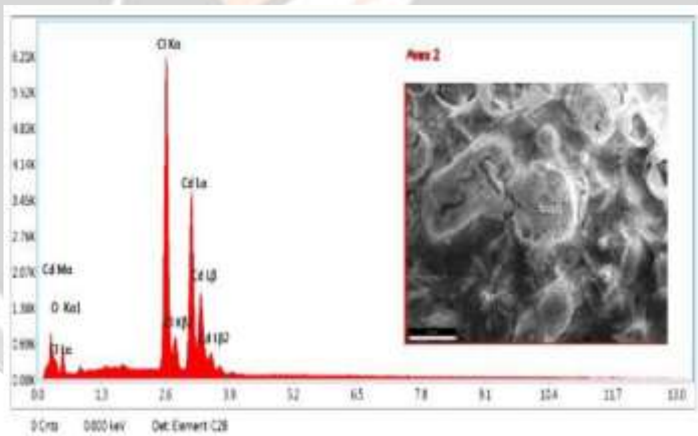
L-proline doped CdO thin film was subjected to EDAX analysis using Energy Dispersive X-ray-Spectrometer Quantax 200 with X Flash® 6130 instrument. From this analysis the presence of metal ions in thin film are confirmed and their percentages are also should be observed. In L-proline doped CdO thin film, a incorporation of metal ion cadmium, oxide and chloride were confirmed, which is used as a deposition material for thin film coating. The EDAX analysis was carried out in two areas of samples and their corresponding graphs are shown in figure 5(a) and 5(b)..



Smart Quant Results

Element	Weight %	Atomic %	Error %	Kratio
O K	11.2	32.3	12.4	0.0135
SiK	0.8	1.4	14.5	0.0062
ClK	33.9	44.1	2.9	0.3322
CdL	54.1	22.2	2.8	0.4298

Figure 5(a). EDAX spectrum of L-proline doped CdO Thin Film



Smart Quant Results

Element	Weight %	Atomic %	Error %	Kratio
O K	11.1	32.4	13.4	0.0153
ClK	34.0	44.8	2.9	0.3356
CdL	54.9	22.8	2.8	0.4370

Figure 5(b). EDAX spectrum of L-proline doped CdO Thin Film

4. CONCLUSION

L-proline doped CdO thin films were prepared on glass substrate with maintained substrate temperature from 600 °C by the JNS pyrolysis technique. The SEM analyses showed the well-structured particles oriented randomly with defined grain boundaries. The EDX analysis showed the presence of cadmium, oxide and chloride in the films without any impurities. From UV spectral analyses, it is concluded that the L-proline doped cadmium oxide thin films fabricated by jet nebulizer spray pyrolysis technique are promising semiconductor materials processing superior optical and electrical properties required for optoelectronic applications. Also the above studies showed that the quality of the structural, morphological, optical and electrical properties of the thin films are enhanced at same mole percentage.

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