ChalcogenideLetters Vol. 8, No. 2, February 2011, p. 53 – 58

STRUCTURAL CHARACTERIZATION ON NICKEL DOPED CADMIUM SULFIDE

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In the present work, conventional chemical co-precipitation method was employed for the prepation of Nickel (2,4,6,8&10 at % of Ni) doped CdS nanoparticles.The particle size and lattice parameters for each sample are determined from X-ray diffraction (XRD) analysis. From XRD patterns the broadening of the diffraction peaks indicates the nanostructure nature of the samples. Surface morphology of the samples was studied by Scanning Electron Microscope (SEM). Compositional Elemental analysis of data is obtained from Energy Dispersive Analysis of X-ray (EDAX) plots.

(Received January 28, 2011; accepted February 2, 2011)

Keywords: II-VI Semiconductors, Nickel doped CdS, Nanoparticles, XRD, SEM

1. Introduction

Nanostructured semiconducting materials have gained wide interest due to their inherently novel optical and electronic properties [1-3]. They are useful in hetero-junction light emitting diodes, solar cells, piezoelectric nanogenerators, photocatalytic reactors, field emitters, logic gates, and photoconducting devices [4-6]. Nanostructured sulfides and selenides (e.g. CdSe, ZnSe. CdS and ZnS) have been extensively studied with a view to establish a relationship between structure, size and optical properties [7,8]. Cadmium sulfide (CdS) with a direct band gap of 2.42eV at room temperature (RT) is a useful candidate for solar cells, green lasers, photoconductors, light emitting diodes, and thin film transistors [9]. Transition metal(TM) doped semiconductors, known as diluted magnetic semiconductors, have attracted widespread scientific attention due to their prospective applications. However, the usefulness of CdS for the futuristic devices resides in the ability to dope it with impurities so as to achieve the desired properties and to make them multifunctional. Transition metal (TM) (Mn,Fe,Co,etc.,) doped CdS has drawn considerable attention as it offers a great opportunity to integrate electrical, optical and magnetic properties into a single material, which makes it an ideal candidate for nonvolatile memory, magneto-optical and future spintronic devices[10,11]. Different techniques such as electrodeposition, coevaporation [12], chemical vapor deposition [13], spray pyrolysis [14] and other chemical routes have been used to synthesize TM doped CdS.

It has been reported that TM doping, Fe and Ni in particular, diminishes the quantum size yields in the visible and near-band-gap region by acting as a quenching or killer centers for fluorescence and photoconduction, and results in short carrier lifetimes useful in fast optoelectronic devices[15-18]. In this study, we investigate structural and morphological properties of Ni-doped CdS nanoparticles prepared by chemical co-precipitation method. The prepared samples were characterized using X-ray diffraction (XRD) and SEM with EDAX.

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2. Experimental

DMS nanoparticles of CdS: Ni^{2+} was prepared by colloidal chemical co-precipitation method using cadmium acetate, sodium sulfide and Nickel acetate as starting compounds. Appropriate quantities of these were weighed in microbalance (M/s SICO, India) according to the stoichiometry to obtain 2,4,6,8 & 10 at% target dopant concentrations and were dissolved in 100ml of methanol to make 0.1M solutions. The stoichiometric solution was taken in a burette and was added in drops with continuous stirring to a mixture of Na_2S(0.1M) + 50ml of H_2O + 1.1ml of thiophenol + 100ml of methanol until fine precipitate of CdS:Ni was formed. After complete precipitation, the solution in conical flask was constantly stirred for about 20h. A single step chemical reaction is given below for the precipitation of the Ni doped CdS nanoparticles. Then the precipitates were filtered out separately and washed thoroughly with de-ionized water. Finally these samples are subjected to sintering process. The green colored nanocrystalline CdS or CdS: Ni^{2+} powders were obtained. The samples were calcined at 300^{o}C/2hrs vacuum. X-ray diffraction has been carried out using SIEFERT X-ray diffractometer. Surface morphology of the samples has been studied using HITACHI S-3400 scanning electron microscope (SEM) with EDAX. EDAX is carried out for the elemental analysis of prepared samples.

3. Results and discussion

Fig. 1 shows the X-ray diffraction pattern of the prepared Ni doped CdS nanoparticles and that of the undoped CdS for comparison. The particle sizes of these nanoparticles have been determined by using the Scherrer formula [19]. Analyzing the most prominent peaks, the crystal structure of these nanoparticles has been found to be in hexagonal phase with particle size distribution of 20-23nm. It is observed that the diffraction peaks of the Ni doped CdS show a small shift towards higher 2θ value when compared to the CdS. The lattice constant a and c have been determined from interplanar spacing of different (h k l) planes using the relation.

$$\frac{1}{d_{hkl}^2} = \frac{4}{3}\frac{h^2 + hk + k^2}{a^2} + \frac{l^2}{c^2}$$

The evaluated lattice parameters of Ni doped CdS are tabulated in Table 1. In Ni doped CdS samples, the lattice parameters are observed to decrease in increase of Ni concentration. Doping of Ni does not lead to any structural phase transformation by introduces a lattice contraction. Doping of Ni does not lead to any structural phase transformation by introduces a lattice contraction. The decrease of the lattice parameters of Ni (shown in Table 1) doping is because utilize hot electrons and/or generate multiple charge carriers with a single photon [20, 21]. When a photon with energy greater than the band gap of material is absorbed, the electron in the valence band is promoted to an excited state in the conduction band and the excited electrons are known as hot electrons. The characteristics of these materials are interesting from the point of view of applications in infrared detectors, lasers and other optical devices [22, 23].The SEM images of Ni doped CdS shown in figure 2(a) -2(e) with different magnifications clearly indicates the formation of nanoclusters. The grains have aggregated to form clusters [24]. The average grain size diameters for Ni doped CdS are found to be in the range of 1-2μm. Figure 3(a)-3(e) shows the EDAX plots of Ni doped CdS. EDAX data shown in Table 2 gives the compositions of prepared samples in weight percentage.

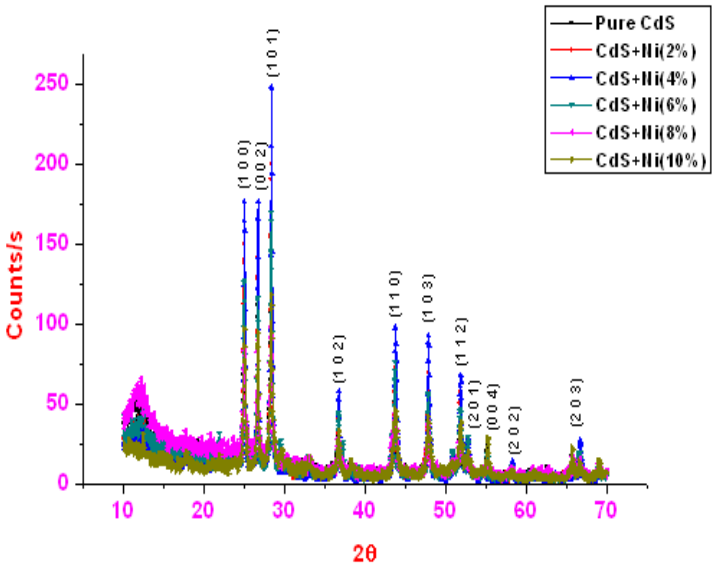
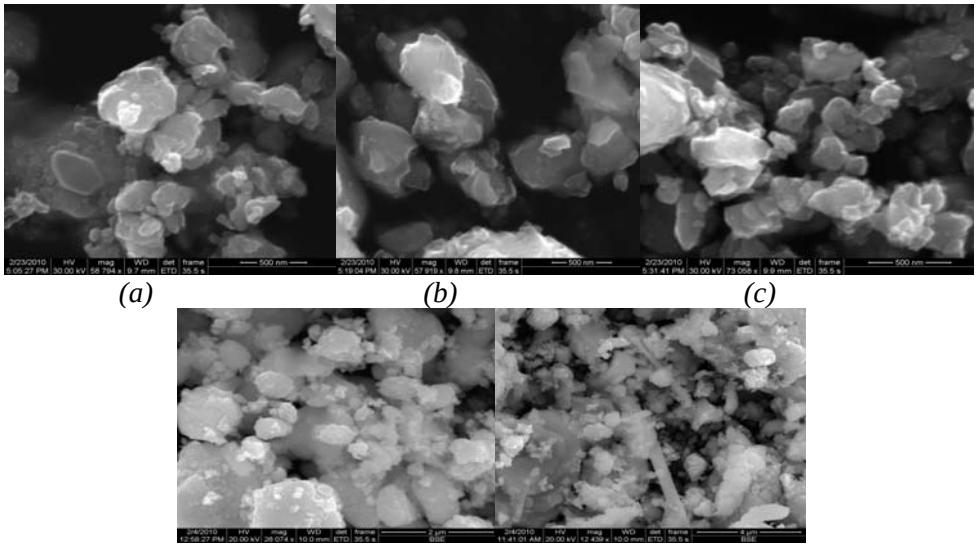


Fig. 1. X-ray diffraction patterns of Ni (2%,4%,6%,8% and 10% concentration) doped CdS nanoparticles

Table 1. Lattice Parameters of undoped and Ni doped CdS

S.No	Compound Name	$2\theta_{(0\,0\,2)}$	d(A°)	Calculated Values	
				a (A°)	c (A°)
1	CdS	26.628	3.344	4.121	6.732
2	CdS+Ni (2%)	26.639	3.343	4.119	6.728
3	CdS+Ni (4%)	26.626	3.345	4.116	6.713
4	CdS+Ni (6%)	26.670	3.339	4.114	6.702
5	CdS+Ni (8%)	26.649	3.342	4.113	6.701
6	CdS+Ni (10%)	26.607	3.347	4.112	6.695



(a) *(b)* *(c)*

(d) *(e)*

Fig. 2. SEM Micrograph of Ni (a) 2% (b) 4% (c) 6% (d) 8% and (e) 10% doped CdS nanoparticles

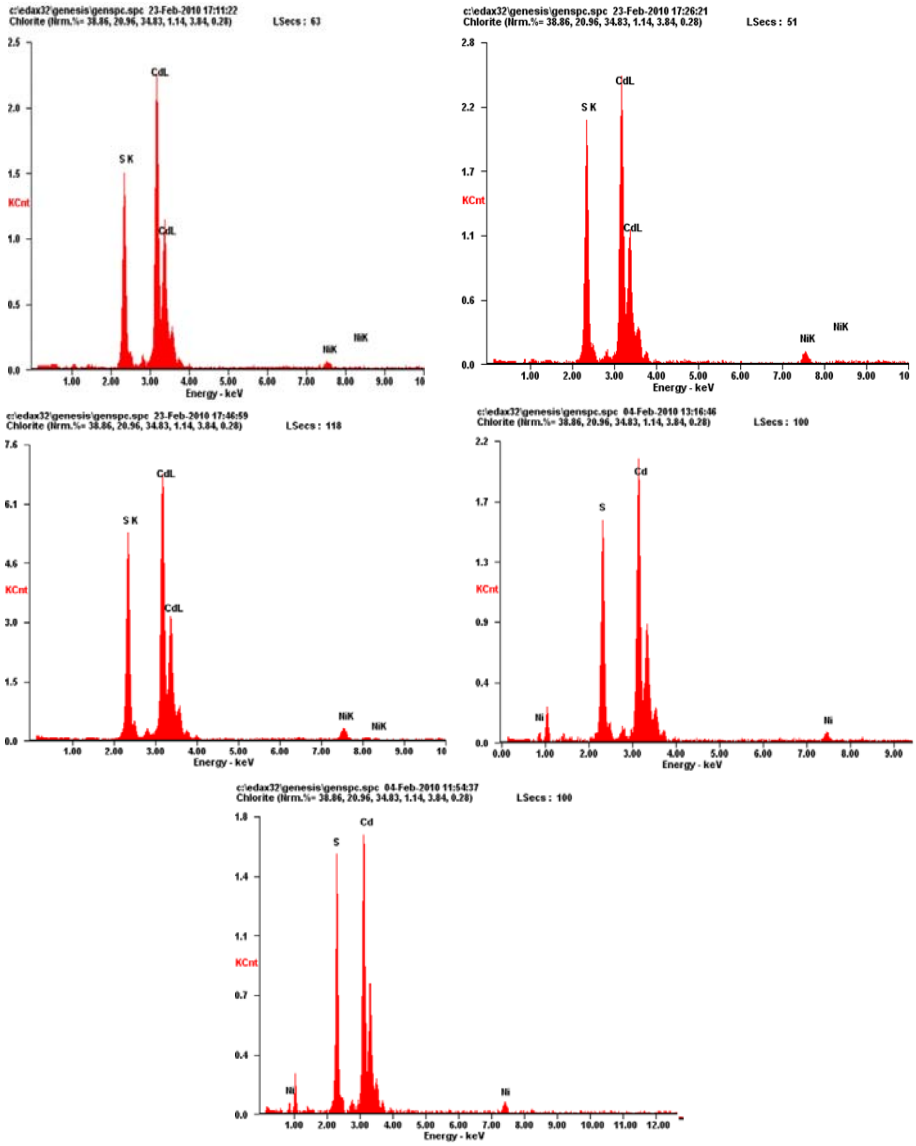


Fig. 3. EDAX plots of Ni (a) 2% (b) 4% (c) 6% (d) 8% and (e) 10% doped CdS

Table 2. Data from EDAX analysis of Ni doped CdS

S.No	Compound Name	Element	Weight Percentage (%)
1	CdS +Ni (2%)	S K Cd L Ni K	46.97 51.05 1.98 Total 100.00
2	CdS +Ni (4%)	S K Cd L Ni K	45.63 50.55 3.82 Total 100.00
3	CdS +Ni (6%)	S K Cd L Ni K	49.24 44.72 6.04 Total 100.00
4	CdS +Ni (8%)	S K Cd L Ni K	48.31 43.66 8.03 Total 100.00
5	CdS +Ni (10%)	S K Cd L Ni K	48.07 42.11 9.82 Total 100.00

4. Conclusion

Nickel doped CdS Nanoparticles have been synthesized by aqueous medium through chemical co-precipitation technique. X-ray diffraction measurement confirms the structure as hexagonal phase having particle size in the range of 20-23 nm. Scanning Electron Microscope (SEM) images clearly indicates the formation of nanoclusters. Compositional analysis by EDAX confirms that the sample with clear peaks of Cadmium(Cd), Sulphur (S) and Nickel (Ni) is around the nominal composition.

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