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Preparation and Characterization of Metal Oxide: PMMA Composite Thin Films

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Abstract: Fabrication of ZnO thin film on glass substrate was patterned using spray pyrolysis technique by spraying 0.05 M of zinc acetate aqueous solution as a fine mist at 250°C and again, Polymethyl methacrylate (PMMA) thin film coating on ZnO thin films was coated using spin coating by dissolving PMMA in 20 mL metacresol. The structural, morphological and optical studies were carried out using XRD, FE-SEM and UV-Vis spectrophotometer, respectively. These explain the effect of PMMA on the surface.

Key words: ZnO, polymethyl methacrylate, spray pyrolysis, spin coating, metacresol

INTRODUCTION

Solid state sensors based on metal oxide thin films offer unique advantages such as compatibility with micro fabrication process and stability at higher temperatures and under harsh conditions. But the sensitivity and selectivity of metal oxide semiconductors sensors should be improved to compete with other technologies. In this context the role of organic materials especially polymers can be used as physical filters to enhance the selectivity of metal oxide semiconductors sensors. ZnO is an attractive semiconducting material due to its physical and chemical properties and it is a wide band gap semiconductor and is effectively used as UV absorber (Yu *et al*., 2005). It has several applications such as catalysis, optoelectronic devices, solar cells, photovoltaic devices and chemical sensors (Sivalingam *et al*., 2011). Polymethyl methacrylate (PMMA) is an amorphous, optically clear thermoplastic polymer material. It is used as a inorganic glass and shows higher impact strength and it has favourable processing conditions (Demir *et al*., 2006).

The nano ZnO/PMMA composites have some applications such as antireflection coatings, UV protecting sheets and films and enhanced thermal stability (Lu *et al*., 2006; Anzlovar *et al*., 2008). Metal oxide semiconducting materials have better sensitivity as a gas/chemical sensor, selectivity is a serious problem. Hence, coating of PMMA on ZnO has been considered to have physical filter towards a specific gas/chemical. In addition, UV filter fabrication is an interesting and challenging application in industries. Hence ZnO-PMMA nanocomposites thin films have been chosen to achieve above mentioned characteristics.

The present study prepared ZnO/PMMA composite thin film on glass substrate using spray pyrolysis technique and spin coating techniques.

MATERIALS AND METHODS

The ZnO/PMMA composite thin film was synthesized (Semaltianos, 2007) with the base chemicals obtained from Sigma Aldrich/Kemphasol. ZnO thin films were deposited on glass substrates using spray pyrolysis technique. Zinc acetate of 0.05 M was dissolved in 50 mL of distilled water, the substrate temperature was maintained at 250°C throughout the deposition, the precursor solution was fed through the spray nozzle at constant pressure and the dry air was used as carrier gas (Gumus *et al*., 2006). The ZnO film was annealed at 350°C for 3 h. Followed by the spray deposition, PMMA was coated on ZnO thin films by using spin coating technique. 0.065 M of PMMA was dissolved in 20 mL metacresol and stirred continuously for making gel. This gel was coated over the annealed ZnO film by spin coating method. In this way ZnO/PMMA composite films were deposited.

The structural and morphological studies were carried out for spray followed by spin coated ZnO/PMMA nanocomposite by using X-Ray Diffraction Technique (XRD, D8, Focus, Bruker, Germany) and Field Emission Scanning Electron Microscope (FE-SEM, JSM 6701F, JEOL, Japan). The optical studies were carried out by

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UV-Visible spectrometer (Perkin Elmer Lambda 25). The film thickness was obtained from a stylus profilometer (Mitutoyo SJ 301).

RESULTS AND DISCUSSION

Structural and morphology studies: Figure 1 shows the X-ray diffraction pattern of ZnO and ZnO/PMMA composite film. The XRD pattern obtained from 20-60° with the scan range of 2 θ min^{-1}. Both the film have polycrystalline nature. The high intense peak observed at 31.70°, 34.38°, 36.10°, respective to the (100), (002), (101) planes. The crystal planes were well accordance with JCPDS 36-1451 of ZnO crystal planes (Gumus *et al*., 2006). When PMMA coated over the ZnO film, the position of the peak varying slightly (±1°), due to effect of PMMA. The grain size D was calculated using Scherer's formula:

$$D = \frac{0.94\lambda}{\beta\cos\theta}$$

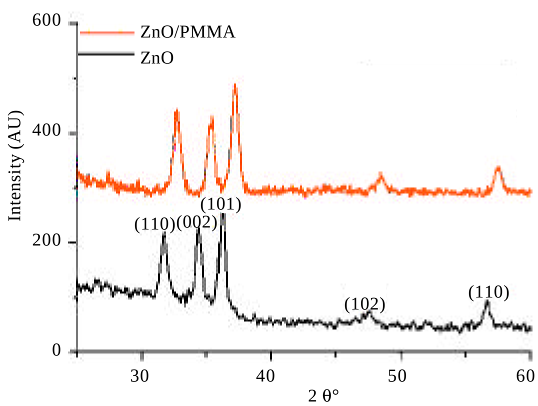

Fig. 1: X-ray diffraction pattern of ZnO and ZnO/PMMA composite film

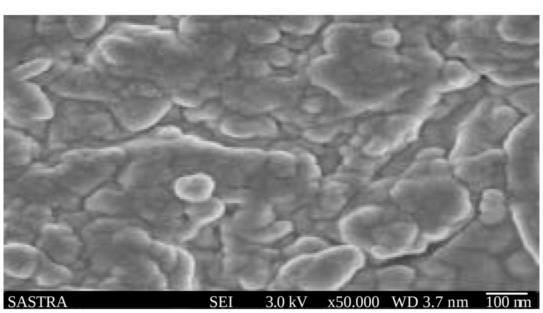

Fig. 2: FE-SEM micrograph of ZnO/PMMA composite thin film

where, λ is the wavelength of X-rays (1.5406 Å), θ is a diffracting angle and β is a Full Width of Half Maxima (FWHM).

The calculated crystallite size for ZnO film was 45-48 and 32-35 nm for ZnO/PMMA. In ZnO/PMMA film have a peak broadening as compare to the ZnO film, because the effect of PMMA over the ZnO. Figure 2 represents that, FE-SEM image of ZnO/PMMA. It clearly identify that closely packed nanograins over the film surface and the average grain size around 30-50 which is concord with XRD results for ZnO/PMMA films.

Optical studies: Optical absorbance and transmittance spectra for ZnO and ZnO/PMMA films as shown in Fig. 3a and b. An absorbance spectrum shows that ZnO/PMMA film has more absorbance as compare to the ZnO, due to the effect of PMMA and transmission spectra shows that ZnO/PMMA have less transmittance as compare to the ZnO (Zhang *et al*., 2011).

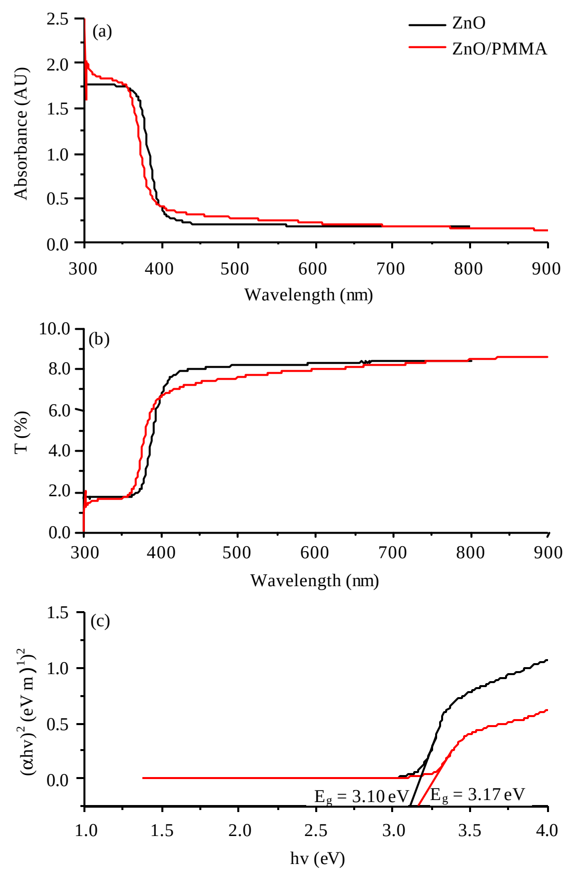

Fig. 3(a-c): ZnO and ZnO/PMMA films (a) Absorbance, (b) Transmittance spectra and (c) Optical band gap

When PMMA coated over the ZnO film, the thickness of the film increases, so the optical transparency of the ZnO/PMMA film decreases. The percentage of transmittance for ZnO and ZnO/PMMA in visible region are 80 and 75%. The thickness of the ZnO and ZnO/PMMA films are 500 and 750 nm.

The optical band gap of the film can be calculating using Tauc's plot, as shown in Fig. 3c. The graph plotted between photo energy vs. $(\alpha h\nu)^2$. The calculated band gap energy for ZnO and ZnO/PMMA were 3.10 and 3.16 eV.

CONCLUSION

Fabrication of ZnO/PMMA nano composite was patterned with the help of Spray Pyrolysis and Spin Coating Technique. Polycrystalline nature of ZnO thin film with hexagonal structure was studied from XRD. The SE micrograph shows closely packed nano grains with the size of 30-50 nm. The average grain size obtained for ZnO/PMMA films from SE micrograph was around 30-50 matches grain size (32-35 nm) obtained from XRD. The optical studies from UV absorption show that ZnO/PMMA nanocomposite film has more absorbance as compare to ZnO film.

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