

# Optical and magnetic properties of Ni doped ZnO nanorods using single-step aqueous approach

Bharati Panigrahy<sup>1</sup>, M. Aslam<sup>2</sup>, D. S. Misra<sup>2</sup> and D. Bahadur<sup>1\*</sup>

(1) Department of Metallurgical Engineering & Materials Science, Indian Institute of Technology Bombay, Powai, Mumbai-400 076, INDIA.

(2) Department of Physics, Indian Institute of Technology Bombay, Powai, Mumbai-400 076, INDIA.

\* Corresponding author.

**Abstract** –Herein we report the optical and magnetic properties of nickel doped ZnO nanorods fabricated by one-step aqueous based chemical method at 85-90 °C. Their physical properties vary significantly due to the change in the dopant ion concentration (0.02%-0.07%). The UV emission band in PL spectra of Ni doped ZnO nanorod reveals a red shift indicating a band edge bending due to the dopant ions. Very interestingly, the defect band at 460-750nm is suppressed considerably as we increase the dopant concentration indicating passivation of the surface of the nanorods. XRD, EDS and RAMAN data reveals a successful incorporation of dopant cations on Zn lattice sites. Both ZnO and Ni-doped ZnO nanorods show a ferromagnetic behavior at room temperature.

ZnO is a direct wide band-gap semiconductor, which can be grown into a wide variety of nanostructures having a broad range of application in the field of opto-electronics and spintronics. For the purpose of introducing new properties, transition metals have been doped in this interesting semiconductor. Introduction of Ni into ZnO shows robust room temperature ferromagnetic property. Besides this, the Ni<sup>2+</sup> ions can also tune the concentration of the defect present in the material.

An aqueous based chemical technique which is facile, economical, and environmentally benign is demonstrated for the synthesis of Ni-doped ZnO nanorods. In brief, zinc chloride, nickel chloride and hexamethylene tetramine (HMTA) are used as precursors. The reaction solution was prepared by mixing 0.01M of both zinc chloride and HMTA, and specific concentration of nickel chloride with MilliQ water in separate containers. Precursors should be completely dissolved in water and then all the solutions were mixed in a beaker. Before the precipitation begins, cleaned substrates are vertically dipped into the reaction solution and the solution contained beaker is kept inside a heating oven at 85-90 °C for 1.5hr. Then the deposited substrate was taken out from the solution, copiously rinsed with MilliQ water and dried at room temperature.

XRD pattern confirms the wurtzite phase of pure and Ni-doped ZnO nanorods. No impurity peaks were found due to NiO or hydroxide separate phase. Due to the incorporation of Ni<sup>2+</sup> into ZnO lattice, there is a slight decrease in lattice parameter which causes shift of XRD peak to a higher 2θ angles. The microscopic image of ZnO (~85 nm) and Zn<sub>0.95</sub>Ni<sub>0.05</sub>O is shown in Fig.1. SAED pattern confirms that the nanorods are single crystals grown in (002) direction. In PL spectra (Fig.2(a)), the red shift of UV emission band by increasing the concentration of Ni<sup>2+</sup> ion has been attributed to the increase in strong exchange interactions between the d electrons of Ni and the s and p electrons of the host lattice. The yellow-orange broad-band emission emanates from the defects, decreases by increasing the concentration of the Ni ions due to the passivation of the surface of the nanorods. The hysteresis curves (Fig.2(b)) provide evidence for the existence of room temperature ferromagnetism both in pure (also shown in the inset) and Ni doped ZnO nanorods. The magnetization value increases by increasing the concentration of the Ni.

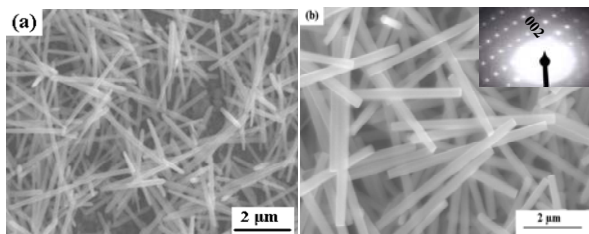


Figure 1: SEM images of (a) ZnO nanorods (b) Ni doped ZnO nanorods.

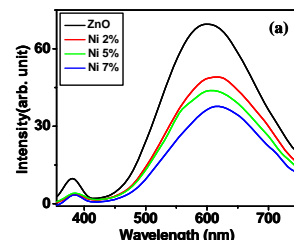


Figure 2(a): Comparison of PL spectra of ZnO and Ni doped ZnO nanorods.

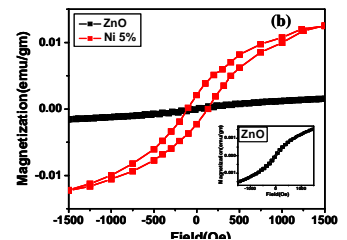


Figure 2(b): Comparison of M versus H curve for ZnO (also shown in the inset) and Ni (5%) doped ZnO nanorods.