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NiZnO nanocomposite thin films deposited by a novel technique: magnetic spin coating

Sinan Temel^{1, a)}, Elif Yaman^{1, b)}, Fatma Özge Gökmen^{1, c)}

¹*Bilecik Şeyh Edebali University, Central Research Laboratory, Gulumbe Campus, Bilecik, TURKEY*

^{a)}Corresponding author: sinan.temel @bilecik.edu.tr

^{b)}elif.yaman@bilecik.edu.tr

^{c)}fatmaozge.gokmen @bilecik.edu.tr

Abstract. ZnO-NiO nanocomposite thin films have been deposited by magnetic spin coating technique at different mixing concentrations. Magnetic spin coating technique is a novel thin film deposition technique in which a sol-gel solution is used and the substrate rotation is made magnetically. The crystal structures of the thin films have been investigated by X-Ray Diffraction (XRD). The crystallinity of obtained nanocomposite thin films improved with increasing doping concentration and the grain size values increased. The surface morphologies of the nanocomposite thin films have been studied by field emission scanning electron microscopy (FESEM). With the increase of the doping, it has been appeared that the grains of NiO structure increased on the surface. The optical properties of nanocomposite thin films have been investigated by using ultra-violet-visible (UV-Vis.) spectroscopy. It has been observed that as the doping concentration increases, the optical band gap energy is widened.

INTRODUCTION

Zinc oxide (ZnO) thin films are widely used for experiments because they are environmentally sensitive, free of toxic substances [1], easily accessible, useful and cost effective. The new generation of semiconductor ZnO thin films have many uses such as gas sensors [2], organic waste water treatment [3], optoelectronic devices [4]. Also, recently there is growing interest in nickel oxide (NiO) thin films because of its magnetic, catalytic, electrochemical and optical properties [5]. NiO thin films are widely used in chemical and magnetoresistance sensors and electrochromic devices [6-8]. ZnO thin films can have different properties by doping with the help of transition-metal elements. NiO is an important dopant to enhance and control the structural, morphological and optical performance of the ZnO [9].

NiZnO thin films can be obtained by many techniques such as, laser etching [10], spray pyrolysis [11], magnetron sputtering [12], chemical bath deposition [13] and sol-gel techniques [14]. In this study, NiZnO thin films were produced with the low-cost sol-gel magnetic spin coating method which will be used for the first time in the literature. Magnetic spin coating method is a new thin film deposition method in which a sol-gel solution is used and the substrate rotation is made magnetically. The structural, morphological and optical properties of the thin films were examined and the effects of the doping were determined.

EXPERIMENTAL DETAILS

In this study, microscope slides were used as substrate for thin film deposition. Microscope slides were cut as 10mm x 10mm. The glass substrates were cleaned following the necessary procedure and made suitable for film coating.

The sol-gel solution, which would be used to produce NiZnO thin films, was prepared as 0.5 M. For this sol-gel solution, zinc acetate dehydrate (ZnAc), nickel (II) nitrate hexahydrate (NiN) 2-methoxyethanol as the solvent and monoethanolamine (MEA) as the stabilizer were used. ZnAc and NiN of 0.5M were mixed together in different nominal solution volume ratios to obtain thin films and named as shown in the Table 1.

TABLE 1: Nomenclature of series.

Solution	Series
$\text{Ni}_{(0)}\text{ZnO}_{(1)}$	NZO1
$\text{Ni}_{(0.25)}\text{ZnO}_{(0.75)}$	NZO2
$\text{Ni}_{(0.50)}\text{ZnO}_{(0.50)}$	NZO3
$\text{Ni}_{(0.75)}\text{ZnO}_{(0.25)}$	NZO4
$\text{Ni}_{(1)}\text{ZnO}_{(0)}$	NZO5

The solutions were stirred at 60 °C. The substrates were placed on the sample holder and were rotated at a speed of 2000 rpm for 30 s. Immediate drying after successive coating was done at 150 °C for 10 min. This process was repeated 9 times. The films were finally annealed at 500 °C for 1 h in air for crystallization. The structural, morphological and optical properties of obtained thin films were characterized by using X-ray diffraction (XRD) method, field emission scanning electron microscopy (FESEM) and UV-Vis. Spectroscopy and the effects of doping were investigated.

RESULTS AND DISCUSSION

The crystal structures of the thin films have been investigated by Panalytical Empyrean X-Ray Diffraction (XRD). Fig. 1 shows comparative XRD analysis spectra of undoped ZnO and doped AZO thin films.

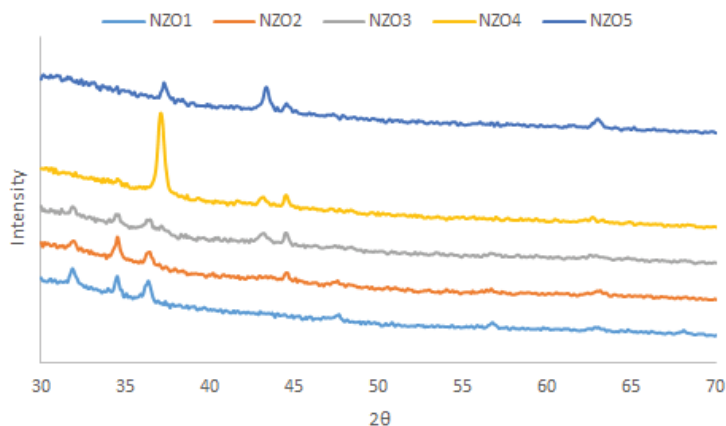


FIGURE 1. XRD spectra of NiZnO thin films.

As seen from the XRD spectra, all series are polycrystalline. In the NZO1 series 5 peaks of the hexagonal ZnO structure (010), (002), (011), (012) and (110) are observed respectively. With the increase of the doping amount, the peak belonging to cubic NiO structure (104) was observed in NZO2 series at 44.58°. In NZO3 series, by increasing the doping amount to 50 %, the peaks (012) at 43.17° and (104) of cubic NiO structure and (101) peak of hexagonal NiOZn structure at 37.40° were observed in addition to the peaks of hexagonal ZnO. In NZO4 series the peak intensity of (101) NiOZn increased significantly as the doping ratio increased to 75 %. In NZO5 series 4 peaks of the cubic NiO structure (003), (012), (104) and (110) are observed respectively. In the NiZnO structure, while NiO dopant value varies from 0 to 1, it is observed ZnO, NiO and related complex structures depending on the NiO dopant value. The crystal structure changes from wurtzite (ZnO) to cubic (NiO) structure.

ZEISS Supra 40VP field emission scanning electron microscope (FESEM) was used to examine the morphological properties of the obtained films. Fig. 2 shows FESEM images at 30 kx magnification of NiZnO thin films.

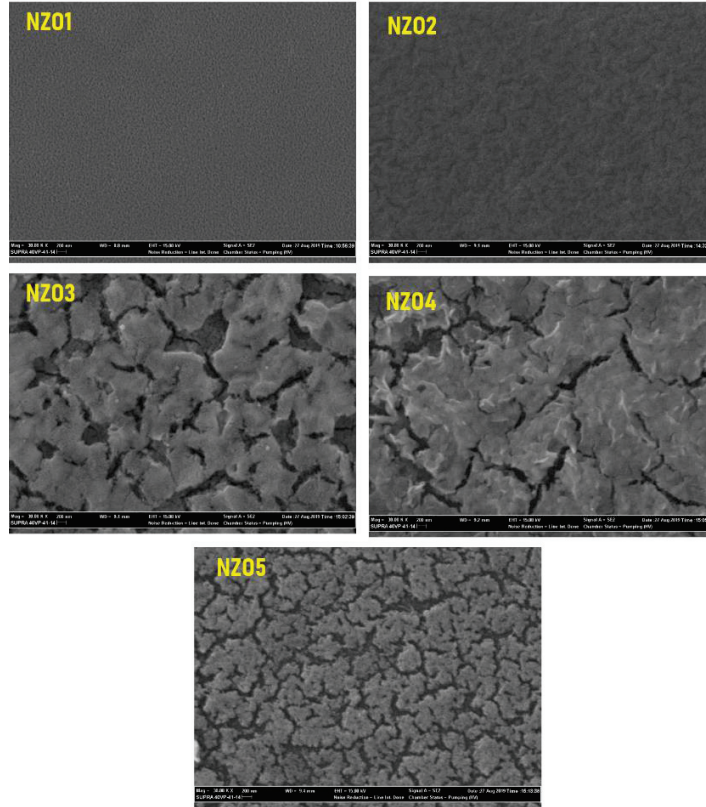


FIGURE 2. FESEM images of NiZnO thin films.

It is observed that the surface morphology of the films changes depending on the increase in Ni concentration. As the Ni content increases, together with the decrease in the crystallite size was also observed the aggregations on the surface. With the increase of the doping, it has been appeared that the grains of NiO structure increased on the surface.

UV-Vis Spectroscopy measurements were performed on the Perkin Elmer Lambda 25 device in the wavelength range of 300 - 1100 nm to examine the optical properties of the films obtained. By using the absorption spectrum data obtained from UV-Vis Spectroscopy measurements, the band gap values of the films were determined by Tauc Method [15]. The band gap values are given in Table 2. As shown in the table, band gap values vary from 3.31 eV to 3.81 eV with NiO concentration. While the band gap values in NZO1 series was 3.31 eV, this value started to increase with Ni doping. As the amount of doping increased, the value of the band gap increased. These results are consistent with the values found for NiZnO thin films in the literature.

TABLE 2: Band gap values of NiZnO thin films.

Series	Band Gap (eV)
NZO1	3.31
NZO2	3.35
NZO3	3.48
NZO4	3.67
NZO5	3.81

CONCLUSION

NiZnO thin films have been deposited by magnetic spin coating method which is used for the first time in the literature and the microstructural, morphological and optical properties of thin films have been investigated. In the

NiZnO structure, while NiO dopant value varies from 0 to 1, it is observed ZnO, NiO and related complex structures depending on the NiO dopant value. The crystal structure changes from wurtzite (ZnO) to cubic (NiO) structure. The surface morphology of the films changes depending on the increase in Ni concentration. As the Ni content increases, together with the decrease in the crystallite size was also observed the aggregations on the surface. With the increase of the doping, it has been appeared that the grains of NiO structure increased on the surface. It has been observed that as the doping concentration increases, the optical band gap energy is widened. These results are consistent with the values found for NiZnO thin films in the literature. As a result of these investigations, it has been determined that NiZnO thin films can be produced successfully by the magnetic spin coating method.

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REFERENCES

1. P. Kanmani and J.-W. Rhim, *Carbohydrate Polymers*, **106**, 190-199 (2014).
2. T. Bhowmick, A. Banerjee, S. Nag, and S. B. Majumder, *IEEE Sensors*, 1–4 (2018).
3. C. Yu, W. Zhou, H. Liu, Y. Liu, and D. D. Dionysiou, *Chemical Engineering Journal*, **287**, 117-129 (2016).
4. C. Ling et al., *J. Alloys Compd.*, **797**, 1224-1231, (2019).
5. Q. Yang, J. Sha, X. Ma, D. Yang, *Mater. Lett.* **59**, 1967–1970, (2005).
6. U.S. Joshia, R. Takahashia, Y. Matsumotoa, H. Koinuma, *Thin Solid Films*, **486**, 214–217, (2005).
7. S.H. Lin, F.R. Chen, J.J. Kai, *Appl. Surf. Sci.*, **254**, 3357, (2008).
8. H. Sato, T. Minami, S. Tanaka, T. Yamada, *Thin Solid Films*, **236**, 27, (1993).
9. A.A.M. Farag, M. Cavas, F. Yakuphanoglu and F.M. Amanullah, *J. Alloys Compd.*, **509**, 7900–7908, (2011).
10. J. A. Guerrero de León et al., *SN Appl. Sci.*, **1(5)**, 475, (2019).
11. Y. M. Hunge, A. A. Yadav, S. B. Kulkarni, and V. L. Mathe, *Sensors Actuators, B Chem.*, **274**, 1-9, (2018).
12. H. Zhu, X. Niu, M. Wan, and Y. Mai, *Vacuum*, **161**, 297–305, (2019).
13. R. Shabannia and A. M. Selman, *Chinese J. Phys.*, **55(6)**, 2218–2223, (2017).
14. J. Li, J. Xu, Q. Xu, and G. Fang, *J. Alloys Compd.*, **542**, 151-156, (2012).
15. J. Tauc, “Amorphous and liquid semiconductors”, Plenum, New York, (1976).