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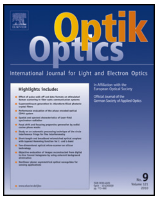

Effect of temperature and pH on structural, optical and electrical properties of Ni doped ZnSe nanoparticles

Priyadharsini N.[a], Elango M.[b], Vairam S.[c], Venkatachalam T.[d], Thamilselvan M.[a,*]

[a] *Department of Physics, Thanthai Periyar Government Institute of Technology, Vellore, India*
[b] *Department of Physics, PSG College of arts and science, Coimbatore, India*
[c] *Department of Chemistry, Government College of Technology, Coimbatore, India*
[d] *Department of Physics, Coimbatore Institute of Technology, Coimbatore, India*

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ABSTRACT

Ni doped ZnSe precipitated particles were prepared using three different pH precursor solutions (8, 9 and 10) and two different solution temperatures (303 K and 363 K) by wet chemical precipitation technique. The SEM analysis reveals that the size of the particles is in the order of 5 nm at 303 K and it becomes 20 nm at 363 K. The XRD studies show that the prepared nanoparticles of Ni:ZnSe switch from cubic zinc blende to hexagonal wuzurite structure as the temperature increase from 303 K to 363 K. The UV–vis spectra of Ni:ZnSe nanoparticles show that there is no change in optical band gap with increase in pH value at 303 K but the gap increases slightly at 363 K. Linear incremental and non linear decremental natured band edge absorptions were identified for the nanoparticles prepared at different conditions of pH and temperature. The weak interaction between Se^{2-} and Zn^{2+}/Ni^{2+} and the property of superficially adhered functional groups were confirmed from the analysis of FT-IR absorption spectra. The conductivity and dielectric studies confirm that the material can be used in high frequency applications.

1. Introduction

Nano electronic devices using novel pristine semiconductors are emerging and going to be a pinnacle in future gadgets. Recently much effort towards fabrication of semiconductor nanocrystals with photo bleaching stability [1], excellent surface functionality [2], tunable photo physical properties [3], the enhanced redox potential between electron and holes in the conduction and valence band have proved as building blocks of the nanoelectronics world [4,5]. ZnSe is a novel semiconductor with suitable property such as n type nature, direct wide band gap (nearly 2.8 eV), expected Bohr radius (3.8 nm), large exciton binding energy (21 meV) and it is best host matrices for dopant. Several methods have been reported, specifically, solvothermal method [6], physical vapor deposition [7], chemical bath deposition [8,9] and wet chemical precipitation method [10] are identified for the fabrication of ZnSe nanocrystals. Among all, wet chemical precipitation method has reported as widely acceptable method due to its features such as cost effectiveness, particle stability, versatility, less complexity, easy doping. The incorporation of transition metal into ZnSe matrices makes major alterations in electrical and optical properties. Ni doping in ZnSe leads to replace certain Zn atoms in the compound in cubic zinc blende crystal structure

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* Corresponding author.
E-mail addresses: mthamilselvan@yahoo.com, mthamil@rediffmail.com (M. Thamilselvan).

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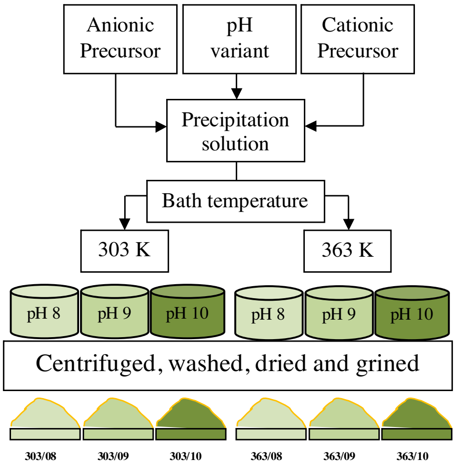

Fig. 1. Flow chart of nano powder preparation.

Table 1
Range of parameters and optimized condition for Ni doped ZnSe nano particles.

S.No	Parameter	Range	Optimized condition
1	pH	2–13	8–10
2	Bath temperature	300 K–453 K	303 K–363 K
3	Dopant concentration	2%–25%	5%–15%

and capable of perfect switching to hexagonal wurzite structure at slightly elevated temperature (363 K). These motivated us to choose Ni: ZnSe semiconductor prepared by wet chemical precipitate technique.

2. Experimental method

2.1. Preparation of Ni doped ZnSe precipitate powder

Analytical grade (Merck company) zinc nitrate hexahydrate ($ZnNO_3{\cdot}6H_2O$), nickel acetate hexahydrate $Ni(CH_3COO)_2{\cdot}6H_2O$, hydrazine hydrate and selenium dioxide (SeO_2) were used without further purification. Precipitation solutions of anionic and cationic precursor were prepared separately using millipore water (solvent) and Hydrazine hydrate (pH variant) in the following stages (flow chart Fig. 1).

2.2. Preparation of anionic precursor

2 g of zinc nitrate hexahydrate and stoichiometry measured nickel acetate hexahydrate (dopant) were added together in 60 ml of millipore water and stirred for one hour to attain the turbid free clear solution.

2.3. Preparation of cationic precursor

2 g of Selenium dioxide was dissolved in 60 ml of millipore water and stirred for one hour.

2.4. Preparation of precipitation solution

Beaker containing the cationic solution was added drop by drop into the anionic solution under vigorous stirring and also adding pH variant (hydrazine hydrate) to fix. Three different pH values in two different bath temperatures (300 K and 363 K) were prepared carefully and allowed to settle for 12 h (ageing period) in six separate beakers. The resultant products were centrifuged and washed thoroughly with acetone and double distilled water, then dried at room temperature. The precipitated powders were collected and labeled with bath temperature and pH value in six air tight containers for characterization. The optimal condition of physical parameters and range are tabulated as shown in Table. 1.

2.5. Characterization

The structure of the precipitated particles was determined by XRD analysis using Shimadzu 6000 diffractometer at the scanning rate of 0.02°/min for the range from 10° to 80° using a source of X-ray of Cu Kα (1.504 Å). The morphology of the