Synthesis of ZnO-CdO Nanocomposite using Spray Pyrolysis Method and it's Effect on Structural and Optical Properties

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Received 25 December 2015; Accepted 25 January 2016; Available 15 February 2016

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ABSTRACT
This research studied preparation of ZnO,CdO ,ZnO-CdO nano composite using Spray Pyrolysis method. The prepared samples were characterized using X-ray diffraction and the photoluminescence spectroscopy (PL) for surface morphology investigation leading to determination of optical energy gap .the grain size determined by Scherrer's equation was ()nm . consequently of Eg calculation ,it was noticed decrement in the value of ZnO-CdO nanocomposite compared to ZnO manner due to addition of CdO content.

KEYWORDS: ZnO, CdO, nanocomposite, spray pyrolysis method

INTRODUCTION
Transparent conducting oxide thin films such as zinc oxide (ZnO), indium tin oxide (ITO), tin oxide (SnO2)and cadmium oxide (CdO) are extensively used in semiconductor optoelectronic applications [1–3].ZnO is a well-known II–VI semiconductor; it has a direct band gap in the ultraviolet range (3.37 eV) and a large exciton binding energy (60meV), which made it a great application prospect due to its extrusive physical properties. CdO is an n-type semiconductor with a rock-salt crystal structure (fcc) and possesses a direct band gap of 2.2 eV [4]. Its high electrical conductivity (even without doping) and high optical transmittance in the visible region of solar spectrum along with a moderate refractive index make it useful for various applications such as solar cells, transparent electrodes, phototransistors, photodiodes, gas sensors, etc. [5, 6].

There are numerous reports on the synthesis of the nanostructure ZnO-CdO through the usage of different methods including the electrodeposition [7],vapor phase transport [8], reactive sputter [9] and spray-pyrolysis-techniques [10].

MATERIALS AND METHOD

The Films Deposition Technique:
The (ZnO, CdO and ZnO:CdO nanocomposite) thin films were deposited on a glass substrates by spray pyrolysis technique. (0.1 M) aqueous solution of precursor salt zinc nitrate, Cadmium nitrate were sprayed separately on to pre-heated glass substrate using atomizer. Then a composition of (0.1)M of both nitrates are sprayed for ZnO-CdO nanocomposites preparation followed by heating at (500 °C) for 1 hour . each spray cycle has a( 1 minute ) wait so that the desired temperature is maintained throughout the decomposition process. Spray pyrolysis system as illustrated in Figure (1).
Structural studies:
X-ray diffraction spectra:
The structure of the prepared films was studied by the X-ray diffraction (XRD) method using Shimadzu system with radiation (0.15406 nm). X-ray tube of target CuKα, voltage 40.0 (kV), current 30.0 (mA). X-ray diffraction (XRD) pattern of ZnO, CdO, and their composites is used to determine the nature of the film and the structural characteristics of the materials. The average grain size of the sample have been estimated using Scherrer's equation:

\[ D = \frac{0.94 \lambda}{\beta \cos \theta} \]  

Where \( \lambda \) is the wavelength (\( \lambda = 1.542 \, \text{Å} \)) (CuKα), \( \beta \) is the full width at half maximum (FWHM) of the line, and \( \theta \) is the diffraction angle. The XRD parameters for pure ZnO, pure CdO, and their composite are shown in table (1) where hkl parameters indicated on each peak as in fig(2).

Thickness measurement:
The thickness of the films is an important parameter that affects the film properties; we have used the Weighting method to measure it. This method gives an approximate thickness for the deposited film. Film thickness (t) is determined by the relation:

\[ t = \frac{\Delta m}{\rho A} \]  

where \( \Delta m \) is the net weight of the film (g), \( A \) is the area of the film (cm²) and \( \rho \) is the density of the film (g/cm³).

Optical properties:
UV-spectrum transmittance spectrum of pure ZnO, pure CdO, and their composition were investigated using Shimadzu spectrometer (2000) of range 190-1100nm as shown in fig(3) to show the optical properties of our samples. Photoluminescence were studied at room temperature using ELICO company spectrofluorometer covering 300-900 nm wavelength range, have been used ZnO, CdO, and their composites using Eg values were estimated for each case as in table(1). While Photoluminescence were tested for samples using excitation wavelength of 320nm as shown in fig (4).

Results:
RESULTS AND DISCUSSION

The XRD patterns of the ZnO, CdO, ZnO-CdO composite nanostructure thin films were shown in figure 2 respectively. The nanostructures are polycrystalline where the observed peaks (100), (101), (102), (110) (112), (111), (002), (220). All the diffraction peaks can also be well indexed to the hexagonal phase ZnO reported in JCPDS. The results indicate that the products consisted of a pure phase. The average crystalline size (D) of the nano-sized ZnO particles can was estimated to be about 44.3 nm. While CdO pattern shows (111), (200), (220) with preferential crystal orientation at 2θ=38.3 with average grain size (28.7) nm with cubic structure. It is obviously noticed that peak intensity of ZnO decrease with increasing the amount of CdO.

The crystallite size can be calculated using sherrier’s equation [12] as seen in table (1) the grain size increase in composite in comparison with pure ZnO, CdO samples.

![Graph showing optical properties](image)

**Fig. 3:** Shows optical properties of a- ZnO Pure, b-CdO pure c- ZnO-CdO nanocomposites.

<table>
<thead>
<tr>
<th></th>
<th>ZnO pure</th>
<th>CdO pure</th>
<th>50ZnO:50ZnO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eg(eV)</td>
<td>3.4</td>
<td>2.4</td>
<td>2.85</td>
</tr>
<tr>
<td>d_{hkl} (nm)</td>
<td>0.265</td>
<td>0.235</td>
<td>0.2717</td>
</tr>
<tr>
<td>β (deg)</td>
<td>1.25</td>
<td>0.32</td>
<td>0.5</td>
</tr>
<tr>
<td>D (nm)</td>
<td>44.3</td>
<td>28.7</td>
<td>71</td>
</tr>
<tr>
<td>ε (*10^{-12} lines m^{-1})</td>
<td>5.17</td>
<td>1.3</td>
<td>2.08</td>
</tr>
</tbody>
</table>

The optical absorption spectrum were represented in figure (3). The band gap energy decreased from 3.4eV for ZnO to 2.85 eV for composite after addition of CdO which has band gap 2.4eV as shown in table (1). The lower band gap obtained can be due to larger particle size [13,14]. Band gap is the major factor for determining the electrical conductivity so decreasing band gap leads to free electron motion within material with better electrical conductivity which can be useful for optoelectronic applications.

The room temperature PL emission spectrum of ZnO/CdO nanocomposite with an excitation wavelength 330 nm as displayed in figure (4). The band gap of ZnO corresponds to UV region absorbance spectrum. The peak observed at 380 nm corresponds to band-edge emission of CdO nanocrystals [15] The absorption wavelength range of ZnO/CdO is wider and has extended to into the red region as compared to ZnO which is in blue region.

The origin of the violet emission at 430 nm and 480 nm could be due to transition occurring from Zn interstitials to the valence band and the peak 430 nm may be due to presence of oxygen vacancies, therefore PL peaks of nanocomposites were observed to be close to ZnO.
Conclusions:

Structural and optical properties were investigated for synthesized nanostructure ZnO, CdO, ZnO-CdO nanocomposite using spray pyrolysis technique. For our composite nanostructures the peak position of the near-band-edge emission is slightly red shifted and also the intensity reduced compared to UV emission peak of ZnO PL emission indicates some cluster defects are due to oxygen vacancy. The composite gap is shifted from 3.4 to 2.85 due to Cd$^{2+}$ ion replace Zn$^{2+}$ ions with great potential to emit excellent luminescence covering whole visible region used in fabrication of white light emitting diodes.

![Fig. 4: shows Fluorescence versa wavelength for (a) ZnO pure (b) CdO pure (c)50 ZnO:50CdO.](image)

REFERENCES