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Morphological and Optical studies on synthesized $Cd_{(1-x)}Fe_xS$ Nanocomposites

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Abstract

The $Cd_{(1-x)}Fe_xS$ nanorods have been synthesized by co-precipitation method. The structural studies have been carried out through XRD and SEM/EDAX analysis. The structure of $Cd_{(1-x)}Fe_xS$ is found to exhibit hexagonal phase with preferred orientations. From SEM image the growth of $Cd_{(1-x)}Fe_xS$ nanorods have been confirmed and reported. The emission spectra of the $Cd_{(1-x)}Fe_xS$ samples have been recorded and analyzed. The band gap of $Cd_{(1-x)}Fe_xS$ have been calculated from the emission spectra of samples and it is reported as 2.14 eV.

1 Introduction

In recent years, II- VI semiconductor receives more attention due to their potential applications in electronic and optoelectronic devices, magnetic devices, in biological fields and in spintronics [1,2,3,]. In spintronic technology, the information's are transmitted in the semiconducting devices are carried by controlling the spin of the electrons. The incorporation of transition metal ions like Mn, Fe, Co, Ni, Cr on the semiconducting lattices will enhance the magnetic spin order of the system [4, 5]. Generally, the lattice site substitution will take place, if the diffusion force of the dopant ions is higher than the self-purification force. This substitution can be easily carried out by synthesizing the nanoparticles through controlled process. The Cds nanoparticles have been prepared through various techniques like chemical methods, Co-precipitation method, hydrothermal method, sol-gel method [4,5,6]. The doping of nanomaterials of dimension lower than Bohr diameter exhibits interesting optoelectronic properties due to the quantum size effect and CdS have been used as important phosphor for photoluminescence, electroluminescence, cathodoluminesence devices due to its better chemical stability [7]. From literature, we found that many researchers are interested to study the properties of doped CdS semiconducting compound due to its wide applications [8, 9, 10] and less work have been carried by doping Fe on CdS semiconducting compound. In the present work, we have synthesized the Fe-CdS nanorods and studied its structural and optical properties of the synthesized nanorods.

2 Experimental

The $Cd_{(1-x)}Fe_xS$ nanorods have been prepared by chemical Coprecipitation method. We have synthesized nanorods at room temperature by dissolving Cadmium Chloride ($CdCl_2$) and Sodium Sulphide ($Na_2S.6H_2O$) in distilled water by magnetic stirring process. After 2 hours of stirring, we added Ferric chloride ($FeCl_2$) powder and stirred for another 2 hours at room temperature. The dissolved solutions are kept in the beaker for 48 hours without any disturbances to obtain the precipitates of the samples. The precipitates are filtered and washed by distilled water for several times to remove the additional products present in the samples. The pure samples are dried and annealed at 400°C for 4 hours in hot furnace. The concentration of Fe on $Cd_{(1-x)}Fe_xS$ samples are varied with the value of x. we have taken the value of x as 0.2, 0.4 and 0.6 for S_1, S_2 and S_3 samples respectively. These samples are collected and subjected to morphological studies like XRD and SEM and optical studies like Photoluminescence spectroscopy.

3 Results and Discussion

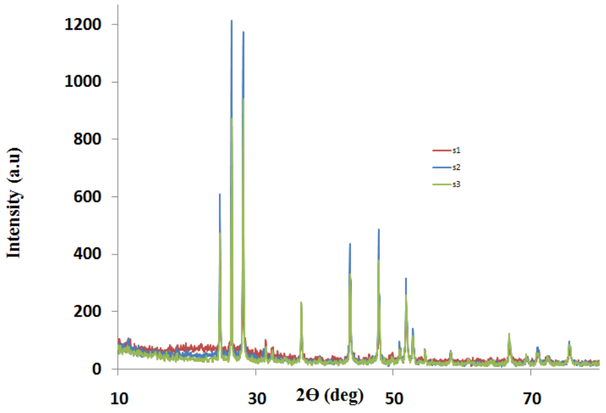

Fig-1 : XRD of $Cd_{(1-x)}Fe_xS$ (x=0.2, 0.4 and 0.6 for S_1, S_2 & S_3)

Figure-1 shows the XRD of synthesized $Cd_{(1-x)}Fe_xS$ nanorods with various Fe concentration. From XRD, we observed that the presence of sharp high intense peaks, which confirms that prepared samples shows good polycrystalline nature. The observed peaks are compared with the standard JCPDS (77-2306) data to determine the

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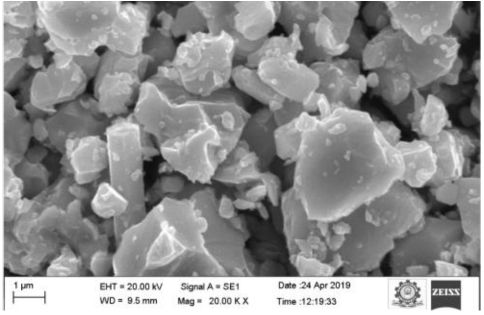
orientations of the samples and hence its structure has been identified. The high intense peaks around 24°82, 26 °1, 27 °9, 43.5, 48 °02, 66 °93 are observed and its corresponding orientations are (110), (002), (110), (112), (211) and (114) respectively. With these observations, we determine the structure of the samples as pure hexagonal structure without any traces of other secondary phases. These results agree well with literature [6, 11].The grain size of the synthesized samples have been determined using standard Debye-Scherer's formula. The average grain size of sample has been calculated as 113 nm.



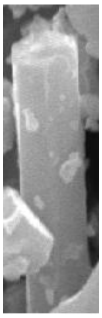
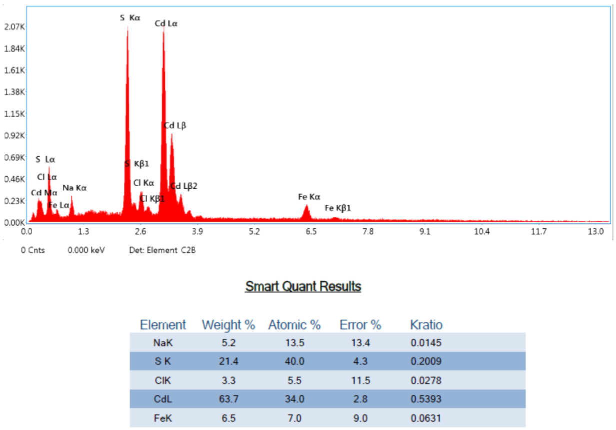


Fig-2: SEM images of $Cd_{(1-x)}Fe_xS$ Nanorods

Fig-2(a): Enlarged view of $Cd_{(1-x)}Fe_xS$ Nanorod

Fig.2 shows the SEM image of $Cd_{(1-x)}Fe_xS$ nanorods. From this image, we observed that the samples are well grown with well defined boundaries. This image confirms that there is no formation of clusters. In this image, we are able to observe clearly that the $Cd_{(1-x)}Fe_xS$ have grown in rod shape with the dimension of 0.6 micrometer in width and more than 5 micrometer in length. Fig-2(a) shows the enlarged view of the $Cd_{(1-x)}Fe_xS$ nanorod.

Fig.3 shows the EDX spectra of $Cd_{(1-x)}Fe_xS$ sample and the table of the compound composition present in it. From this table, we also confirm the presence of Fe element in CdS compound.



Smart Quant Results

Element	Weight %	Atomic %	Error %	Kratio
NaK	5.2	13.5	13.4	0.0145
S K	21.4	40.0	4.3	0.2009
ClK	3.3	5.5	11.5	0.0278
CdL	63.7	34.0	2.8	0.5393
FeK	6.5	7.0	9.0	0.0631

Fig-3: EDAX of $Cd_{(1-x)}Fe_xS$

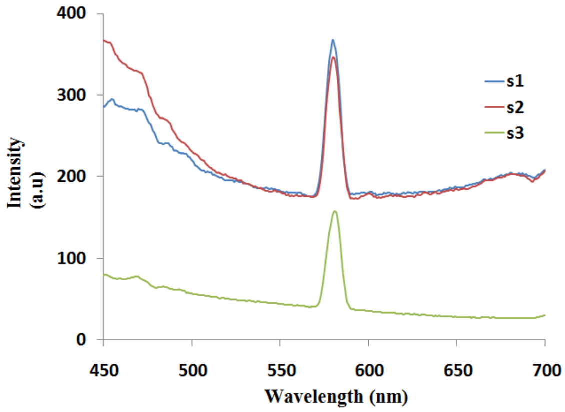


Fig-4: PL-Emission spectra of $Cd_{(1-x)}Fe_xS$

Figure-4 shows the emission spectra of $Cd_{(1-x)}Fe_xS$ samples recorded in the wavelength range between 300 nm and 700 nm with the excitation wavelength of 390nm. From emission spectra, we observed that the presence of sharp high intensed emission peak around 581 nm. The sharp emission peaks also indicates that the grown samples are exhibiting good crystalline nature which have been reported in the XRD studies. The emission peak of all samples is observed in the same wavelength range and there is no shift has been observed with the change in concentration of the Fe. The effect of Fe in the sample inhibits the growth of $Cd_{(1-x)}Fe_xS$ in nano rod form. The emission peak is associated with the lowest optical transitions and we can determine the band gap of the grown $Cd_{(1-x)}Fe_xS$ nanocompounds. We also determine the optical band gap of $Cd_{(1-x)}Fe_xS$ and the value of is calculated as 2.14eV. The band gap of pure CdS is 2.99 eV and Co doped CdS is 3.00 eV [1]. Generally for bulk CdS the emission peak will be broad in the 500 nm to 700 nm region which is attributed to the recombination from surface defects [1]. Emission spectrum shows that the broadness of the emission peaks are reduced and narrows compared to the bulk CdS which also confirms the reduction of defects on the surface of the samples. From the above discussions, we determined that the band gap is lesser than the reported values in literature. This occurs due to the quantum size effect in $Cd_{(1-x)}Fe_xS$

4 Conclusions

The $Cd_{(1-x)}Fe_xS$ nanorods have been synthesized successfully using Co-precipitation method. From XRD, the structure of samples is found to exhibit hexagonal structure. The SEM image of samples have been recorded and the growth of $Cd_{(1-x)}Fe_xS$ nanorods are clearly seen and its dimensions are reported in this work. The emission spectra of samples have been recorded and analyzed. From Pl spectra, the band gap of $Cd_{(1-x)}Fe_xS$ nanorods are calculated and reported as 2.14 eV. In this work, we have narrowed the band gap of bulk CdS from 2.9 eV to 2.14 eV by doping the Fe in CdS

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