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OPTICAL AND STRUCTURAL PROPERTIES OF Er DOPED ZnO THIN FILMS

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ABSTRACT
Optical and structural properties of Er doped ZnO thin films were studied. $Zn_{1-x}Er_xO$ (x=0.0, 0.01, 0.02, 0.04, and 0.05) precursor solutions were prepared by sol-gel synthesis using Zn, and Er acetates which were dissolved into solvent and chelating agent. $Zn_{1-x}Er_xO$ thin films with different concentration were produced on glass substrate using sol-gel dip coating. Thin films were annealed at 600°C temperature for 30 minutes, were tried to observe the effect of doping ratio on mentioned properties. The surface morphology of the $Zn_{1-x}Er_xO$ films depend on substrate nature and sol-gel parameters such as withdrawal speed, drying, heat treatment, deep number (film thickness) and annealing condition by using scanning electron microscope. It was observed that surface morphologies of Er doped ZnO thin films are dense, without porosity, crack and pinhole free. The particle size, surface morphology, optical and structural properties of the thin films are presented.
Keywords: Sol-gel Chemistry, Microstructure, Thin Films

1. INTRODUCTION
Due to its potential in technological applications, there's an intense study on Zinc oxide (ZnO) in energy and electronics area like transparent conductive electrodes, displaying devices, LED's, gas sensors, solar cells, laser systems etc. ZnO and doped ZnO films and nanostructures have been prepared by many groups by various methods such as sputtering, PLD, molecular beam epitaxy, hydrothermal etc. Among these methods, the sol-gel methods have advantages such as application in ambient atmosphere, low cost and simplicity [1-5].
In present work the effect of Er doping on ZnO structure was investigated. ZnO and Er doped ZnO films deposited on glass substrate using sol-gel dip coating method and the effects of doping on optical transparency and microstructure are observed.

2. EXPERIMENTAL PART
The mixed oxides $Zn_{1-x}Er_xO$ were prepared as polycrystalline nano particle powders with various compositions ($0.0 \leq x \leq 0.05$) using sol-gel technique. Zinc acetate dihydrate ($C_4H_6O_4Zn{\cdot}2H_2O$) and Er 2, 4 pentanedionate ($Er(CH_3COCHCOCH_3)_2$) were used as precursor materials and methanol

(CH_3OH), and monoethanolamine (MEA) are used as solvent and stabilizer. The appropriate weighing amount of the Zn and Er were put all together in a Pyrex container and dissolved in methanol. Following this, MEA was added to containing solution in order to improve the adhesion on the glass substrate. They mixed with a magnetic stirrer at room temperature until a transparent solution was obtained. Powder samples were prepared by gelling and drying of sol–gel derived precursor's solutions in a beaker. After that powders were preheated at different temperatures (300-400 °C) for 10 min. The obtained powders were ground and annealed at 600 °C using box furnace. Glass substrates were cleaned in pure acetone and distilled water by using ultrasonic cleaner, respectively. ZnErO films were growth on glass substrate using the sol-gel dip coating technique at a varying withdrawal rate. XRD scans were recorded using a Rigaku diffractmeter with Cu K_α radiation. Microstructure properties of prepared samples were observed using scanning electron microscope (SEM) (JEOL, JSM-5910LV). The thermal behaviour of the xerogels of ZnErO solutions were studied by using thermogravimetric analysis (TGA)/SII 7300 Extar thermal analyser system in air with a heating rate of 10 °C/min. PG Instruments model UV–Vis–NIR spectrophotometer is used to determining the optical properties.

3. RESULTS AND DISCUSSION

The thermal behaviors of the exrogels are analyzed by using TGA to find the heat treatment temperatures of the polycrystalline nano particle powders and thin films. Fig. 1 shows the TG chart for the ZnErO exrogels which are obtained by drying the sol-gel solution at room temperature in air for 3 days. The ZnErO exrogels were analyzed in the temperature range between 23 and 1000 °C in air. The first weight decrease due to removal of the solvent and evaporation of volatile organic component is seen at 100 °C as shown in Fig. 1. The percentage of lost weight was 18%. The Carbon–based materials were burn out the second weight decrease was observed at 110-300 °C. The percentage of lost weight was 50 %. The oxidation was started around 300 °C and finished around 600 °C. The third weight decrease with 15 % at 600 °C.

The transmittance-wavelength graph of the Er doped ZnO thin films are shown in Fig.2. According to the optical transmission spectrum, a sharp absorption is observed in the wavelength range between 360-400 nm. It is observed that the average optical transmittance is about 81% in the visible region. The average transmittance values of all doped ZnO films are higher than un-doped ZnO thin film.

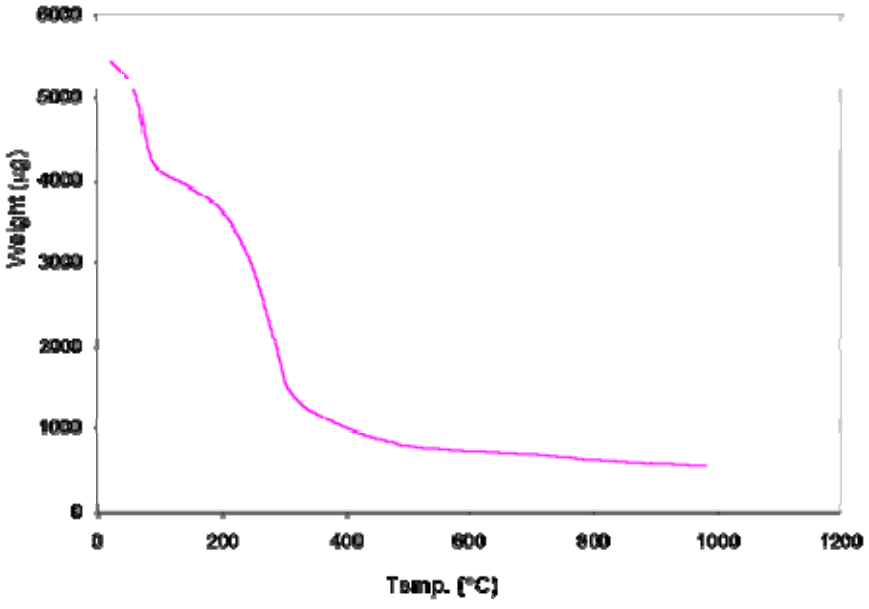

Fig.1. TGA curve of the ZnErO exrogels

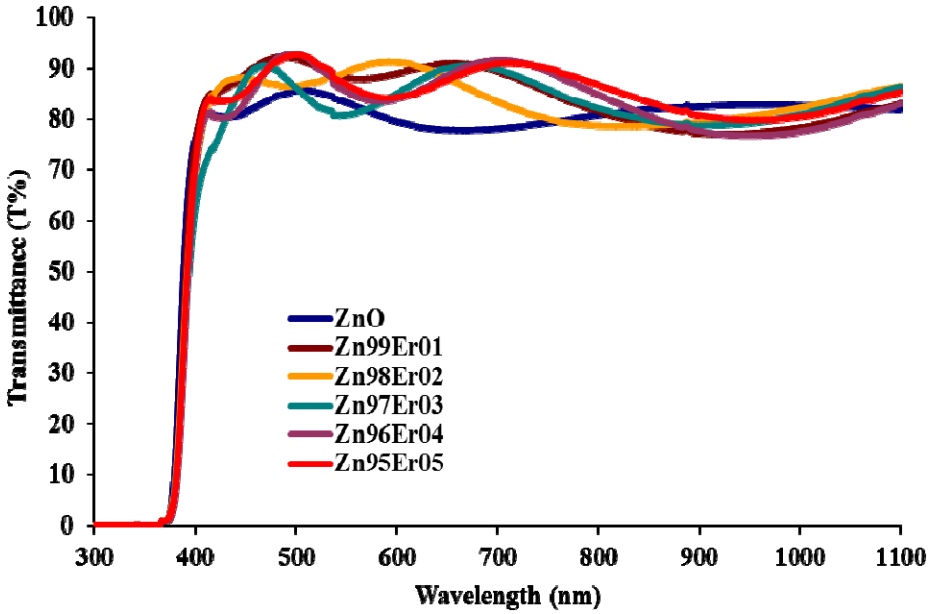

Fig.2. Optical transmittance spectra of ZnO and Er doped ZnO thin films

ZnErO thin films were deposited on glass substrate using the sol-gel dip coating system. 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.

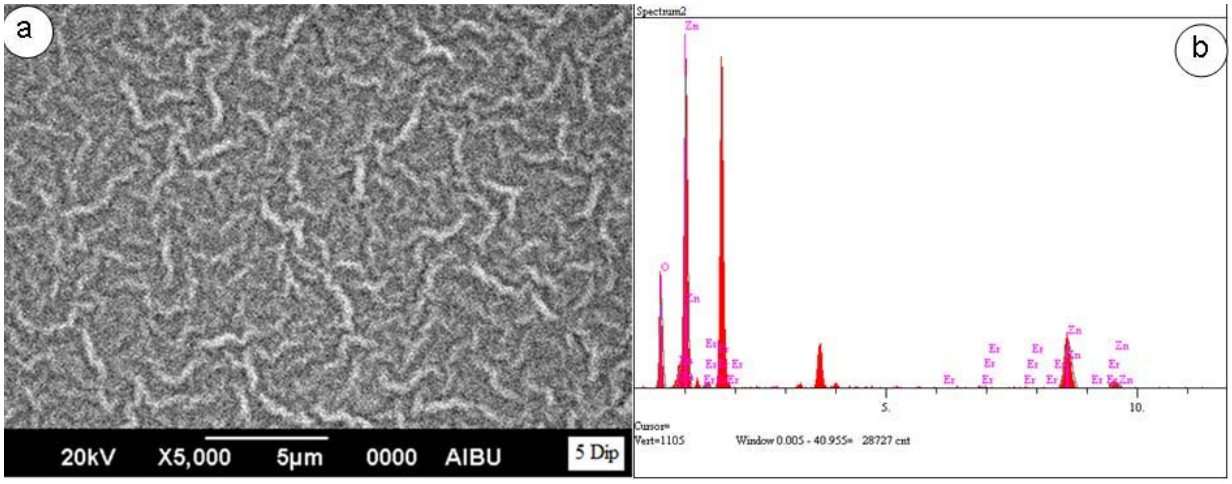

Fig.3 a) SEM micrograph *Fig.3 b) EDS of 5 dip $Zn_{0.98}Er_{0.02}O$ thin film at 600 ℃ for 30 min.*

Fig. 3a depicts morphologies of ZnErO thin films. As seen Fig. 3a surface is dense and without crack and porosity. Thickness of the coating was controlled by viscosity of solution, number of dipping, changing withdrawal rate and temperature of the furnace. Zn and Er peaks are clearly seen in figure 3b. Zn and Er contents are the same as those in the preparation of samples.

4. CONCLUSIONS

ZnErO thin films were coated on the glass substrate using sol-gel dip coating system. The thickness of the Er doped ZnO thin film increases by increasing the number of dipping, withdrawal speed, and solution density. Dense and crack free thin film was produced. When the results are evaluated, the optical and structural properties strongly depend on the growth condition.

Acknowledgements

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