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Synthesis & characterization of Li doped ZnO thin film By sol-gel spin coating method

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Abstract:

Thin films have found many applications in many fields such sensors, solar cells and many optical devices. In the present work we study about ZnO thin film and lithium doped ZnO thin film prepared by sol-gel spin coating technique. In all the films the reflections are from (100), (002), (101) lattice planes SEM Micrograph shows morphological structure. For pure ZnO small spheres appears all over the surface and for lithium doped ZnO small spheres with rod like structures are formed. The absorption peaks 334nm for ZnO and 359 for Li doped ZnO with 12 deposited layers. In both cases it shows UV absorption peak. The PL spectrum of the sample shows one UV emission peak and one visible peak. In this work structural & optical properties of ZnO and Lithium doped ZnO film fabricated by sol-gel spin coating technique have been investigated. Based on the research results of lithium-doped Zn reported by us and other groups, it is considered that Li play an important role in the variation of properties of ZnO. XRD analysis clearly shows the crystalline structure of ZnO. PL spectrum of samples shows UV emission peak & also a visible peak.

Keywords: ZnO; ZnO: Li; Thin film; spin-coating; XRD; UV; SEM etc.

Introduction

ZnO is a fascinating & well-studied transparent conducting oxide [1]. The direct broad band gap (Eg3. 3eV at 300K) of ZnO fuels and inflamed interest in its products in optoelectronics applications. The high exaction binding energy of ZnO is an advantage (60meV). Because ZnO crystal formation technique is more easier, ZnO-based devices may be less expensive. There has recently been a lot of interest in development of ZnO films for ultraviolet & blue light generating device applications. In general, ZnO films have n-type conductivity. Conductivity can be increased by doping with gallium and aluminum[2-4]. This property, along with optical transparency, has prompted studies of ZnO as transparent electrodes in flat-panel displays[5,6],thin film transducers[7], & solar cells[8]. ZnO thin films have been grown using a variety of methods, including radiofrequency & direct current sputtering[,8,9],chemical vapour deposition[10],sol-gel spin coating, molecular beam epitaxy, We used the sol-gel spin coating approach in our study because it is straightforward and easy to utilise.

Experimental method

Sol-gel spin coating was used to create Li doped ZnO thin films on glass (2.52.5 cm2) substrates. The glass substrates were first washed with soap solution, then placed in an ultrasonic bath of acetone for 5 minutes before being placed in a degreasing device for final cleaning. In boiling iso-proponal, a 10% solution of Zinc acetatedihydrateZn (CH3COO)2.2H2O was prepared for sol preparation. The turbid solution was then cleared by adding 10 drops of diethanolamine. The clear sol was then treated with 0.05 gramme of lithium hydroxide LiOH.H2O and heated for 30 minutes. After then, the sol was allowed to cool to room temperature. To prepare film, glass slide was placed on the spin coater and 5-6 droplets of sol were put over it while spinning at 3000 rpm. Following this, the wet coated slide was dried at 100oC for 10 minutes before being annealed at

450oC for 1 hour. Multiple coatings were applied, and a multilayer film with 12 layers was created. X-ray diffraction measurements were used to investigate the structural characteristics of the produced films. (= 1.54059 A)).The average crystallite size of film was calculated using the Scherer formula by broadening the diffraction peaks. The morphology of film was examined using a transmission electron microscope. The surface morphology & cross view pictures of films were examined using field emission electron microscopy. UV-VIS NIR Spectrophotometer was used to test the optical properties of Li doped ZnO films in wavelength range of 200 nm to 800 nm. Thin film samples' transmission spectra were obtained. To determine optical constants, the envelope approach was employed to study the transmission spectrum using the programme Origin 6.1. Optical band gap, refractive index, and extinction coefficient The thickness of the films was determined as well.

Characterization of the samples XRD analysis

X-ray diffraction was used to analyse crystal structure of Li doped ZnO films (XRD). Figures 1 (a) and 1 (b) show the X-ray diffraction spectra of Zno & Li-doped ZnO films of various deposition layers (b). It has distinct reflection planes. The XRD spectrum peaks correlate to the bulk ZnO patterns from the JCPDS data, which have a hexagonal wurtzite structure. In all the films the reflections are from (100), (002), (101) lattice planes. A very broad peak around 2θ = 34° is caused by the glass substrate. On doping with lithium upto 12 layers the preferential growth occurs at 2θ=47° at (012) lattice plane.

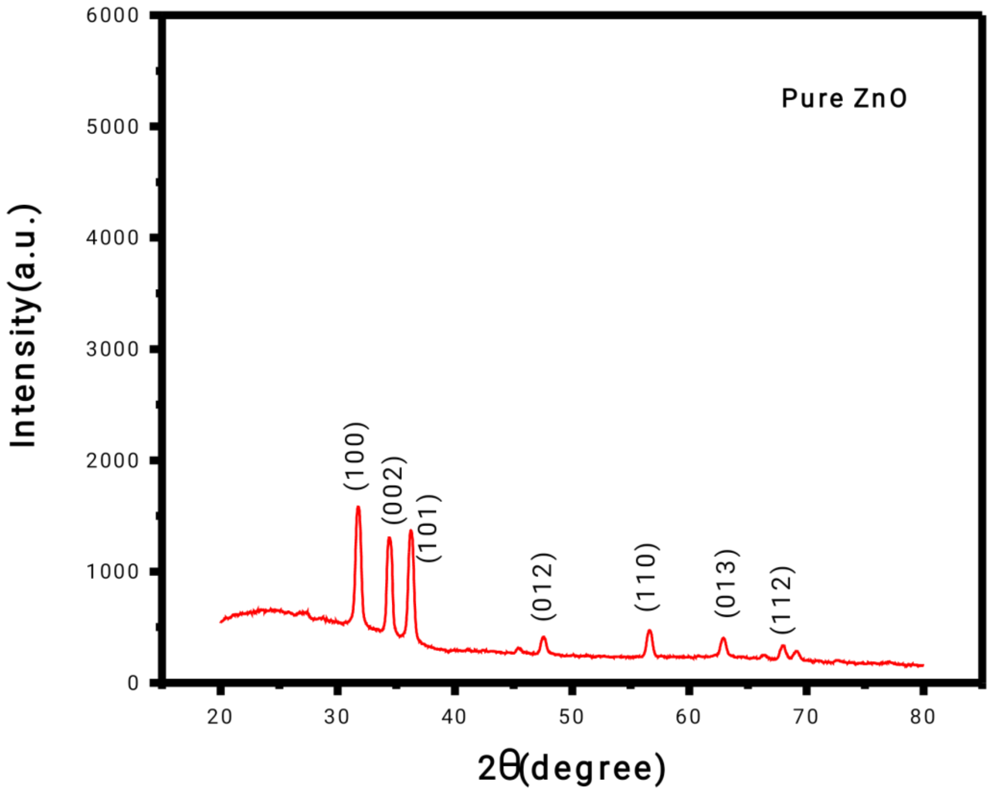

Figure1 (a) XRD Pattern of ZnO.

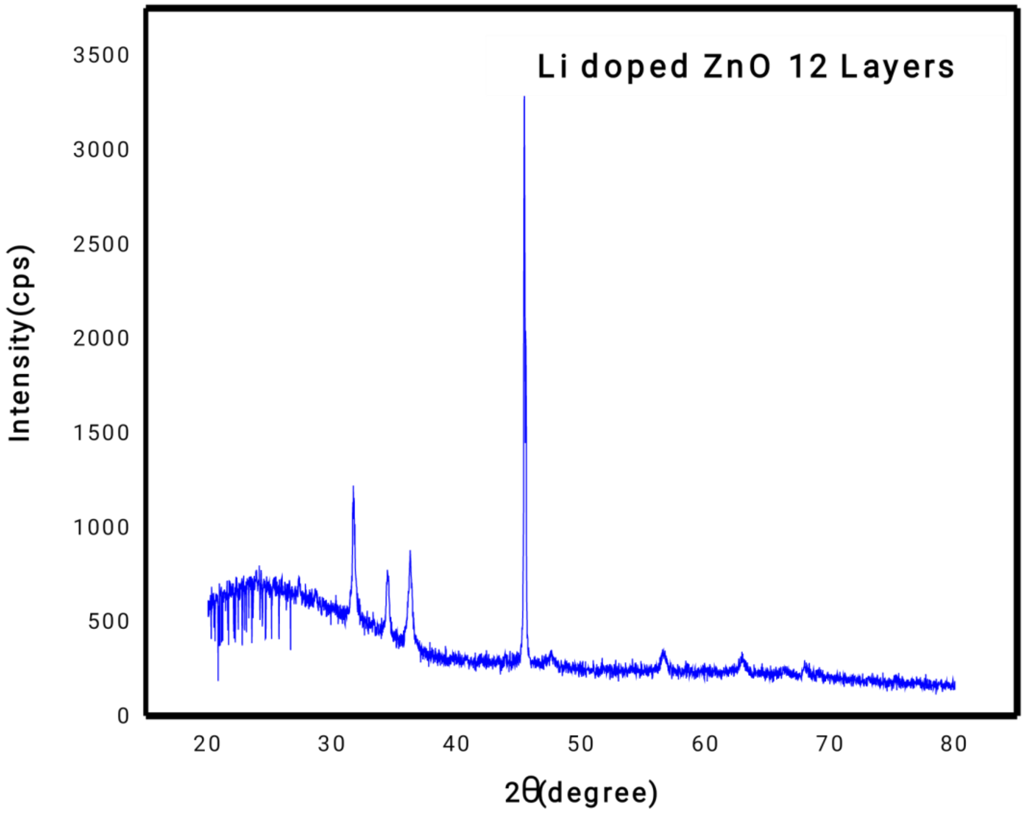

Figure 1(b) Lithium doped ZnO 12 Layers Micro structural analysis:

Figure2 (a) and 2(b) shows SEM micrograph for pure ZnO and Lithium doped ZnO. The doping is done up to 12 layers .For pure ZnOsmall spheres appears all over the surface which are too much dense and looks like in a cluster form. For lithium doped ZnO small spheres with rod like structures are formed.

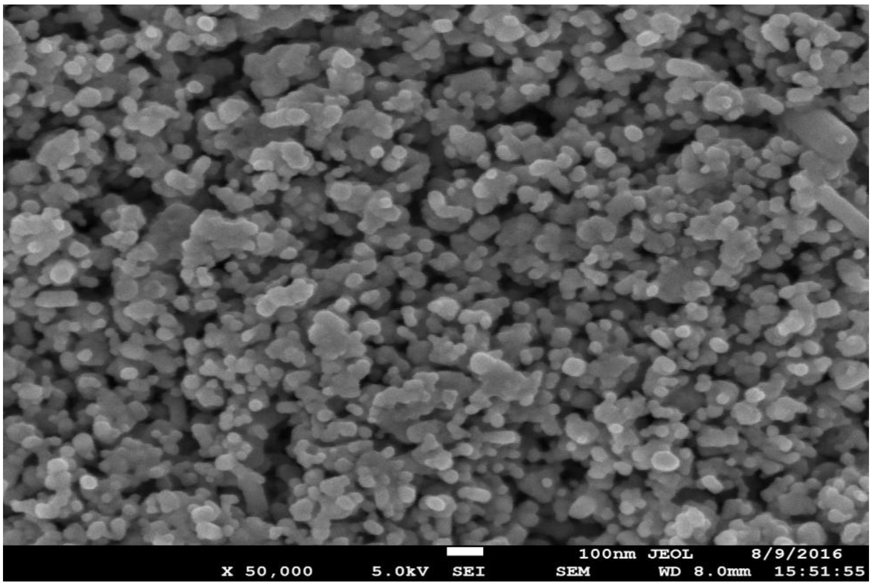

Figure 2 (a)SEM micrograph of pure ZnO.

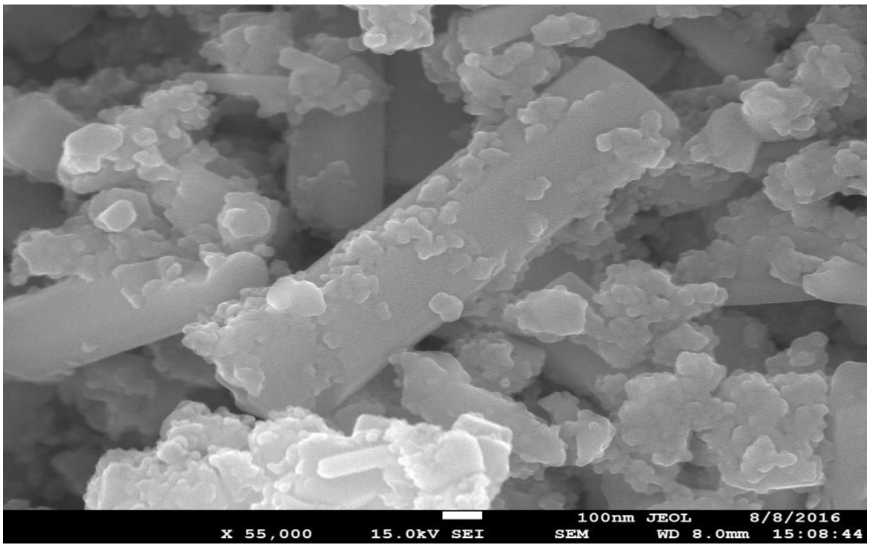

Figure 2 (b) SEM micrograph of Lithium doped ZnO 12layers

Optical properties:

The UV-Vis absorption spectrum of ZnO and lithium doped ZnO is recorded at room temperature by using spectrometer between the wavelengths ranges 300 to 1100nm. Optical spectroscopy is a useful tool for understanding the conducting states that correspond to the conduction bands of ZnO's inter and intra gap states [13]. The absorption spectra of ZnO and Li doped ZnO are shown in Figures 3(a) and 3(b). The figure illustrates the absorption peaks 334nm for ZnO and 359 for Li doped ZnO with 12 deposited layers. In both cases it shows UV emission peak.

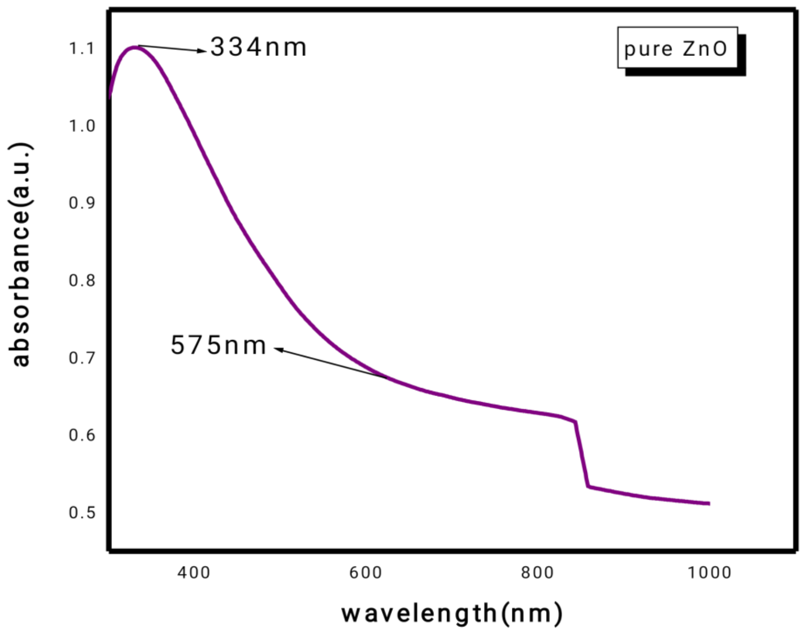

Figure 3(a) Absorption spectra of pure ZnO.

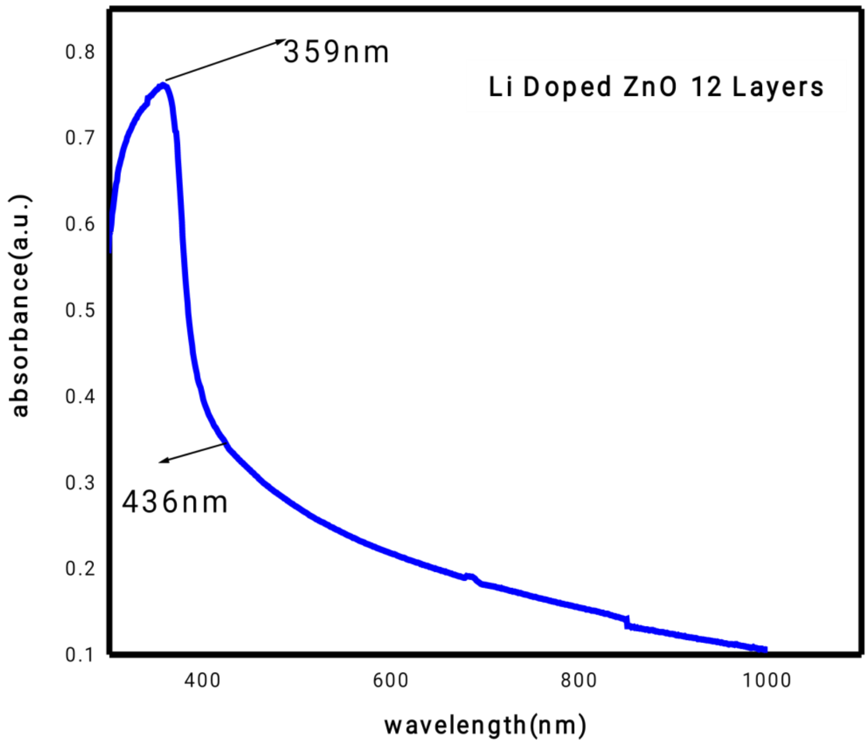

Figure3 (b) Absorption spectra of Li doped (12 layers) ZnO.

'**Photolumniscence study:**

Figure 4(a) depicts the PL spectrum of pure ZnO. Two emission peaks are found in the Photolumniscence spectrum. A significant peak centred at 569nm, near band edge, is observed in the Photolumniscence spectrum due to free exciton emission. A weak peak centred at 353nm is also observed in the Photolumniscence spectrum [14], and broad band observed in region of 300nm to 400nm in the PL spectrum of ZnO thin films is related to amount of non-stiochiometric intrinsic defects, which may be due to zinc vacancy in ZnO films, as reported by Kim et al. [15]It has also been observed that pure ZnO can emit green or orange light depending on growth temperature & oxygen supply during sample preparation. We detected one visible band, the appearance of which is related to stiochiometric flaws that develop during the

a film synthesis. For lithium doped ZnO thin film also two peaks are observed one strong peak centered at 568nm and other at 352nm.

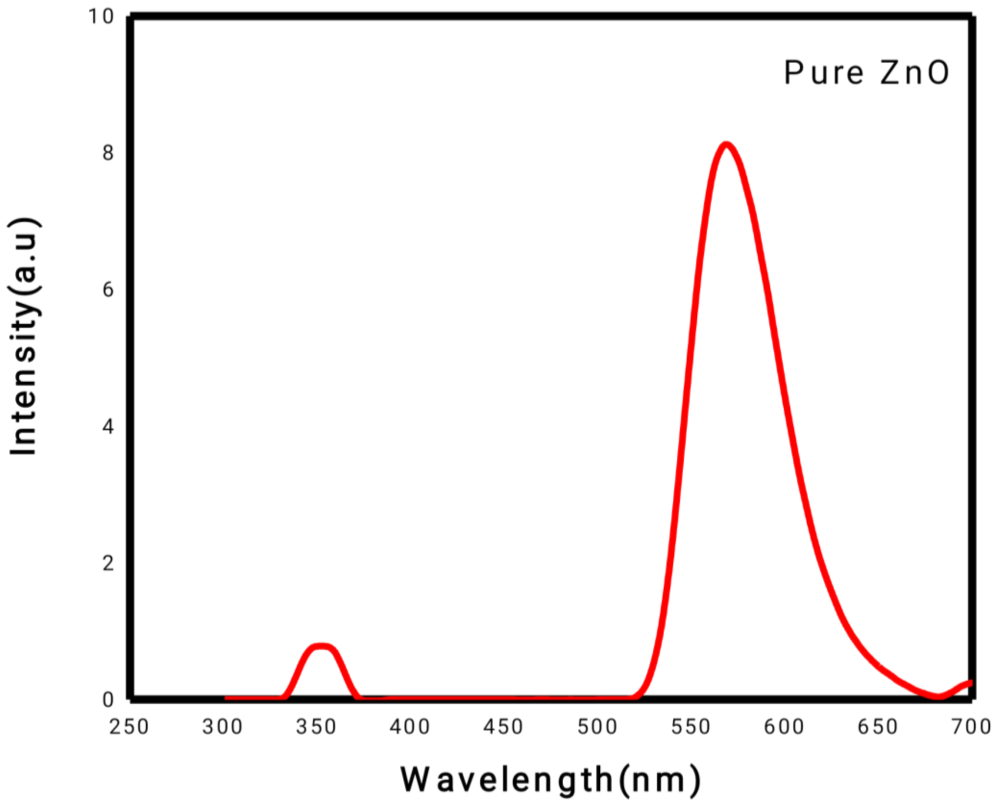

Figure 5(a) PL spectra of pure ZnO

Figure 5(b) PL spectra of Li doped ZnO

Conclusion:

In this work structural & optical properties of ZnO and Lithium doped ZnO film fabricated by sol-gel spin coating technique have bee investigated .Based on th research results of lithium doped Zn reported by us and other groups, it is considered that Li play an important role in the variation of properties of ZnO.XRD analysis clearly shows the crystalline structure of ZnO.PL spectrum of samples shows UV emission peak & also a visibl peak.

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