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Research Paper

Physics

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Study The Surface Morphology of the Undoped and Mn Doped ZnO Thin Films

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ABSTRACT

Undoped and Mn-doped nanostructured ZnO thin films were deposited on glass substrates surface morphological properties was investigated the polycrystalline nature with hexagonal Wurtzite structure of ZnO thin films. The crystallite size was found to be decreased with Mn-doping. Scanning electron micrographs showed a closely packed spherically shaped grains distributed uniformly over the film surface. AFM microscopes provide the highest levels of performance, flexibility and productivity, and incorporate the very latest advances in atomic force microscopy techniques.

Introduction

Applications range from materials science to biology, from semiconductors to data storage devices, from polymers to optics with measurement of nanoscale topography, nano-mechanical, nano-electrical and nanoscale chemical mapping [1]. Additionally, Bruker is the only major atomic force microscope manufacturer with a state-of-the-art probes nanofabrication facility with products that support a wide range of applications. Bruker provides its users with world-wide, application –specific customer support, and is uniquely positioned to deliver the equipment, guidance, and support for all their nanoscale research needs. Atomic force microscopy (AFM) was employed to study the effect of Mn doping on the crystalline quality and morphology of the synthesized films [2]. Band gap has been evaluated from optical absorption spectra and observed red shift has been interpreted.

The nature of change of pattern of exitonic as well defect mediated emission peaks with variation in Mn doping has been analyzed by PL spectroscopy. Magnetic property of ZnO film doped with 5at% (maximum) of Mn has been chosen for analysis. Field (at room temperature) and temperature dependent magnetization were analyzed [3]. The evaluated structural, morphological, optical and magnetic parameters have been interpreted in the light of modification of the electronic structure and disorder introduced in the films through Mn doping. Pure zinc oxide thin films have certain limitations in their application. In order to widen the potential areas where ZnO thin films can be applied, dopant ions have to be incorporated into them to obtain certain desired properties like wider or narrower bandgap, higher optical absorbance, lower or higher melting point, ferromagnetism, etc. Mn-doped ZnO has the potential to be a multifunctional material with coexisting magnetic, semiconducting and optical properties [4].

Experimental

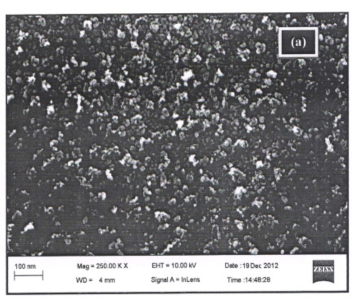
To synthesize $Zn_{1-x}Mn_xO$ (x = 0.00, 0.05, 0.10, 0.15) thin films by sol-gel technique stoichiometric amount of zinc acetate Dihydrate [$Zn(CH_3COO)_2.2H_2O$] and manganese acetate Di-hydrate [$Mn(CH_3COO)_2.2H_2O$] was added to a solution containing 2-propanol and Di-ethanolamine (DEA). DEA was used as the solution stabilizer. The solution was mixed thoroughly with a magnetic stirrer for 3 hours and kept for 48 hours. Glass substrate was used for film deposition. The substrate was cleaned by ultrasonic cleaner in equi-volume acetone and alcohol and through rinsing in de-ionized water. The substrate temperature was maintained at 500°C during the deposition [5]. Compressed air was used as a carrier gas with an air flow rate of 40 lbs/in^2. The solution was sprayed onto the substrate in several spraying cycles of 3 sec, followed by an interval of no spray for 1 min, which avoided the strong cooling of the substrate due to the continuous spray. The films were sprayed for 3 h with the above systematic steps.

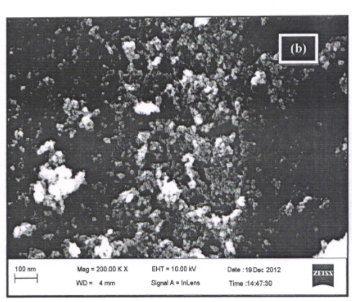
Scanning Electron Microscopy (SEM)

Surface morphological studies of undoped and Mn doped ZnO films have been carried out using a scanning electron microscope. Fig.(1) show SEM images of an undoped and Mn doped ZnO film. The SEM images of ZnO resemble a granular surface. The incorporation of Mn ions changed surface morphology to a wrinkle network. The crystalline nature of films was affected due to the enhancement of dopant concentration, by which more impurities were included in the ZnO crystal. The SEM images of ZnO : Mn films show that the grain boundaries are well defined and the grains distribution over the surface is more uniform comparing to the undoped ZnO film. For Mn concentration of 10%, the morphology of the film was neither wrinkle nor whiskers and for 15% of Mn concentration the morphology of the film changed to whiskers.

Atomic Force Microscopy (AFM)

AFM measurement performed to study the surface morphology of the undoped and Mn doped ZnO thin films. Fig. (2) shows the 2D AFM images. Micrographs reveal that films are closely packed and granular in nature; signature of agglomeration of grains is almost absent. There is close monitoring of the AFM images of films with different Mn concentration reveal that, crystalline quality of films degrades slightly with increasing Mn doping concentration [6]. AFM images have also been utilize to estimate the grain size of the samples. It is found that the grain size estimated from AFM data found to decrease with increase in Mn doping concentration.





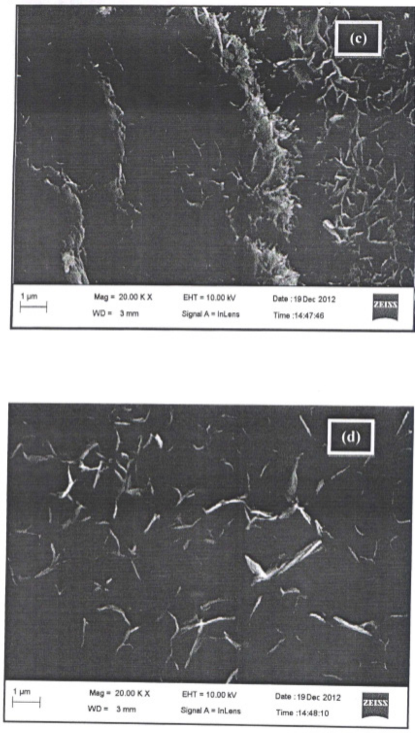


Fig. 1 : (a-d) SEM images for ZnO-Mn films

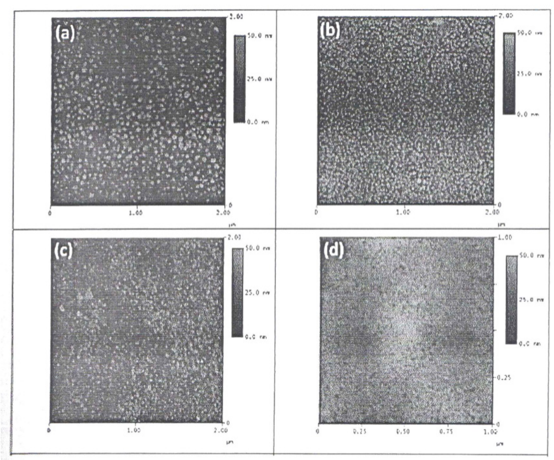


Fig. 2 : 2-D AFM images of undoped and Mn-doped ZnO thin films: (a) 0% Mn (b) 5% Mn doped (c) 10% Mn doped (d) 15% Mn doped.

Results and Discussion

The aim of the present investigation was to study the surface morphology of doping ZnO with manganese. Crystallite size of the ZnO film was found to be decreased with Mn-doping. Scanning electron micrographs (SEM) showed a closely packed spherically shaped grains distributed all over the film surface. The strong presence of AFM interaction has been established qualitatively and it actually acts as a reducing agent for the observed ferromagnetic moment of 5 at% Mn doped ZnO film.

REFERENCE

1. D. Mukherjee, T. Dhakal , H. Srikanth ,P. Mukherjee , and S. Witanachchi, Phys Rev B 81 (2010) 205202. 2. S. Dutta , S. Chattopadhyay , A. Sarkar , M. Chakrabarti , D. Sanyal , D. Jana, Prog Mat Sci 54 (2009) 89. 3. Y. Guo, X. Cao ,X. Lan , C. Zhao , X. Xue and Y. Song, J Phys Chem C 112 (2008) 8832. 4. CY Tsay ,WC Lee. Curr Appl Phys 2013; 13: 60–65. 5. K Vijayalakshmi, K Karthick. J Mater Sci Mater Electron 2013; 24: 2067–2071. 6. AG Ali, FB Dejene, HC Swart. Cent Eur J Phys 2011;10: 478–484.