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Enhancement of Electrical Resistivity in Nickel Doped ZnO Nanoparticles

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Abstract

A systematic investigations on the structural, morphological and electrical properties of $Zn_{1-x}Ni_xO$ (x = 0.00, 0.03 and 0.05) nanoparticles synthesized via sol-gel auto combustion technique. The prepared samples were characterized by X-ray diffraction technique (XRD) and scanning electron microscopy (SEM). X-ray diffraction pattern shows the formation of single phase with hexagonal wurtzite structure. The lattice parameter of Ni doped ZnO is slightly greater than that of un-doped ZnO nanoparticles. The crystalline size of prepared nanoparticles is found to be in 30 to 32 nm. SEM image shows that the grains are in nanometre range which confirms the nanocrystalline nature of present samples. The temperature dependent DC electrical resistivity measurements have been carried out in the temperature range of 303-573 K. The DC electrical resistivity was found to increase with increase in Ni^{2+} concentration into ZnO matrix. The resistivity decreases with increasing temperature which interpreted semiconducting nature of ZnO nanoparticles.

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Keywords: ZnO; XRD; SEM; D.C. Resistivity.

1. Introduction

Zinc oxide is a promising candidate belonging to II-VI semiconductor for many applications in the field of solar cells, gas sensors, acoustic devices, piezoelectric transducers, high frequency electronic devices etc [1-3]. ZnO is an

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n-type metal oxide semiconductor having large band gap of the order of 3.37 eV and a large excitation binding energy, which makes them useful for optoelectronic device applications [4, 5]. Doping of transition metal ions such as Ni, Co, Fe, Cu etc. form dilute magnetic semiconductor which are technically most important for spintronic device applications. Doping of transition metal ions into ZnO lattice can lead to modification in optical, electrical and magnetic properties. The electrical properties, piezoelectricity, etc. can be tailored to desired applications by doping different amounts of dopant in ZnO lattice. However, the electrical behaviour of Ni doped ZnO nanoparticles is not systematically reported in the literature [6]. Ni has a unique chemical stability on zinc sites considers it as one of the most important doping element to tune the optical and electrical properties of ZnO [7, 8]. Therefore, the structural, morphological and electrical properties of Ni doped ZnO ($Zn_{1-x}Ni_xO$ with x = 0.00, 0.03, 0.05) nanoparticles synthesized via sol-gel auto combustion technique were investigated and results are presented in this work.

2. Experimental

The samples of $Zn_{1-x}Ni_xO$ (x = 0.00, 0.03 and 0.05) were prepared by standard sol-gel auto combustion technique. The high purity analytical grade chemicals such as zinc nitrate hexahydrate ($Zn(No_3)_2\,6H_2O$), Nickel nitrate tetra hydrate ($Ni(No_3)_2\,4H_2O$) were used as a raw material. Citric acid monohydrate ($C_6H_8O_7\,H_2O$) was used as a fuel. The metal nitrate to fuel ratio was taken as 1:3. The obtained powder was ground and sintered at 600 °C for 5h in air and used for further characterizations. The samples were characterized by X-ray diffraction (XRD) using Bruker D8- Advance diffractometer (Cu Kα radiation, λ = 0.15149 Å). The morphological analysis was carried out using Scanning electron microscopy (SEM) technique (JEOL JSM-636). The DC electrical resistivity was measured as a function of temperature by using two probe techniques in the temperature range of 303 K to 573 K.

3. Results and Discussion

3.1. X-ray Diffraction study (XRD)

The XRD pattern of the $Zn_{1-x}Ni_xO$ (x=0.00, 0.03, 0.05) nanoparticles are shown in fig.1. The analysis of XRD pattern confirms the single phase with hexagonal wurtzite structure of ZnO lattice. The XRD pattern shows the formation of strong and narrow diffraction peaks which shows good crystallinity of prepared samples. Using the XRD data various structural parameters were obtained.

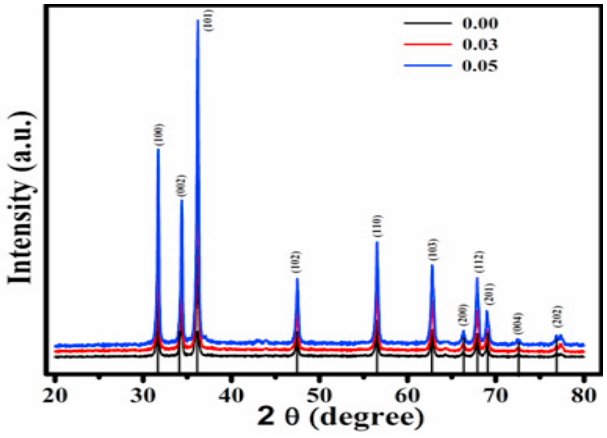

Fig. 1. XRD pattern of undoped and Ni doped ZnO nanoparticles.