Structural and Optical Properties of CdS and Ni doped CdS Nano particles Synthesized by Chemical Bath Deposition Method-A Comparative Study

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Abstract: The analysis of pristine and Ni doped CdS nanoparticles grown on Ammonia has been studied in this paper. The nanoparticles are prepared at room temperature using the simplest method Chemical Bath Deposition (CBD) method. Nano crystallite size of CdS and Ni doped CdS is confirmed by XRD analysis and particle size is found to be decreasing with doping. TEM studies shows the average particle size in nano form which is well matched with XRD values. The optical properties for undoped and Ni doped CdS nano particles are studied with the help of UV and PL analysis. Band gap is increased with the variation of doping compared to undoped CdS. PL spectra shows its absorption intensities for both CdS and Ni doped CdS nano particles. SEM studies show the morphological studies along with shape and size of particles. An EDAX spectrum shows the element present in the nano material.

Keywords: XRD, TEM, UV, PL, SEM, EDAX

1. Introduction:

Semiconductors nano materials are very interesting field in the science of technology. When materials are in nano range they show unique behaviour as compared to bulk materials. Among all semiconductors, II-VI semiconductors have widely used. CdS nano materials have unique electrical, optical properties having band gap of about 2.42eV. Having wide band gap, it is useful in many optoelectronic devices like photodetectors [1], window layer in solar cells [2], photocatalysts [3] , biological sensors [4]etc.

When CdS nanoparticles are doped with Ni, band gape increases. Due to this wide band gap of doped CdS, they are of great advantage in the field of biological, electrical, health and pharmaceutical etc.

2. Materials and Methods:

Various methods can be used for the synthesis of CdS nanomaterials semiconductors. Popular methods are chemical bath deposition method [5], sol-gel method [6], spray pyrolysis[7] etc. Here chemical bath deposition method has been employed for synthesis and preparation of samples. It is a low cost method which could be performed at room temperature.

For synthesis of CdS nano material, Cadmium Chloride ($CdCl_2$) and Sodium Sulphide Flakes ($Na_2S \times H_2O$) are taken in wt percentage. Both the solution is dissolved in distilled water separately. Liquor Ammonia (NH_3) is added drop wise to the mixture of CdS solution and the whole solution is stirred for four hours at 60^0C. The solution is kept overnight at dark place for complete dissolution.

For Ni doped CdS, Nickel Chloride Hexahydrate ($NiCl_2.6H_2O$) is used as a source of Ni. The wt percentage of Ni (7%) is measured and dissolved in 50ml of distilled water. The Ni solution is added to CdS solution drop wise and stirred for two hours at 60^0C. The Ni doped solution is kept overnight for complete dissolution. The solution is filtered and washed with distilled water and the residue obtained is dried in air.

3. Results and Discussion:
3.1 XRD analysis:

The formation of nano range CdS is examined by XRD study.   XRD analysis of Ni doped and pristine CdS is analysed with the help of X'pert Pro Diffractometer with operating voltage 40kv and current 35mA as shown in fig3.1. The intensity peaks are found at diffracting plane (111), (220) and (311) for CdS. For Ni doped CdS, 2Θ intensity peaks are very slightly displaced and no other changes occurred due to doping. Hence it is confirmed that Ni $^{2+}$ ion does not affect the structure of CdS atom. The particle size is calculated from Debye Scherrer formula and the formula is

$$D=k\lambda/\beta\cos\theta$$

Where, k is a dimensionless constant, λ is the wavelength of X-Ray used, β= Full width at Half maxima (FWHM) of the diffraction peak and θ is the diffraction angle for the (*hkl*) plane Bragg's angle. From XRD studies, the average particle size is found to be 6nm to 4nm for undoped and Ni doped CdS. It can also be found that the the particle exhibit zinc blende i.e cubic structure in accordance with the standard diffracting plane values. Since Ni^{2+} ion has less ionic radius (0.69 ˚A) than that of Cd (0.96 Å), therefore it has not been found any change in structure of CdS nano particle due to substitution of Ni.
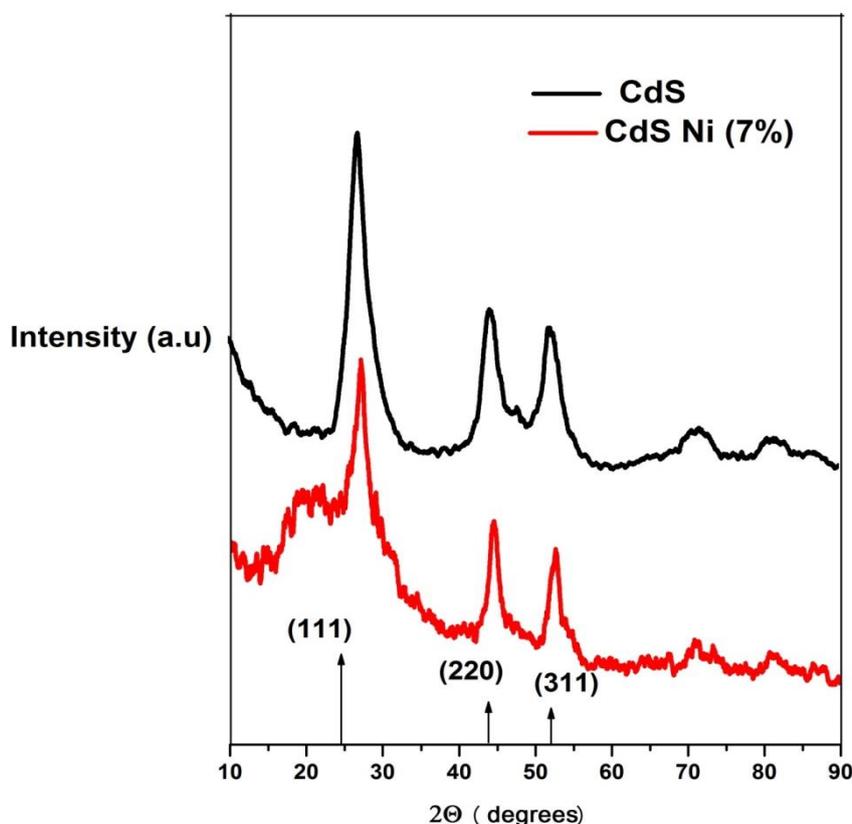
Fig3.1 XRD pattern of CdS and Ni doped CdS nanoparticles

3.2 TEM Analysis:

TEM analysis was performed for pristine and Ni doped CdS with the help of TEM (JEOL-100 CX) as shown in fig3.2(a) and (b). It can be observed from the figure that the particle size of CdS is found to be approximately about 7nm and for Ni doped it is calculated as 5nm. Hence it is well matched with XRD analysis data and the particles are spherical in shape. The figure shows that the particles are well distributed and small agglomerations are present in nano particles.
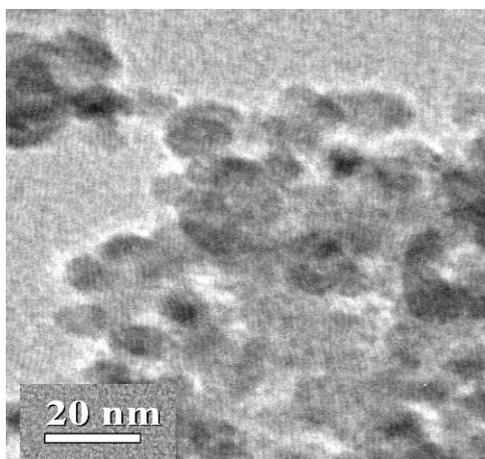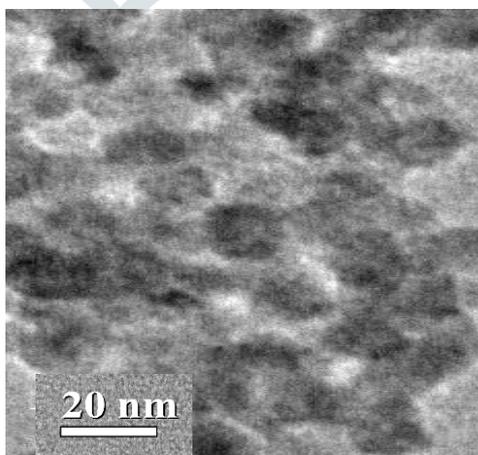

Fig.3.2 (a) TEM image of CdS   **Fig3.2 (b) TEM image of Ni doped CdS**

3.3 Optical absorbance and Band gap study:

Optical properties are studied with the help of of UV- Visible absorption spectrometer Shimadzu UV-2600 as shown in figure 3.3 The absorption peak for pristine and Ni doped CdS is observed at 415nm and 410nm. The band gap is calculated from Tauc's Relation which is given as,

$$(\alpha h\nu)^2 = A(\,h\nu - E_g)$$

Where α is the absorption coefficient, $h\nu$ is the photon energy, E_g is the optical band gap and A is a constant. The band gap is found from the graph $h\nu$ vs $(\alpha h\nu)^2$ graphs as shown in fig3 and inset.

It is seen from the graph that with increase in concentration of Ni doping, band gap increases than pristine CdS. The band gap values for undoped CdS is 2.7eV and Ni doped CdS is found to be 2.8eV. Also doping indicates the blue shift (8) absorption of light.
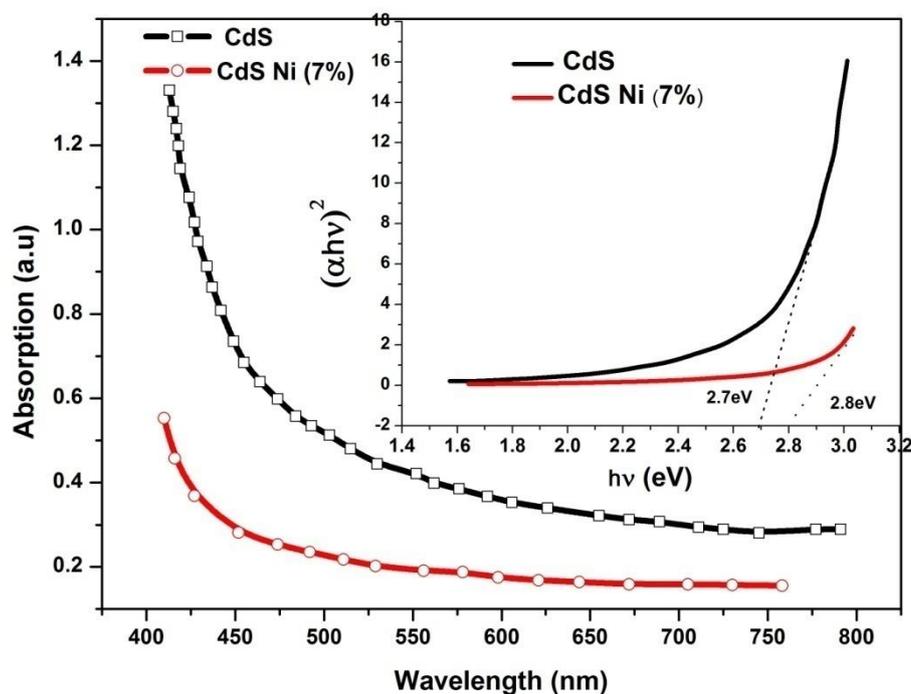

Fig3.3 UV-VIS Spectra of CdS and Ni doped CdS

3.4 FESEM AND EDAX ANALYSIS:

The FESEM analysis is performed with the help of model SIGMA 300 to study the surface morphology of the sample as shown in figure 3.4(a) and 3.4(b). It is seen from the figure that particles are distributed uniformly throughout the surface. Nano particles are observed as spherical symmetry for CdS and Ni doped CdS. Due to agglomeration, the average particle sizes are found to be approximately 20nm.

The EDAX spectra shows that in Ni doping process, Ni is seen as shown in figure3.4(c) along with Cd and S. Perfect weight percentage are observed in EDAX analysis. Therefore it is well matched with our theoretical data.
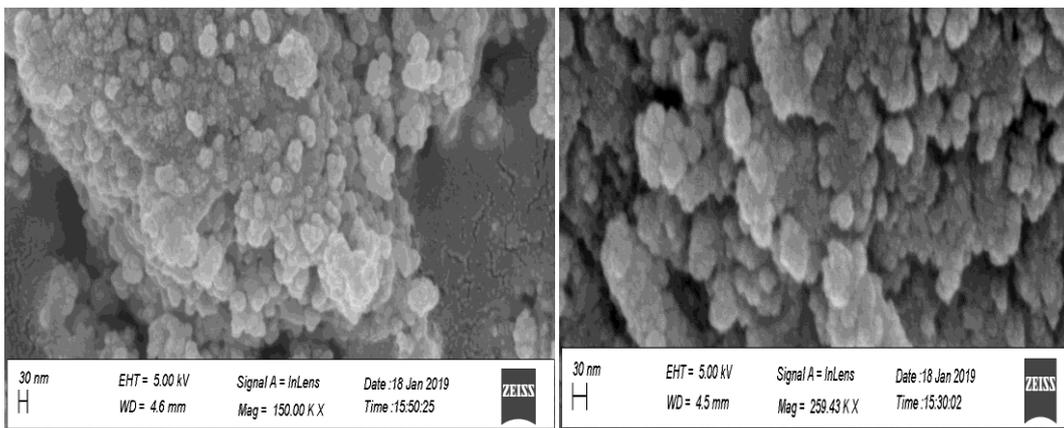
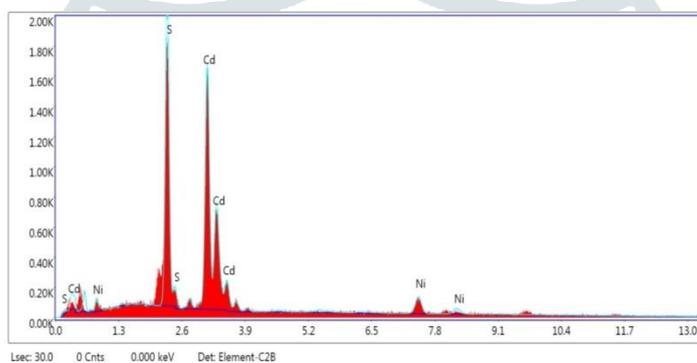Fig3.4 (a) SEM image of Cds   Fig3.4 (b) SEM image of CdSNi

Fig3.4(c) EDAX spectra of Ni doped CdS nanoparticles

3.5 Photoluminescence Study:

The photoluminescence properties of CdS and Ni doped CdS is studied with the help of Fluorescence Jasco Specfluorometer FP-8300 in the range of 200 – 600nm as shown in fig 3.5. The PL intensity peaks are found at 494nm and 560nm for pristine CdS and 493nm for Ni doped CdS. It is seen from the graph that intensities of CdS decreases when doping with Ni.
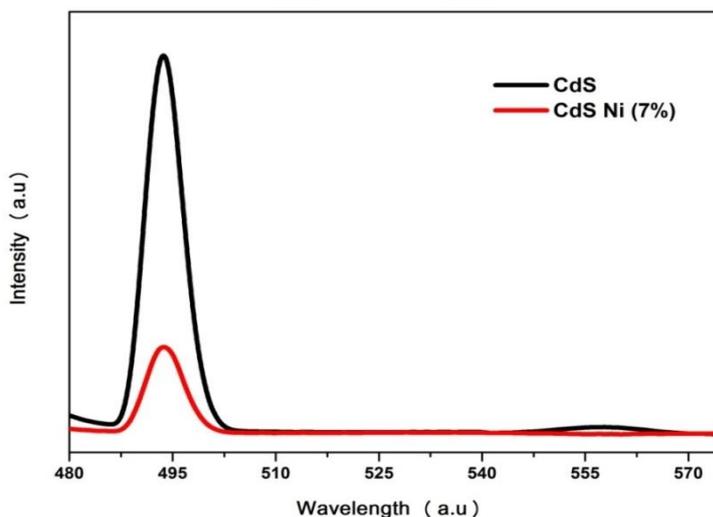

Fig.3.5 PL spectra of CdS and Ni doped CdS

4. Conclusion:

We have synthesized nano range CdS and Ni doped CdS by chemical bath deposition method at room temperature. Structural and optical properties have been studied with different instrumentation technique as XRD, TEM, SEM, EDAX, UV and PL. The particle sizes are found to be 6nm and 5nm for CdS and Ni doped CdS nanoparticles. Band gap increases with the concentration of doping which shows blue shift and it is found as 2.6nm and 2.8nm for CdS and Ni doped CdS nano particles. The advantage of doping element with Ni is that Ni is a ferroelectric substance. Hence it can be concluded that CdS with Ni doped could be great advantage in making semi conductor devices.

6. References:

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