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Preparation and Characterization of Ni Added ZnO Thin Film by Sol-Gel Spin Coating Techniques

S. Senthilkumar, A. Rajendran

S. Senthilkumar
Department of Physics, Nehru Memorial College, (Autonomous), Puthanampatti, Tiruchirappalli, Tamilnadu India -621007.

A. Rajendran
Department of Physics, Nehru Memorial College, (Autonomous), Puthanampatti, Tiruchirappalli, Tamilnadu India -621007.

Corresponding author:
A. Rajendran
Department of Physics,
Nehru Memorial College, (Autonomous),
Puthanampatti, Tiruchirappalli,
Tamilnadu India -621007

E-mail: neelrajnmc@gmail.com

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Abstract

Pure and Ni added zinc oxide thin films were prepared by sol-gel method using spin- coating technique on glass substrates. The influences of nickel on ZnO thin films are characterized by Powder X-ray diffraction study. Pure and Ni added thin films are hexagonal wurtzite structure without any secondary phase in c-axis orientation. The SEM images of thin films show uniform sphere like particles covered completely on glass substrates. All the films exhibit transmittance of 85-95% in the visible range up to 800nm and cut-off wavelength observed at 394 nm corresponding to the fundamental absorption of ZnO. The photoluminescence property for pure and Ni added ZnO thin films has been studied and results are presented in detail.

Keywords: Sol-gel method, Scanning electron microscopy, Powder diffraction.

INTRODUCTION

Zinc oxide (ZnO) is considered as the most promising semiconductor material for the fabrication of ultraviolet (UV) light-emitting diodes and laser diodes and it has been extensively investigated in recent years because of its wide band gap value of 3.37 eV and large exciton binding energy of 60 meV at room temperature. The realization of p-type conduction is very important for ZnO applications in optoelectronic devices and there are reports on the electrical property of the first group element-doped ZnO thin films [1]. Various techniques such as pulsed laser deposition, magnetron sputtering and molecular beam epitaxy have been used to deposit thin films of ZnO. The sol – gel method has been receiving high attention due to its advantages such as low cost, simple deposition procedure, easier composition control, low processing temperature and easier fabrication of large area films. In this paper, we report the deposition and characterization of nickel added ZnO thin films by sol – gel spin-coating method and also the effect of nickel on the structure, morphological and optical characteristics of the ZnO thin films were analyzed and discussed.

SYNTHESIS OF MATERIALS

For the synthesis of Ni-ZnO, zinc acetate dihydrate was used as a starting material; DEA as stabilizer and the nickel source is added from [Ni ($CH_3COO.6H_2O$]. Required amount of zinc acetate dihydrate and 3 wt% of nickel acetate were dissolved in propanol solution and DEA used as a stabilizer at room temperature. The resultant solutions were allowed to maintain at 60˚C for 2 hours under stirring. The different homogeneous solutions were used for preparing films by spin coating method. The ZnO thin films were deposited at the rate of 3000 rpm for 30 sec time duration, and then the films were preheated at 300˚C for 10 min using hot plate to evaporate the solvent and removable organic residuals. The coating procedure was repeated for 5 times. Finally, the dried films were annealed at 500˚C in air atmosphere to obtain pure and Ni added ZnO thin films.

RESULTS AND DISCUSSION

Fig.1 shows the X-ray diffraction spectra for pure and Ni added ZnO thin films. This XRD spectrum reveals that all the obtained films are polycrystalline phase with hexagonal wurtzite structure (JCPDS card no. 89-0510).

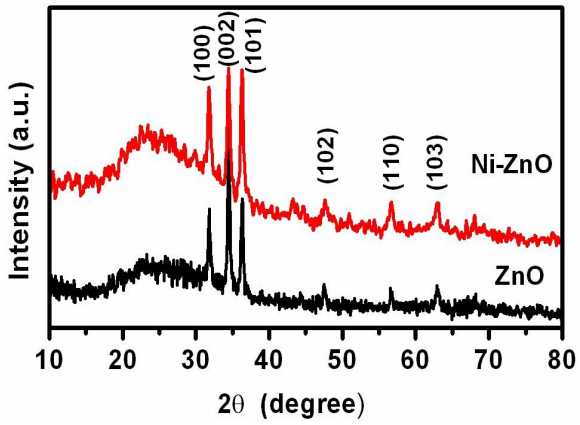

Figure 1: XRD patterns of pure and Ni added ZnO thin films.

It is found that the pure and Ni admixtured thin layers show peaks corresponding to (100), (002) and (101) planes. All the peaks are matched with the reported values of the hexagonal ZnO structure. The intensity of the peak corresponding to the (002) plane is much stronger than that of the (100) and (101) plane in the pure ZnO. This suggests that the c -axis of the grains are uniformly perpendicular to the substrate surface. The XRD pattern of nickel-added layer is dominated by (002) plane with low intensity. Ni^{2+} ions are incorporated as Zn^{2+} substitution in interstitial positions of ZnO thin films.

The SEM images of pure and Ni added ZnO thin films are shown in fig. 2. It could be seen that the surface morphologies of these films are more homogeneous, dense and the granules distribute more uniformly in the films.

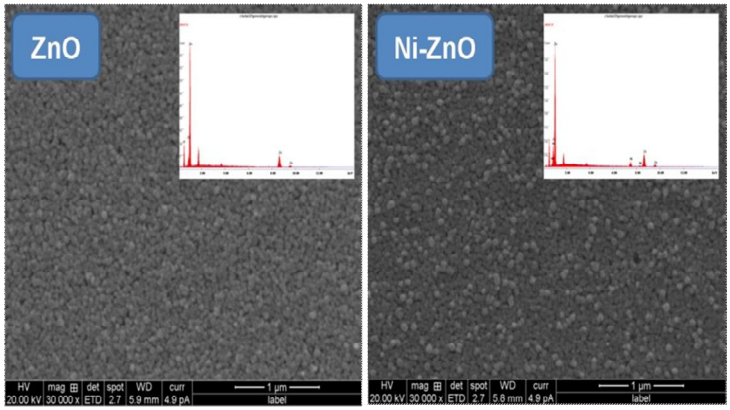

Figure 2: SEM with EDS spectrum of pure and Ni added ZnO thin films.

The energy dispersive X-ray spectrums of samples are shown in the inset of Figure 2. It explores that the material is only composed of Zn and O atoms in pure ZnO and the presence of Ni is confirmed in Ni added ZnO thin film. The optical spectrum displays that, all the films exhibit high transmittance in the visible range shown in Figure 3.

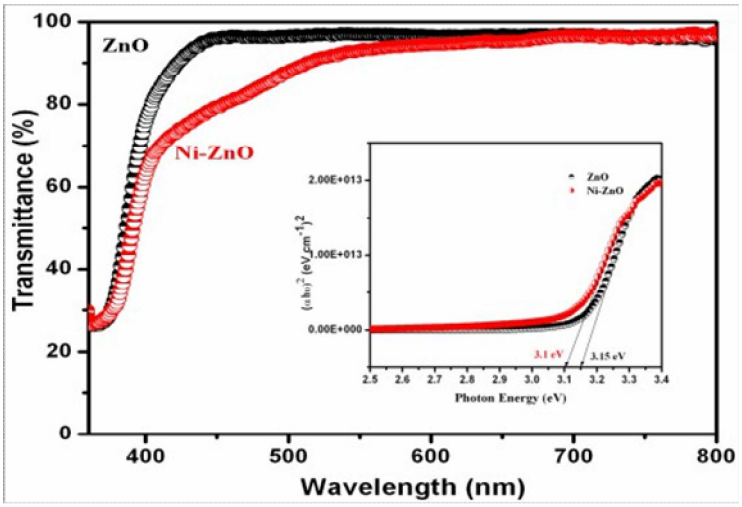

Figure 3: Optical transmission and Tauc's plot spectra (inset) of the Pure and Ni added ZnO thin films.

An abrupt absorption edge observed at around 394 nm in pure ZnO. The characteristic Ni absorption centered at around 400 nm is found from the Ni admixture ZnO thin film. The calculated optical gap of the thin films is found to be 3.15 eV for pure ZnO and 3.1 eV for 3 wt% of Ni added ZnO. This blue shift of the absorption on the Ni added ZnO thin films can be explained by assuming that the highest states in the conduction band, well known as the Burstein-Moss effect [2].

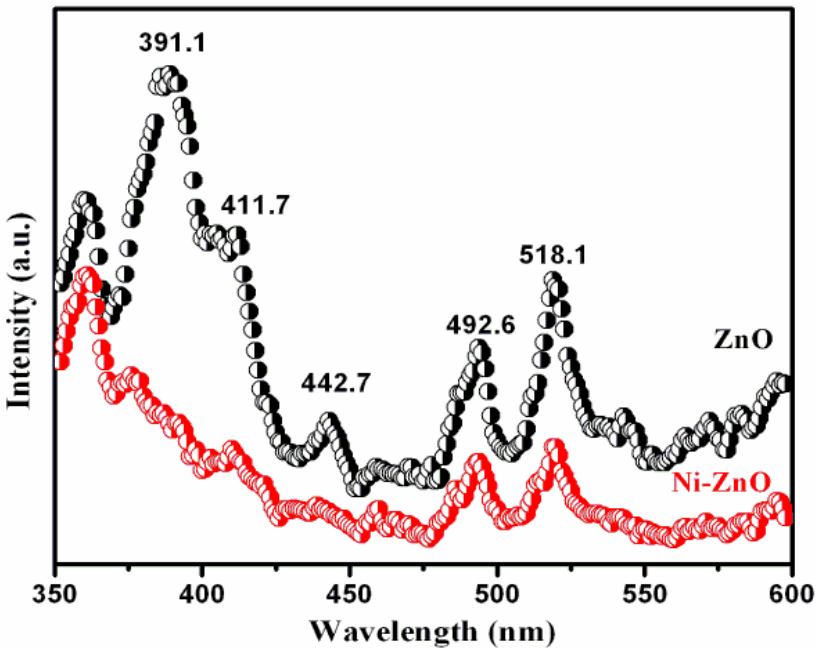

Figure 4: Photoluminescence spectra of pure and Ni added ZnO thin films.

Fig. 4 gives the photoluminescence spectra of pure and Ni admixture ZnO. The UV emission peak of ZnO thin film observed at 391 nm (3.15 eV) corresponding to the near band-edge emission of ZnO. The violet emission peaks is observed at 411 nm (3.02 eV). The emission peaks found at 443 nm (2.80 eV) and 494 nm (2.51 eV) corresponds to blue emission, the peak It was reported that the visible emissions are related to several intrinsic defects in ZnO materials such as Zn (Zn_i), interstitial O (O_i), and substitution of O at Zn position (O_{Zn}) [3]. In the NBE emissions, some shifts are occurring due to the dopant content of Ni^{2+} ions substituted in Zn^{2+} ions.

CONCLUSION

The pure and Ni added ZnO thin films were deposited on glass substrate using spin coating method. The thin films were characterized structurally by means of X-ray diffraction. The film exhibited a polycrystalline nature with hexagonal wurtzite structure. The morphological study was carried out by SEM analysis, and EDS spectrum confirmed the presence of Ni in ZnO thin films. The optical studies by UV-Vis and PL analysis indicate the absorption centered at 400 nm and the occurrence of peak shift due to the addition of Ni ions that occupies Zn^{2+} ions sites.

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