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STRUCTURAL PROPERTIES OF NICKEL DOPED CADMIUM SULFIDE

**B. Srinivasa Rao¹, B. Rajesh Kumar², G. Venkata Chalapathi³,
V. Rajagopal Reddy¹, T. Subba Rao²**

¹ Sri Venkateswara University,
Department of Physics, 517502, Tirupati, India

² Sri Krishnadevaraya University,
Department of Physics, 515055, Anantapur, India
E-mail: rajind08@gmail.com

³ Loyola Degree College,
Department of Physics, 516390, Pulivendula, India

In the Present work, conventional chemical co-precipitation method was employed for the preparation of Nickel (2, 4, 6, 8 and 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.

Keywords: II-VI SEMICONDUCTORS, CdS, NANOPARTICLES, X-RAY DIFFRACTION, SCANNING ELECTRON MICROSCOPY.

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1. INTRODUCTION

II-VI semiconducting chalcogenides nanoparticles, especially sulfides and selenides have been investigated extensively, owing to their interesting opto-electronic properties [1]. Cadmium sulfide (CdS) with a direct band gap of 2.42 eV at room temperature (RT) is a useful candidate for solar cells, green lasers, photoconductors, light emitting diodes, and thin film transistors [2]. 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 [3, 4]. Different techniques such as electrodeposition, coevaporation [5], chemical vapor deposition [6], spray pyrolysis [7] and other chemical routes [3] 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 centres for fluorescence and photoconduction, and

results in short carrier lifetimes useful in fast optoelectronic devices [8-11]. 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.

2. EXPERIMENTAL

In the present work, DMS nanoparticles of CdS: Ni²⁺ was prepared by colloidal chemical co-precipitation method using cadmium acetate, sodium sulphide 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 and 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 Na₂S (0.1 M) + 50 ml of H₂O + 1.1 ml of thiophenol + 100 ml of methanol until fine precipitate of CdS: Ni was formed. After complete precipitation, the solution in conical flask was constantly stirred for about 20 h. 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: Ni²⁺ powders were obtained. The samples were calcined at 300 °C/2 hrs 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

Figure 1 shows the X-ray diffraction pattern of the prepared Ni doped CdS nanoparticles and that of the undoped CdS for comparison. The crystalline sizes of these nanoparticles have been determined by using the Scherrer formula [12]. Analyzing the most prominent peaks around 43.711° and 51.845° (1 1 2) the crystal structure of these nanoparticles have been found to be in hexagonal phase having particle size distribution (20 – 23 nm). 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 (hkl) planes using the relation.

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

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 [13, 14]. 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 [15, 16]. The SEM image shown in Fig. 2a-2e with different magnifications clearly indicates the formation of nanoclusters. The grains have aggregated to form clusters [17]. Fig. 3 a-e shows the EDAX plots of Ni doped CdS. EDAX data shown in Table 2 gives the compositions of prepared samples in weight percentage.

Table 1 – Structural Parameters of undoped and Ni doped CdS

S.No	Materials	$2\theta_{(002)}$	d(Å)	Calculated Values	
				a (Å)	c (Å)
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

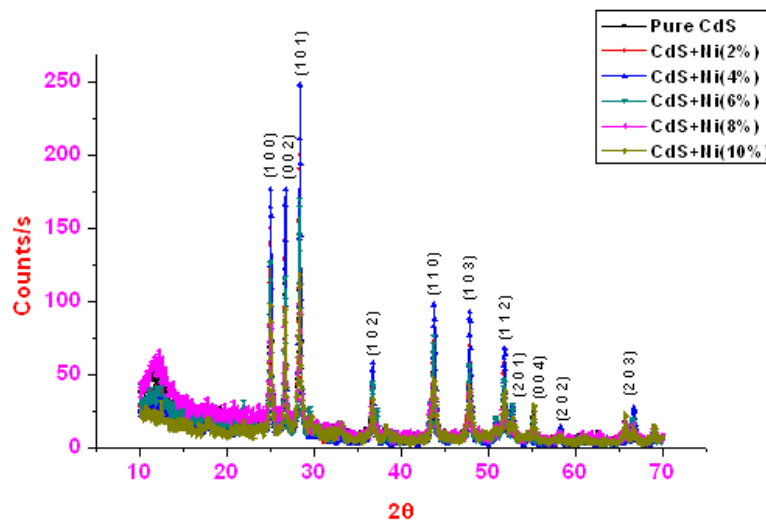


Fig. 1 – X-ray diffraction patterns of Ni (2%,4%,6%,8% and 10% concentration) doped CdS nanoparticles

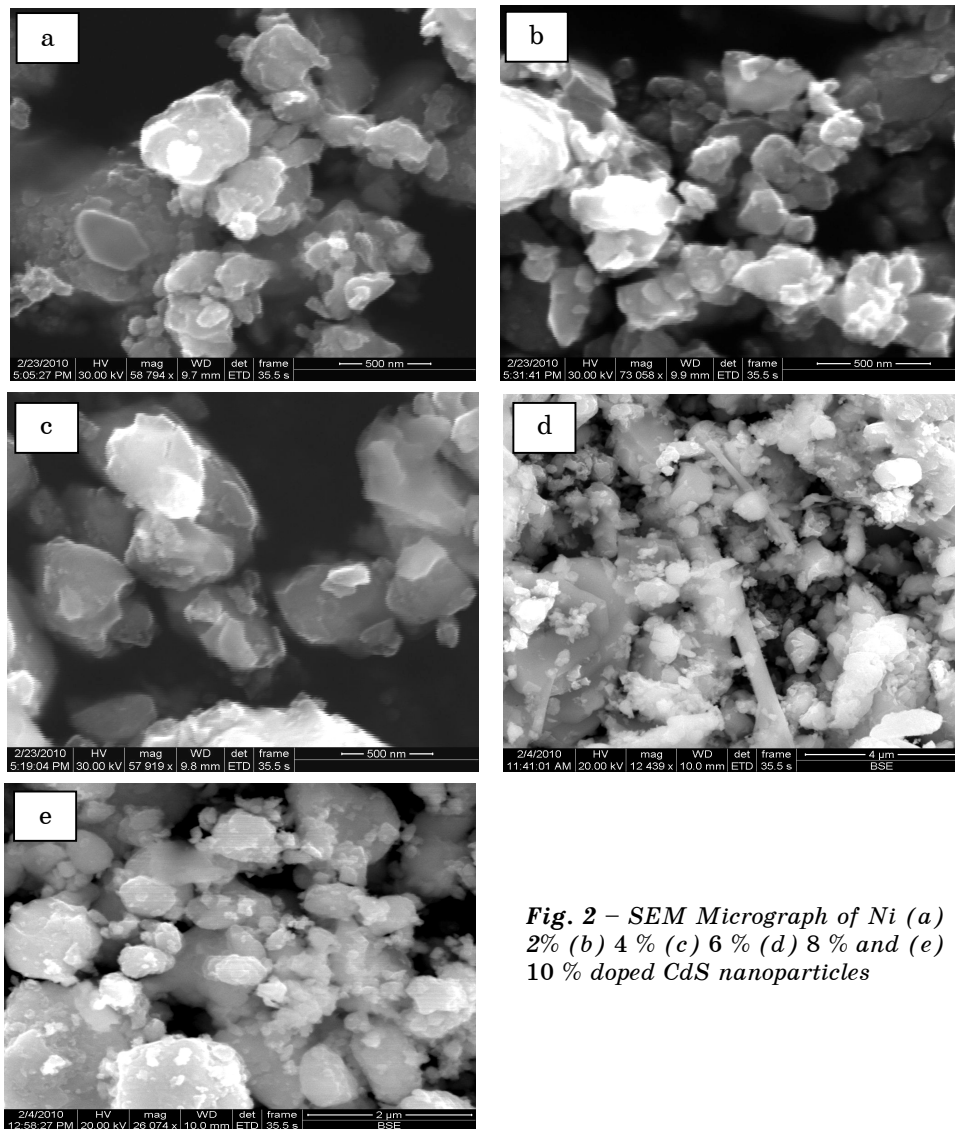


Fig. 2 – SEM Micrograph of Ni (a) 2% (b) 4% (c) 6% (d) 8% and (e) 10% doped CdS nanoparticles

Table 2 – Data from EDAX analysis of Ni doped CdS

Sr. No.	Material	Element	Weight Percentage (%)
1	CdS +Ni (2%)	S K	46.97
		Cd L	51.05
		Ni K	1.98
2	CdS +Ni (4%)	S K	45.63
		Cd L	50.55
		Ni K	3.82
3	CdS +Ni (6%)	S K	49.24
		Cd L	44.72
		Ni K	6.04

Sr. No.	Material	Element	Weight Percentage (%)
4	CdS +Ni (8%)	S K	48.31
		Cd L	43.66
		Ni K	8.03
5	CdS +Ni (10%)	S K	48.07
		Cd L	42.11
		Ni K	9.82

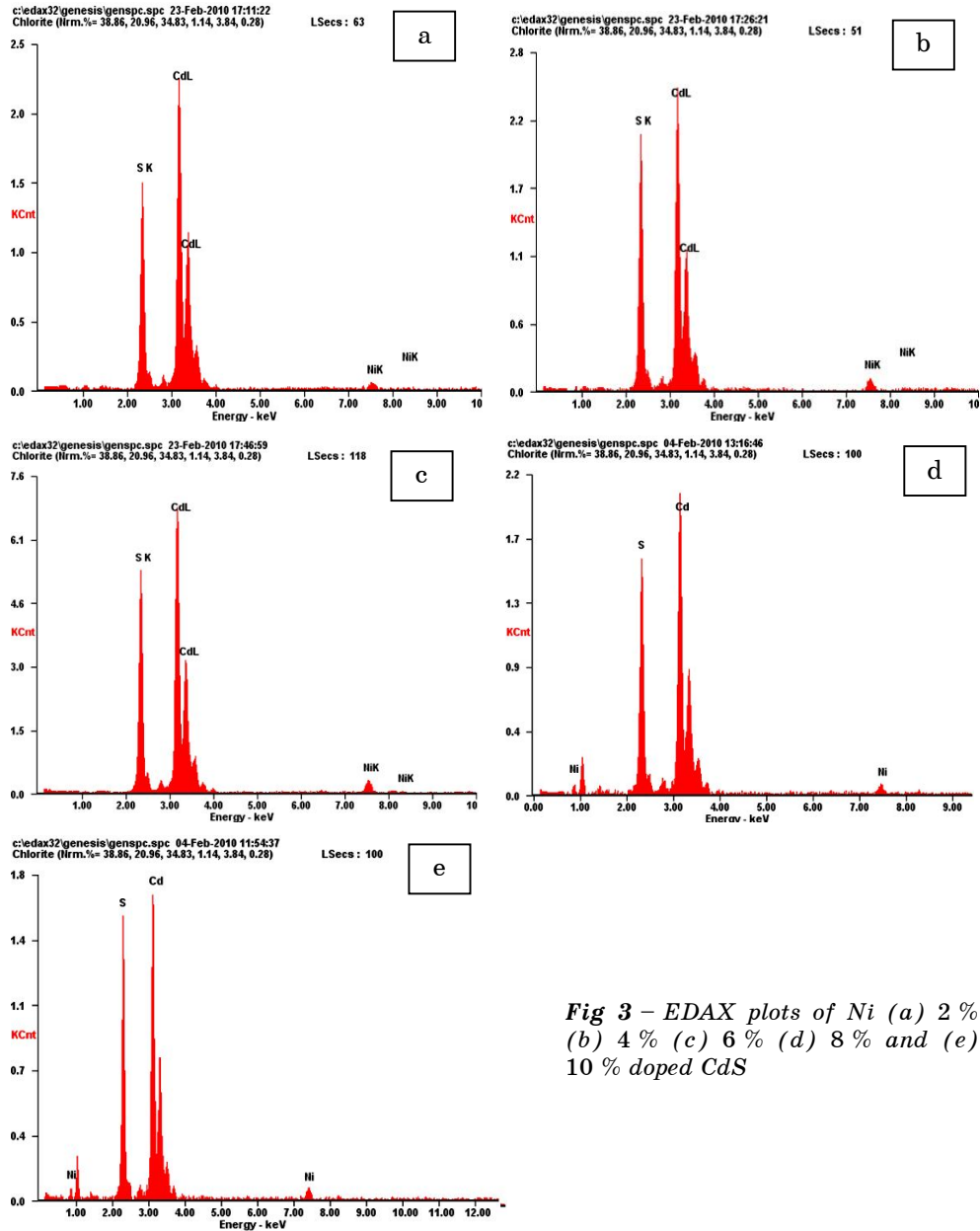


Fig 3 – EDAX plots of Ni (a) 2 % (b) 4 % (c) 6 % (d) 8 % and (e) 10 % doped CdS

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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