



Properties of $\text{Cd}_x\text{Zn}_{1-x}\text{O}$ thin films and their enhanced gas sensing performance



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ARTICLE INFO

Article history:

Received 25 March 2017

Received in revised form

16 May 2017

Accepted 22 May 2017

Available online 23 May 2017

Keywords:

CdZnO thin films

TCO

Spray pyrolysis technique

Gas sensor

ABSTRACT

$\text{Cd}_x\text{Zn}_{1-x}\text{O}$ ($0 \leq x \leq 0.20$) thin films with different Cd concentrations were successfully deposited on glass substrate using spray pyrolysis technique. X-ray diffraction (XRD), scanning electron microscope (SEM) and energy dispersive X-ray analysis (EDAX) were used for structural, surface morphological and compositional characterization. The XRD analysis revealed that the synthesized films were hexagonal in structure with (002) orientation. The SEM studies confirm the formation of homogeneous and uniform films. Optical transmittance and electrical conductivity of the films were evaluated using UV–Visible spectroscopy and two probe method respectively. The optical studies showed that the $\text{Cd}_x\text{Zn}_{1-x}\text{O}$ thin films have optical transmittance in entire visible region. The resistivity of undoped films were very high and it decreases with addition of cadmium. The gas sensing properties were investigated at optimal temperature of 350 °C for various volatile organic compounds like acetone, ethanol and methanol. The $\text{Cd}_x\text{Zn}_{1-x}\text{O}$ thin films with 10 at. % cadmium concentration showed the sensitivity of 50% for 1 ppm ethanol.

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1. Introduction

Zinc oxide (ZnO), an important n-type semiconductor material, which is nontoxic, low cost and abundant in nature. It is an important wide bandgap material which finds application as transparent conducting electrode in light emitting diodes [1], solar cells [2]. ZnO is also important material in the field of piezoelectric devices [3], acoustic wave transducers [4], photocatalysis [5], thermoelectric [6] and gas sensitive devices [7]. It can be synthesized in different forms such as pellets [8], powders [9], thick films [10] and thin films [7]. Among these, thin film form is more effective because of low consumption of precursor material and high surface to volume ratio. Properties of ZnO thin film can be controlled by doping with different elements like In [7], Ga [11], Al [6], Cd [12] etc. Cadmium is an important doping material, could be an ideal doping candidate for ZnO to improve its opto-electronic properties. CdZnO films are very useful for the fabrication of ZnO/ZnCdO heterojunction and superlattice structures, which are the key elements in ZnO based light emitters and detectors [13]. Many reports deal with study of cadmium doped ZnO thin films using

various techniques such as vacuum sputtering [14], sol-gel [15], pulsed laser deposition [3] and spray pyrolysis [16]. As compared with different methods, spray pyrolysis is simple, reproducible and inexpensive, as well as suitable for large area applications. Simple experimental arrangement, high growth rate and mass production capability for large area coatings make it useful for industrial applications.

Every activity in daily life results in the release of organic species to the atmosphere. Some examples of specific sources and processes that commonly emit high levels of volatile organic compounds include vent gas, water separation techniques, industrial waste water, petroleum refining, natural gas processing, petrochemical processes, and paints. Consequently, the increased emissions of volatile organic compounds (VOCs) and their resulting impact on the air quality are now considered as a major environmental concern. VOCs like Acetone and Ethanol are colourless highly inflammable liquids which can evaporate easily. Methanol is another example for VOC which is highly toxic. Literature survey reveals that the ZnO based thin film is a promising candidate for detection of VOCs [17–19]. Variety of techniques have been used to improve the sensitivity of ZnO thin film sensors. These include doping of different metal ions to ZnO thin films [7], decoration of sensor surface with other oxide materials [20]. Hetero-structures of

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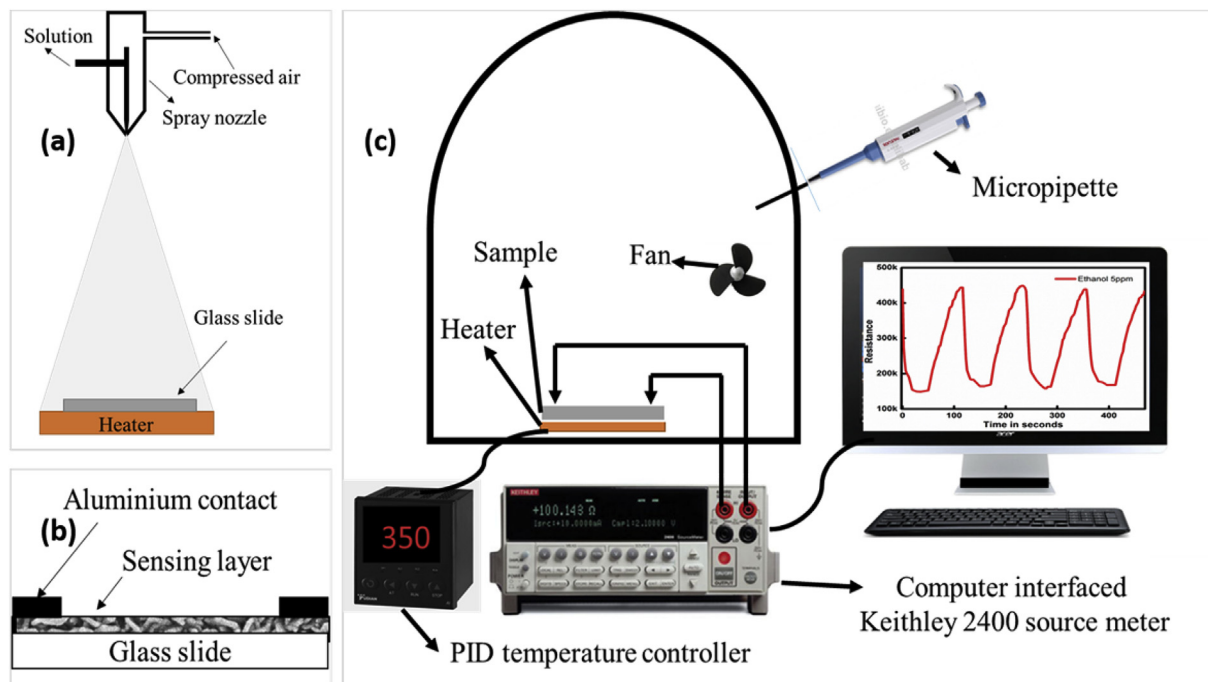


Fig. 1. Schematic representation of (a) film deposition unit, (b) specimen geometry of sensing element and (c) gas sensing set up.

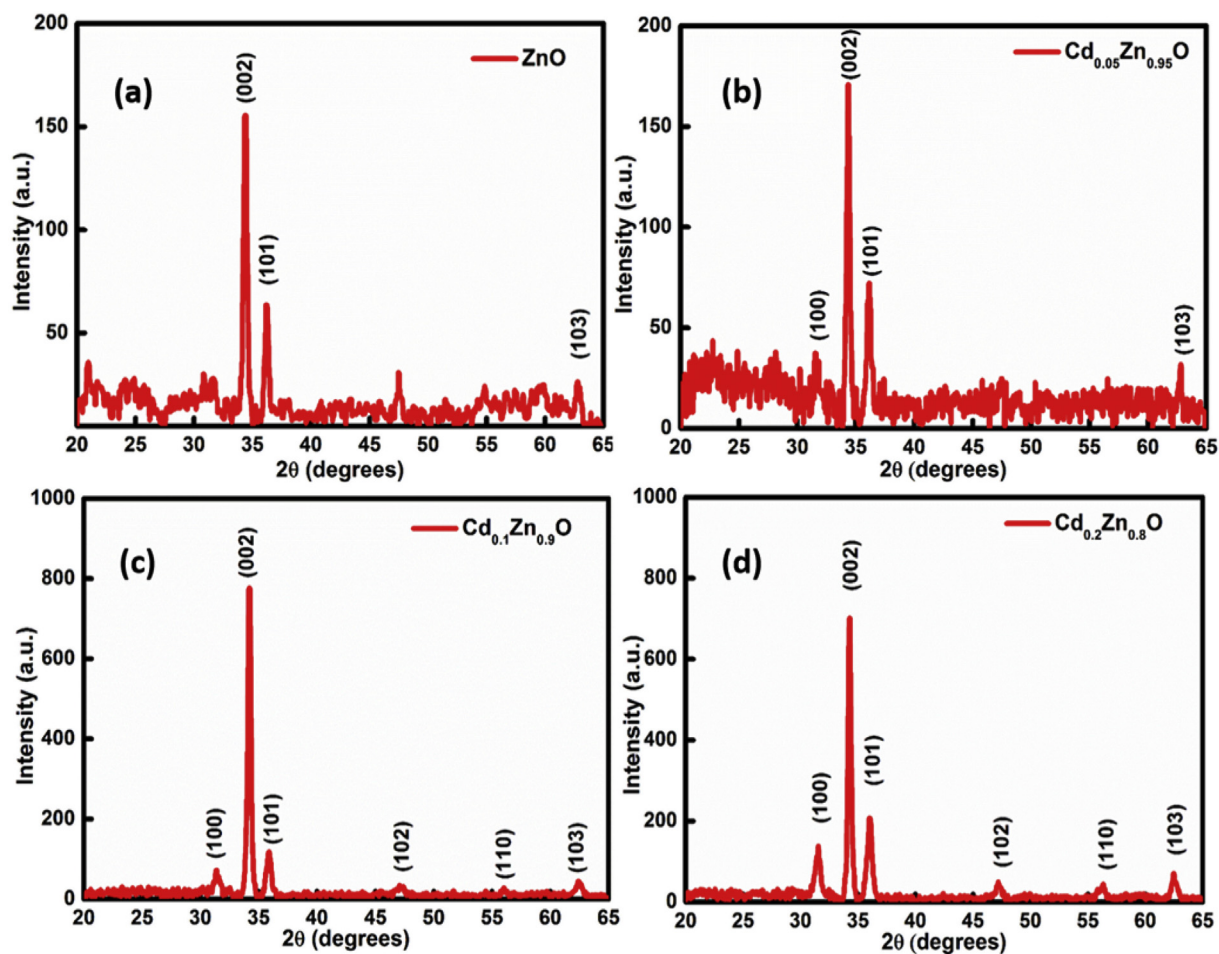


Fig. 2. XRD patterns of Cd_xZn_{1-x}O thin films (a) 0%, (b) 5 at.%, (c) 10 at.%, (d) 20 at.%.

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