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STRUCTRAL AND ELECTRICAL STUDIES OF Ni DOPED ZnO THIN FILMS DEPOSITED BY SOL-GEL METHOD

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ABSTRACT

Nickel is an attractive dopant for ZnO because it is isomorphic to Zn, possess variable oxidation states and have different acceptor properties in a ZnO matrix, thus affecting the electronic surface band structure of ZnO. Ni^{2+} has the same valency as that of Zn^{2+}. Also, its ionic radius (0.069 nm) is close to that of Zn^{2+} (0.074 nm). Hence Ni^{2+} can replace Zn^{2+} in ZnO lattice. In the present study, 0.1 to 0.5 at% Ni doped ZnO thin films are prepared by sol-gel spin coating method. All the films possess a hexagonal wurtzite structure. All the films are in a state of compressive strain and average crystallite size increased from 16.83 to 26.16 nm with increase in Ni content from 0.1 to 0.5 at%. XPS spectra indicated that Ni exhibits an oxidation state of +2 in the films. The films are crack free and hexagonal shaped granules are seen on the surface of films in the SEM images. A decrease in film resistivity was observed with increasing Ni content which is in accordance with the XRD analysis and SEM images.

Keywords: Nickel, Sol-gel spin coating.

I. INTRODUCTION

Oxide semiconductors are wide band gap materials, and are usually transparent in the visible region. Hence, if they are optimally doped with n-type carriers, they can be potential candidates for transparent conductors[1]. ZnO doped with transition metals such as Ni is one such suitable candidate. Ni is also an important dopant that can increase the magnetic properties of ZnO thin films. Ni^{2+} has the same valency as that of Zn^{2+}. Also, its ionic radius (0.069 nm) is close to that of Zn^{2+} (0.074 nm). Hence Ni^{2+} can replace Zn^{2+} in ZnO lattice [2]. In this paper, we report the preparation of Ni doped ZnO thin films and its structural and electrical characterization.

II. EXPERIMENTAL

Pure and Ni doped ZnO thin films were deposited onto glass substrates by sol-gel spin coating method. 0.5 M ethanolic solution of zinc acetate was used as the precursor sol. Diethanolamine (DEA) was added as the stabilizer. Ni was added as dopant in the form of nickel chloride hexahydrate. The mixture was stirred by a magnetic stirrer at 60^{o}C for 1 h, until a clear and homogeneous sol was formed. The atomic percentage of Ni^{2+}/Zn^{2+} in the sol was 0, 0.1, 0.2, 0.3, 0.4 and 0.5 at%. Films were deposited on well cleaned glass substrates after the sol was aged for 24 h. The films were characrerised using X-ray diffraction (XRD), Scanning Electron Microscopy (SEM) and UV-vis spectroscopy.

III. RESULTS AND DISCUSSION

3.1 XRD studies

Figure 1 shows the XRD patterns of pure and Ni doped ZnO thin films. All the films possesses a hexagonal wurtzite structure. At lower doping concentrations of 0.1 to 0.3 at% the films are in a state of tensile strain, but at higher doping concentrations, films are in a state of compressive strain.

Average crystallite size increases from 16.83 to 26.16 nm with increase in Ni content from 0.1 to 0.5 at 0.3 at% Ni doping was identified as the optimum Ni doping concentration for obtaining Ni doped ZnO thin films with better structural properties.

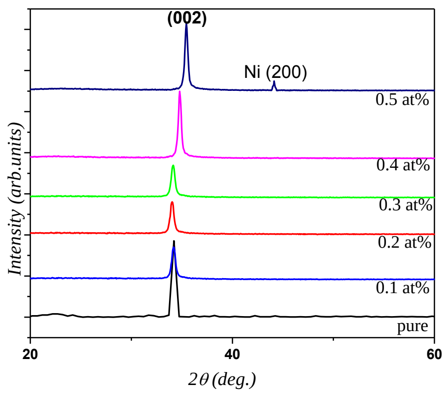

Figure 1: XRD patterns of pure and Ni doped ZnO thin films

3.2. SEM analysis

SEM analysis of the films showed that surface morphology of the films is modified significantly when doped with Ni. Clear hexagonal shaped granules of varying grain sizes were observed on the surface of 0.5 at% Ni doped ZnO film as shown in figure 2.

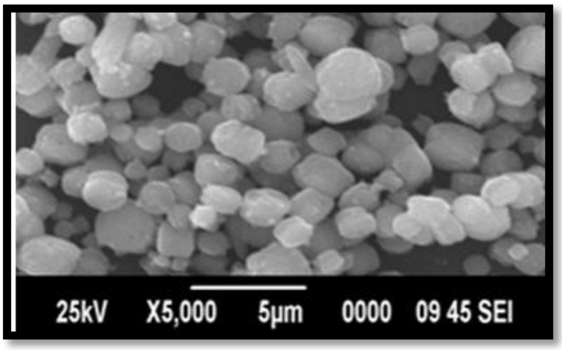

Figure 2: SEM image of 0.5 at% Ni doped ZnO thin film

3.3. Electrical studies

Variation of electrical resistivity and carrier concentration with Ni doping concentration is shown in figure 3. A decrease in film resistivity was observed with Ni doping. Increase in average crystallite size with increase in Ni content leads to a reduction in carrier trapping within the films, which results in a decrease in resistivity of the Ni doped films [3]

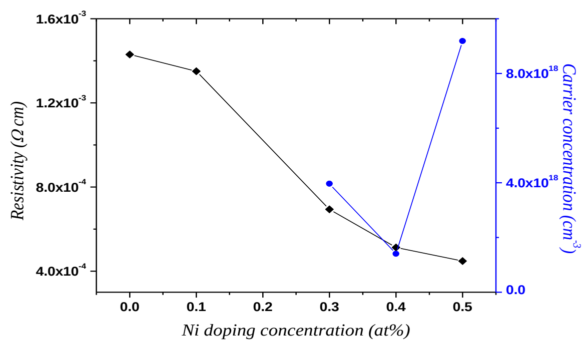

Figure 3: Variation of electrical resistivity and carrier concentration with Ni doping

VI.CONCLUSIONS

Pure and Ni doped ZnO thin films were prepared by sol-gel spin coating method. An increase in average crystallite size was observed with increase in Ni content, which resulted in decrease of film resistivity. Ni atoms exhibited an oxidation state of +2. These films with low values of resistivity are suitable candidates as TCO devices.

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