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Thin Film Synthesis and Morphological Studies of In-Doped ZnO

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Abstract **– Thin films ZnO: In were prepared simple and cost effective spray pyrolysis technique. The so prepared film is characterized for structural behavior by using XRD technique. The Change in Crystal size is observed with change in doping concentration. SEM reflects grains with uniform coverage of the substrate surface and the grain size is increased from 80 nm to 150 nm as the concentration of in increased.**

Keywords **– Spray Pyrolysis, In-Doped ZnO Films, Structural Properties, Morphological Properties.**

I. INTRODUCTION

A defined study on the properties of doped film is need for controlling the doping parameters. Also it is crucial for optoelectronic device applications. This control on doping can be achieved by the use of synthesis techniques. However Spray pyrolysis is good and lost cost method for this purpose. Because in this method it is easy to vary the doping concentrations to adjust the properties of the films. Till date many researchers carried out different kind of studies on the properties of indium doped ZnO thin films. It is been evidenced that when ZnO is doped with group III elements, like Al, Ga or In, it is expected that the dopants act as singly charged donors by substituting Zn. The excess carriers supplied by the impurities to the conduction band contribute to the increase of the electrical conductivity of ZnO. Moreover out of these elements Indium has proved to be one of the best candidates for making ZnO low resistive [1-4].

In this paper, we have tried to utilize the same method reported by the researchers to evidence the reliability of the reports available. So the indium doped ZnO thin films prepared using spray pyrolysis technique.

II. EXPERIMENTAL DETAILS

Thin films ZnO: In (ZOI) were prepared simple and cost effective spray pyrolysis technique. The precursor used were Zinc acetate and Indium chloride. The mixture was dissolved in solution of methanol and double distilled water with 3:1 ratio. The concentration of zinc acetate was 0.7 M in solution whereas the In /Zn ratio in the solution was varied from 0.25 at% to 1 at% in the starting solution with regular difference of 0.25%. The prepared solution is then sprayed on the hot glass substrates. The temperature of the substrates was kept constant at 350 ^{0}C throughout the experiment. The so prepared film is characterized for structural behavior by using XRD technique and AFM.

III. RESULTS AND DISCUSSIONS

A. *X-ray Diffraction Analysis*

To identify the crystal structure of prepared material X-ray diffraction data were analyzed. Fig. 1 shows the XRD patterns of In-doped films with different doping levels. As seen in Fig. 1, ZOI films have polycrystalline nature with a wurtzite structure. The films exhibit a dominant peak at $2\theta = 36.44$ corresponding to the (101) plane. However other peaks corresponding to (100) and (002) planes are also presents in the spectra indicating polycry-

-stalline nature.

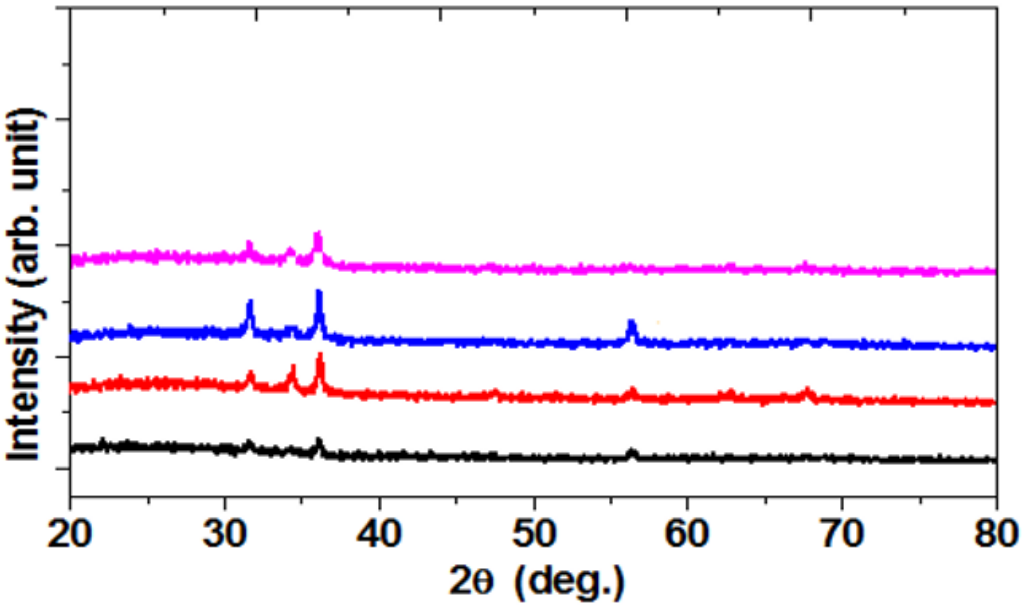


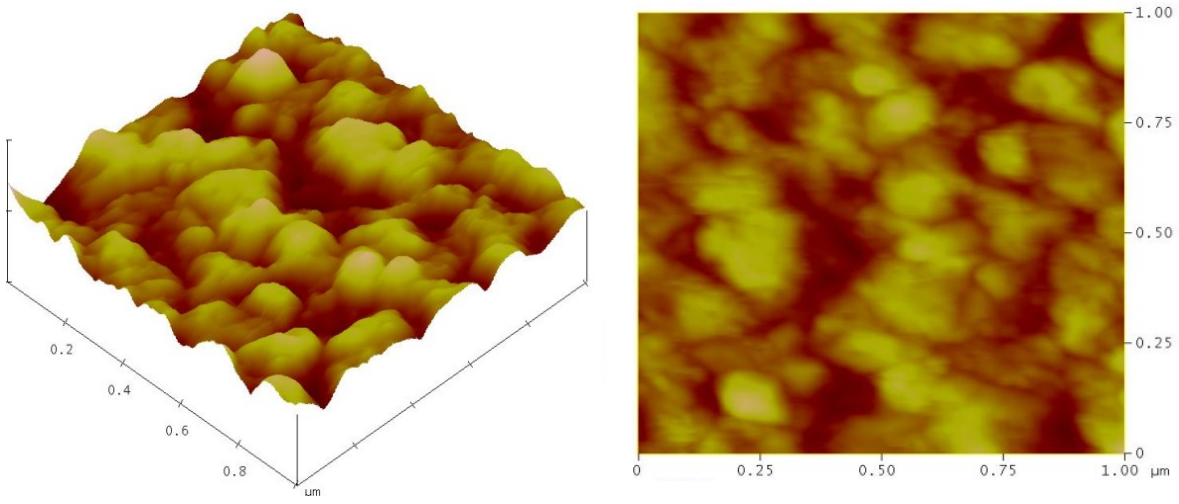
Fig. 1. X-ray diffraction spectra of In-doped ZnO thin films.

It is observed that the preferential (101) peak intensity increases with increasing In-dopant concentration. This indicates film crystalline nature of film is improved with concentration of Indium. This is because of the incorporation of Indium in film network enables more nucleation sites. The XRD also exhibits that there is no presence of any secondary phase in prepared material. However, the doping affect the (101) diffraction peak and is in continues progress with concentration of dopant.

B. *Surface Morphological and Compositional Studies*

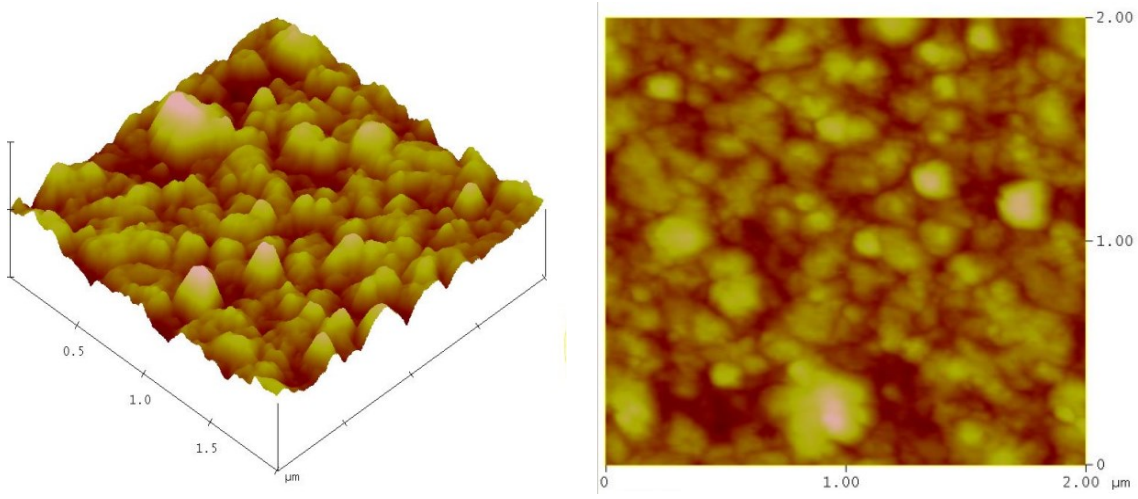
For representation AFM Images of ZOI thin films for doping 0.25% and 0.1% were used in studies. Figure 2 (A) and (B) 3D and 2D shows the AFM Images of ZOI thin films for doping 0.25% and 0.1% respectively. The images are observed to analyze the roughness. From the surface morphology of the films it is observed that the grain growth is of nano meter size with uniform structure. It is evidenced that at higher doping levels of indium the very few nuclei were formed but they are larger. However, Growth of these larger nuclei is more three-dimensional than in films prepared at lower doping levels. This combination should result in large and irregularly shaped grains [5-6].

The Uniformity of the films is confirmed by measuring the surface root mean square and average roughness of ZOI films. It is seen that the films deposited at various In-doping levels show different surface roughness. At the In 0.25 %, the average and rms root mean square roughness is very low as 10.705 nm and 8.517 nm, respectively. However at 1 % the values of average roughness and rms roughness increases found to be 24.157 nm and 18.247 nm. It is witnessed that the particle size measured the AFM is higher than the values calculated from XRD studies, indicating that these particles are probably an aggregation of small crystallites on the surface of the films [7-8].



(a) (b)

Fig. 2. (A) AFM 3D (a) and 2D (b) roughness analysis of ZOI thin films (In 0.25%).



(a) (b)

Fig. 2. (B) AFM 3D (a) and 2D (b) roughness analysis of ZOI thin films (In 1%).

IV. Conclusion

Thin films of Zinc oxide doped with different concentration of In (ZOI) were deposited by spray pyrolysis method using an aqueous zinc acetate solution. XRD revels that ZOI films have polycrystalline nature with a wurtzite structure. Also the orientation of (101) is the dominant plane in the doped films. The film consists of grains with uniform coverage of the substrate surface and the grain size is increased nearly double as in concentration increased from 0.25 % to 1 %. From the surface morphology of the films it is observed that the grain growth is of nanometer size with uniform structure.

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