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STRUCTURAL AND OPTICAL PROPERTIES OF Y-DOPED ZNO FILMS BY SOL-GEL PROCESS

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ABSTRACT
$Zn_{1-x}Y_xO$ (x=0.01-0.05) solutions were prepared by sol-gel synthesis using metal-organic precursors. $Zn_{1-x}Y_xO$ thin films were grown on glass substrates by using sol-gel deep coating system. Y-doped ZnO thin films, annealed at 600 ℃, were observed in terms of the doping ratio effects on micstructural and optical properties. The surface morphologies of all samples were characterized by SEM and EDS. The crystal structures of the $Zn_{1-x}Y_xO$ films were characterized using 2θ-θ X-ray diffraction (XRD). Optical transmittance spectra of the Y-doped ZnO films were analyzed at room temperature by using a UV-NIR (Shimadzu-2101 PC). The structural and optical properties of the best quality films with dopant ratio are presented.
Keywords: Zinc oxide, Sol-gel, Thin films, ZnYO

1. INTRODUCTION
Zinc oxide (ZnO) and doped ZnO thin films have been gained a great interest because of their potential usage in many technological applications such as display materials, light emitting diodes (LED), gas sensor, solar cell, laser system, etc [1-3]. Therefore, ZnO films have been prepared by many groups using various methods. These methods include magnetron sputtering, sol-gel process, pulsed laser deposition spray pyrolyses, and metal organic chemical vapour deposition [2-4]. Among these methods, the sol-gel method has advantages which are continuous process at room temperature, inexpensive method, low cost and simplicity [1-5].
In this study, we have investigated processing, characterization, and sol-gel parameters (solution properties, withdrawal rate, drying, heat treatment, annealing condition), and optical properties with varying Y doping ratio of the $Zn_{1-x}Y_xO$ thin films on glass substrate using sol-gel coatings technique.

2. EXPERIMENTAL METHOD

The system $Zn_{1-x}Y_xO$ (ZYO) was prepared as solutions and polycrystalline powders with various compositions ($0.01 < x < 0.05$) by applying the sol-gel technique. Zinc Acetate (Fluka), Yttrium Acetate (Alfa Aesar) were used as precursor materials. Methanol was used as solvents. In order to improve adhesion of ZYO on the glass substrate, monoethanolamine was used in the solution. After weighting the appropriate amount of the constituents, they were all mixed with a magnetic stirrer for 8 hours at room temperature until transparent solution was obtained. Fig. 1 shows flow cart for the preparation of ZYO coatings on glass substrate.

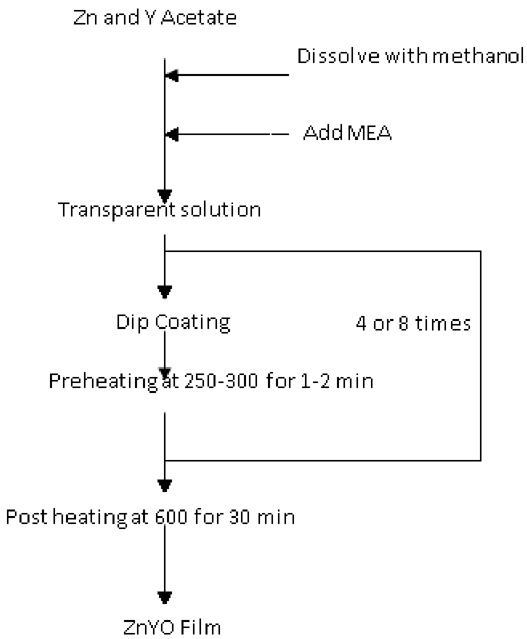

Fig. 1. Flow chart for the preparation and coating of ZYO solution on glass substrate

Glass substrates were cleaned in pure acetone and distilled water by using ultrasonic cleaner, respectively. ZYO films were growth on glass substrate using the sol-dip dip-coating technique at a varying withdrawal rate. Process was repeated 4-8 times in order to achieve thicker thin film. Then, samples were annealed at 600 °C for 30 min. X-ray diffraction profiles of powder samples and coating films were recorded using Rigaku difractometer with Cu K_α radiation. The data for powder and coating samples were collected at a room temperature over the range $20° < 2\theta < 80°$ in 0.02° 2θ step, with an integration time of 0.5 seconds. Surface morphology, thickness, and stochiometry of thin films were observed by using Scaning electron Microscope (SEM, Jeol), the Energy Dispersive Spectroscopy (EDS). Optical properties are measured by using a UV-NIR (Shimadzu-2101 PC)

3. RESULTS AND DISCUSSION

ZYO thin films were deposited on glass substrate using the sol-gel coating system as shown in Fig. 1. Y doped ZnO films were preheated from 250 to 350 °C for 1-2 min in vertical furnace. Then, samples were annealed at 600 °C for 30 min under air using box furnace. The quality of thin film depends on withdrawal rate, drying, heat treatment condition, and sol structure such as chemical composition, purity of precursor solvent catalyst materials and pH value of starting and stabilized solution [3-4].
XRD analysis were used to find phase and crystal structure of the samples. The X-ray diffractions of the Y-doped ZnO samples with varying ratios (x=0.00-0.05) at 600° C for 30 min in the air are shown in Fig.2. The obtained peak belong to the hexagonal lattice of ZnO, and second phase was not observed.

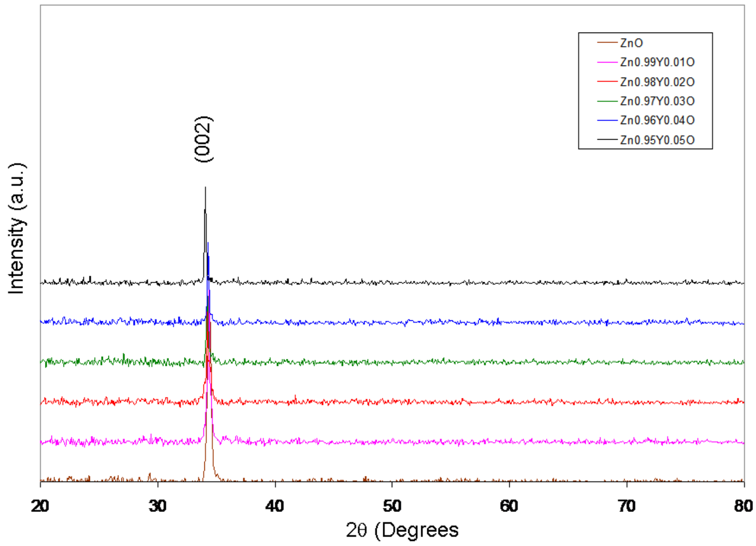

Fig.2. The x-ray diffraction patterns of the $Zn_{1-x}Y_xO$ thin films for x = 0.00, 0.01, 0.02, 0.04,and 0.05 running upwards.

The microstructure of $Zn_{1-x}Y_xO$ ($0.0 \leq x \leq 0.05$) were examined by SEM. Fig.3 depicts surface morphologies of ZnO thin film, As seen Fig. 3a and b surface are dense, without porosity, uniform, crack and pinhole free.

The film thickness was observed approximetly 230 nm. In Fig. 3d EDS spectrum of the ZnO is seen. Zn, O, and Si, peaks, belong to film and substrate, respectively were observed from spectrum.

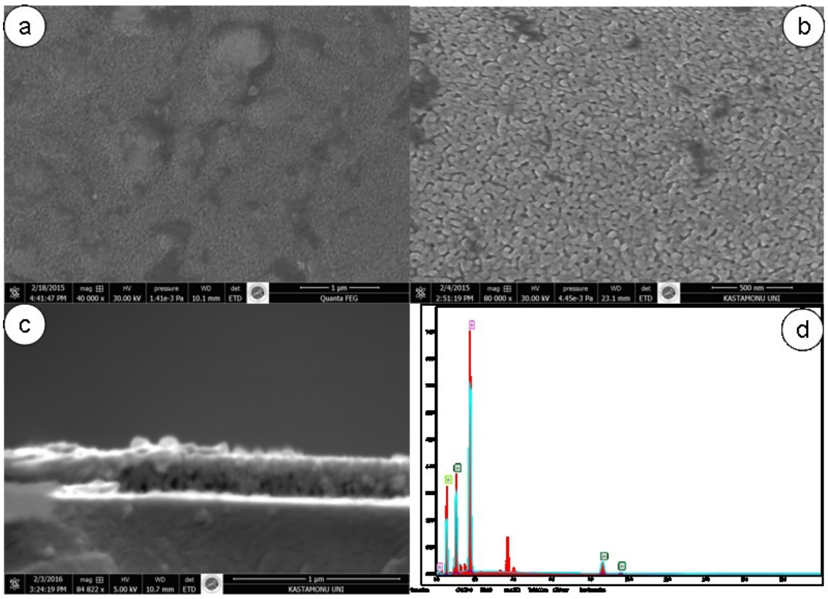

Fig. 3: SEM micrographs of a) and b) ZnO, c) Cross-section SEM micrograph d) EDS of ZnO film on glass substrate

Optical transmittance properties of ZnYO films were measured by means of a UV-NIR (Shimadzu-2101 PC). Optical transmittance of ZnYO thin films are shown in Fig. 4. Absorption edge is under 300 nm. Transmittance is increased by Y concentration rate.

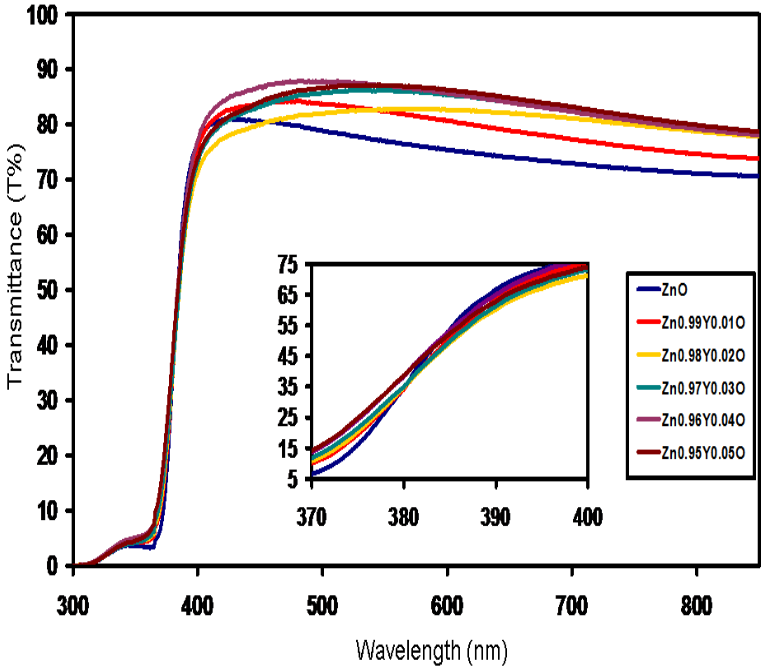

Fig. 4: Optical transmittance graph of ZnYO thin films with different Y doping ratio

4. CONCLUSIONS

$Zn_{1-x}Y_xO$ (x=0.00-0.05) thin films were growth on glass substrate by using sol-gel dip coating system. The main factor of the increment of thickness of the thin film was the number of dipping, withdrawal speed, and solution density. Crack free and thin film coating was produced. The monitored thin film surface by SEM tool was uniform on the glass substrate. Optical transmittance of ZYO films were observed over 85%.

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