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Studies on the OPTICAL Constants of K and Fe Codoped Zno Thin Films Prepared by Chemical Bath Deposition Technique

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***Abstract*— ZnO: K: Fe_x (x=1, 2, 3 and 4%) codoped ZnO thin films were prepared on glass substrate by chemical bath deposition technique at room temperature. The X-ray diffraction pattern was recorded for the codoped thin films and it showed hexagonal wurtzite structure without any unwanted phases. The morphological analysis (FESEM) revealed that the surface of the thin films was altered by the doping materials. The optical transmittance was recorded for the deposited thin films and the observed change in the transmittance was due to film thickness. The optical constant such as refractive index and dielectric constant were determined for codoped ZnO thin films from transmittance data.**

Keywords- codoped ZnO, Surface Morphology, Optical constant.

I. INTRODUCTION

Zinc oxide is a n-type semiconductor with large binding energy (60meV) and wide band gap (3.37eV).Recently ZnO has offered numerous applications such as solar cell, transistor, varistors, UV light emitting diode, transparent electronic device [1]. Undoped and doped ZnO thin films have been developed by sputtering, pulsed laser deposition, chemical bath deposition, metal-organic chemical vapor deposition and atomic layer deposition techniques [2-6]. Optical and Magnetic properties were improved by various doping materials to ZnO. The group I elements such as Li, Na and K are used as doping materials for improve and tune the optical and magnetic properties of ZnO. These doping elements will act as a donor during the incorporation into ZnO lattice. Santa Chawla et al studied the ferromagnetism for Li-doped ZnO thin films [7]. S. Ghosh et al reported that the K element has enhanced the magnetic properties in ZnO [8]. These potential alkali metals have been widely considered for doping in ZnO semiconductor.

The transition metals have also been studied to understand the optical and magnetic properties of ZnO. Materials such as Ti, V, Co, Cu, Mn, Ni doped ZnO thin films were synthesized for enhancing the optical and magnetic properties of ZnO thin film [9, 10]. In recent years, the dual doped ZnO thin films such as Mn-Li doped ZnO, Fe/Cu, Li-N, Cu-Co, Mn -Co ,Al-Cu and N-Al codoped ZnO thin films have been reported for optical and magnetic applications [11-17]. We report first time developed, Fe with K-doped ZnO thin films have not been prepared on glass substrate for optical and magnetic behavior by chemical bath deposition technique.

We report the development of dual doped ZnO thin films on glass substrate by chemical bath deposition technique. Because, the chemical bath deposition is widely adopted due to its simple procedure and it has some advantages (low cost and large area coating) than other methods. The dual ZnO thin films have characterized by X-ray diffractometer, field emission scanning electron microscope and UV spectrometer. The optical constant was also investigated for codoped ZnO thin films.

II. EXPERIMENTAL WORK

Codoped (K, Fe) ZnO films were synthesized by chemical bath deposition method. Here, $ZnCl_2$ (AR MERCK), KOH (AR MERCK), KCH_3COO (AR MERCK) and $FeSo_4.7H_2O$ (AR MERCK) were the precursor materials and doping source materials respectively. Initially, $ZnCl_2$ and KOH were dissolved in the triple distilled water with 1:1 ratio and stirred using magnetic stirrer at 60°C for 10 minutes .Then one percentage of potassium acetate was added in 1:1 ratio prepared homogeneous solution. After that, different percentages of Fe (1 at. %, 2 at %, 3 at % and 4 at %) were added to the solution for doping. In the synthesized homogenous solution, HCl is added to maintain the pH at 8. The solution was cooled to room temperature and micro glass slide was used as substrate. The substrate was cleaned by HCl, acetone and double distilled water. Then the cleaned substrate was immersed vertically in the solution using substrate holder. Finally, the solution was steadily stirred by magnetic stirrer to obtain the uniformly coating on the substrate. After 45 minutes of deposition, the uniform coated substrates were taken out from the solutions and cleaned with double distilled water and then dried in air. Finally, thin films are kept in the furnace and calcined at 400°C for 1 hour.

III. RESULTS AND DISCUSSION

A. X-ray diffraction

The structures of codoped ZnO thin films were analysized by X-ray diffractometer. Fig (1) shows the XRD pattern of codoped ZnO films and all the films have hexagonal wurtzite structure. For all the doping concentrations, the prominent peaks at (100), (002) and (101) are obtained in the XRD pattern (PDF # 891397, 890510). For ZnO:K(1%) thin film, the prominent peaks are reported on shan et al [4].The peak position was shifted to higher angle for 2, 3 and 4% Fe concentrations due to low ionic radius..

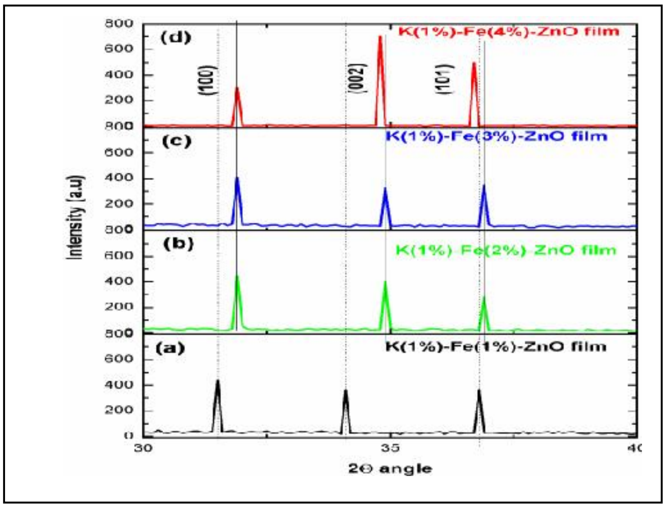

Figure 1. X-ray diffraction pattern of (K (1%), Fe) Co- doped ZnO for Fe concentrations (a) 1% (b) 2% (c) 3% and (d) 4%.

B. Surface Morphology

The surface morphology of codoped ZnO thin films were analysized and shown in fig (2). The morphology of all films is varied with respect the doping concentrations. For grain shape morphology were observed for 1 and 3 % Fe, agglomeration was observed for 2 % Fe and slightly hexagonal shape was obtained for 4 % Fe. The chemical compositions of thin films such as Zn, O, K , Fe and substrate peak were confirmed by energy dispersive analysis x-ray spectroscopy.

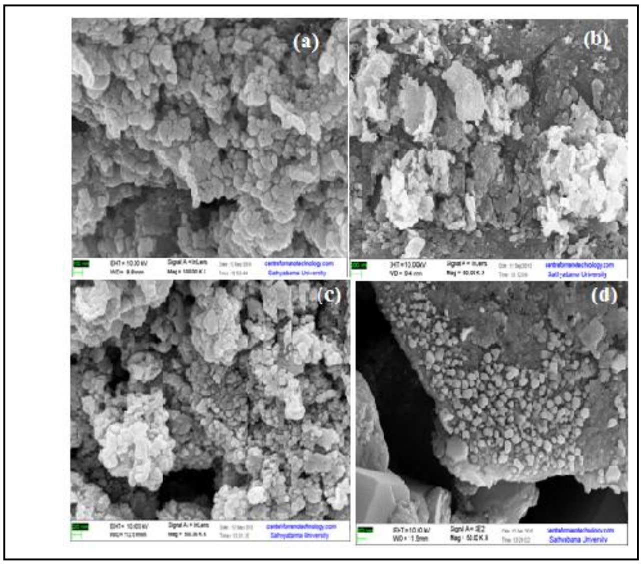

Figure 2. Surface morphology of (K (1%), Fe) Co- doped ZnO for Fe concentrations (a) 1% (b) 2% (c) 3% and (d) 4%.

C. Optical Transmittance

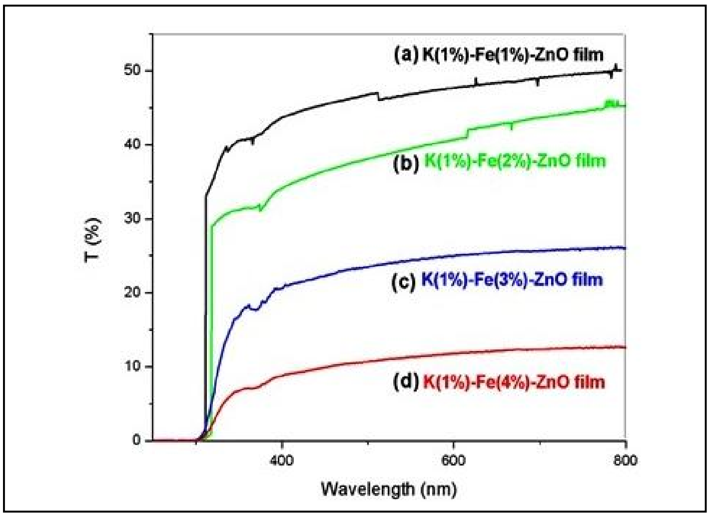

Figure 3. Optical transmittance of (K (1%), Fe) Co- doped ZnO for Fe concentrations (a) 1% (b) 2% (c) 3% and (d) 4%

Fig (3) shows the optical transmittance of codoped ZnO thin films with various doping concentrations. It is evident that all the codoped thin films exhibits different percentages of transmittance in the visible region. The transmittance are 50 %, 45%, 25% and 10% for 1, 2, 3 and 4 % Fe concentrations respectively. The low transmittance occurred due to the film roughness, scattering of light and lattice defects of the thin film material [20].

D. Refractive index

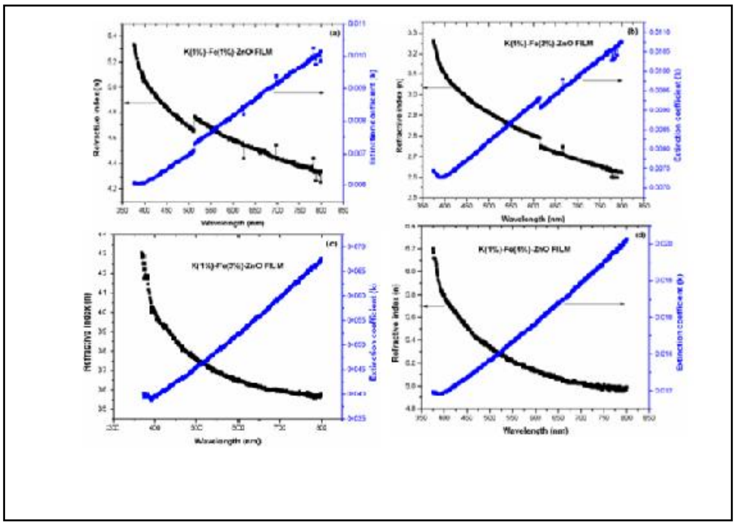

Figure 4. Refractive index of (K (1%), Fe) Co- doped ZnO for Fe concentrations (a) 1% (b) 2% (c) 3% and (d) 4%.

Fig. (4) shows, refractive index of films are determined using the following formula.

$$n=((1+R)/(1-R))+\sqrt{(4R/(1-R)^2 - k^2)} \quad (1)$$

$$k = \alpha\lambda/4\pi \quad (2)$$

The refractive index behavior of ZnO thin films were explained by light dispersion on optical medium. Fig (4) shows the refractive index of codoped ZnO thin films. The different refractive index values were observed for all the Fe concentrations. In the UV region, refractive index are 5.3, 3.2, 4.3and 6.2 for 1, 2, 3 and 4 % Fe respectively. In these thin film surfaces,the visible light is normally dispersed on through the film medium due to the contribution of virtual electronic transition [23].

E. Dielectric constant

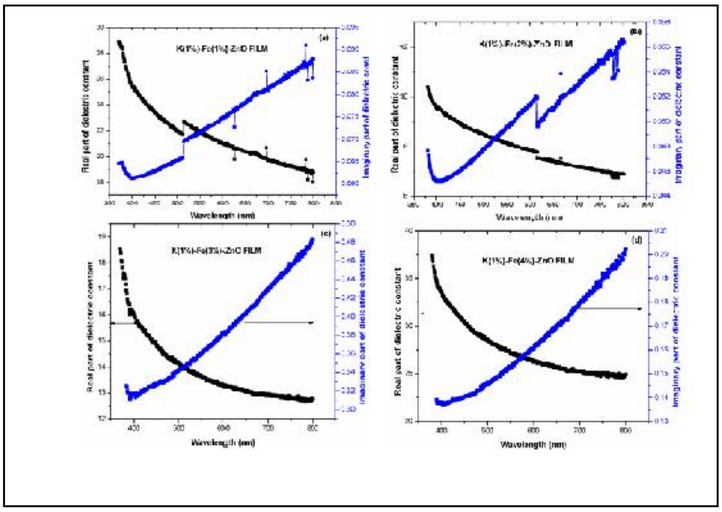

Figure 5. Dielectric constant of (K (1%), Fe) Co- doped ZnO for Fe concentrations (a) 1% (b) 2% (c) 3% and (d) 4%.

$$\varepsilon_r = n^2 - k^2 \qquad (3)$$

$$\varepsilon_i = 2nk \qquad (4)$$

Naturally, the dielectric constant parts are similar to index of refraction because of the absolute index of refraction are corresponding to dielectric constants. In the visible region, the real part of dielectric reduces and increased in ultraviolet region similarly index of refraction. The doping element is involved in ZnO lattice site and it reveals the interaction between photons and electrons [23].

IV. CONCLUSION

In the current work, codoped (K, Fe) ZnO thin films were successfully synthesized on glass substrate by chemical bath deposition technique. The X-ray diffraction analysis confirms the hexagonal crystal structure of ZnO thin films. The grains of hexagonal morphology were observed for different Fe ion concentrations. The average thin film surface roughness decreases with the increase in Fe ion concentration. The optical transmittance decreases due to the film thickness. The optical constant such as refractive index and dielectric constant reveals the optical behavior of thin films and the low extinction coefficient value indicates the quality of the thin film.

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