

EFFECT OF GROWTH TEMPERATURE IN THE FORMATION OF CdS NANOPARTICLES

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ABSTRACT

In the present work different-sized CdS nanoparticles are grown by a chemical reduction method. The CdS nanoparticles are synthesized at different growth temperature. The structural and optical properties of CdS nanoparticles are characterized using TEM, SAD, XRD, optical absorption and photoluminescence study. The grown particle sizes are in the range of 6-11 nm. An increase in band gap is observed in each case as compared to bulk CdS. Also particle size increases with increase of growth temperature. Structural and optical properties of as prepared CdS nanoparticles are correlated.

KEYWORDS: CdS Nanoparticles, Structural Properties, Optical Properties, Photoluminescence

INTRODUCTION

The CdS nanoparticle is an important material in semiconductor industry. It has generated much interest because of their size dependent properties. The structural and optical properties of CdS nanoparticles are very different from their bulk form (1-4). CdS nanoparticles are very attractive for their application in solar cell, photo detector, laser, LED, sensor, bio leveling etc. (5-11). Its band gap energy can be tuned to employ the whole solar spectrum and enhance the efficiency of solar cell. CdS nanoparticles are prepared by various physical and chemical methods. Some of the chemical methods are arrested precipitation within the amphiphilic system, solid state reaction, thermolysis of single molecular precursor, sol gel process, solvothermal route etc. (12-16).

In the present work we have followed a simple chemical reduction method which is free from any environmental hazards and reliable (17). This chemical reduction method is cost effective also.

EXPERIMENTAL SECTION

CdS nanoparticles were prepared by a chemical reduction method. CdS was synthesized from anhydrous cadmium chloride (CdCl_2) and sulphur (S) powder. Sodium borohydride (NaBH_4) was used to initiate the reaction between CdCl_2 and S in the medium of tetrahydrofuran. In this process sodium borohydride acted as reducing agent. The dispersed solution of CdCl_2 , S and NaBH_4 in THF was magnetically stirred for three hour duration. The reaction was carried out separately at three different growth temperatures 25°C, 45°C and 55°C at a constant stirring speed. The grown CdS nanoparticles were washed and dried.

The microstructures of the as prepared CdS samples were studied by TEM (JEOL-JEM-200). SAD Pattern of CdS nanoparticles was also recorded. The Crystal phase grown CdS samples were characterized by x ray diffractometer

(RigakuMiniFlex-II). UV-Vis absorption spectra of the samples were obtained by using Shimadzu-Pharmaspec-1700 UV-Visible spectrophotometer. Photo luminescence spectrum of as prepared samples at room temperature was collected on Perkin-Elmer LS55 spectrophotometer.

RESULTS AND DISCUSSIONS

Figure 1 shows The TEM images of as prepared CdS nanoparticles at different temperature with corresponding SAD pattern. The as prepared particles are nearly spherical in shape. TEM images clearly indicate that sizes of the particles are affected by growth temperature.

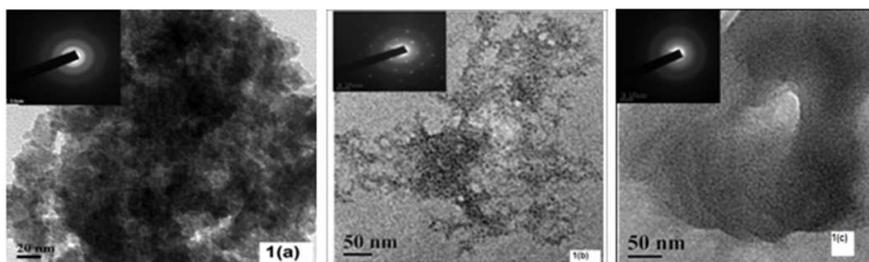


Figure 1: TEM image of (a) CdS-298K (b) CdS-318K (c) CdS-328K

The particle size of different samples is measured and it is found 11nm, 8.2nm and 6 nm for the sample grown at 298K, 318K and 328 K respectively. Figure 2 displays the diffraction pattern of as prepared samples with different growth temperature. X ray diffractogram of CdS nanoparticles show broad peaks.

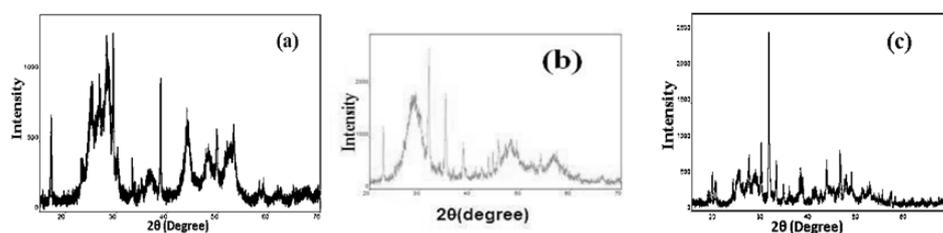


Figure 2: XRD Pattern of CdS Nanoparticles Grown at Different Temperature.

(a) 298 K (b) 318K (c) 328K

The inter planar spacing (d) of different planes corresponding to different peak is also calculated and illustrated in table1. The synthesized samples are in a mixture of hexagonal and cubic phase of CdS.

Table 1: Inter Planer Spacing Determination from XRD 2θ Plot of Samples

CdS 298 K			CdS 318 K			CdS 328 K		
2θ (degree)	Plane	d_{hkl} (Å)	2θ (degree)	Plane	d_{hkl} (Å)	2θ (degree)	Plane	d_{hkl} (Å)
25.89	(002) _{Hex}	3.438	23.03	(100) _{Hex}	3.859	24.48	(200) _{Cubic}	3.027
30.27	(200) _{Cubic}	2.95	24.62	(002) _{Hex}	3.614	26.92	(101) _{Hex}	3.31
36.39	(102) _{Hex}	2.467	26.47	(111) _{cubic}	3.36	43.14	(220) _{cubic}	2.095
43.97	(220) _{Cubic}	2.058	30.21	(200) _{Cubic}	2.072	48.367	(200) _{Hex}	1.88
49.66	(112) _{Hex}	1.834	43.65	(220) _{Cubic}	2.072			
51.3	(201) _{Hex}	1.781	52.86	(311) _{cubic}	1.73			

Figure 3 shows optical absorption spectrum of CdS nanoparticles. The absorption peak shifts to lower wavelength relative to bulk CdS. The band gap of as prepared nanoparticles are determined from the relation

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

Where C is a constant E_g is the band gap of the material and α is the absorption coefficient.

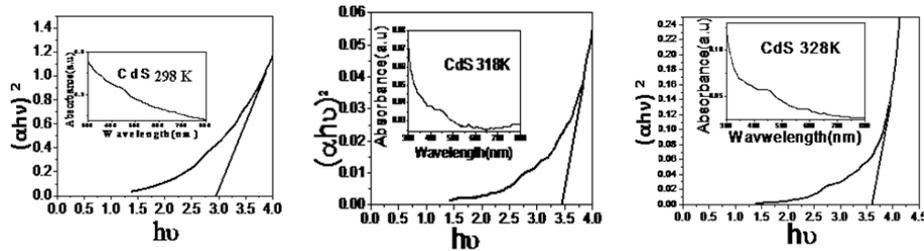


Figure 3: Optical Absorption Spectra of as Prepared CdS Nanoparticles

(a) CdS-298K (b) CdS-318K (c) CdS-328K

The plot of $(\alpha h\nu)^{2vs h\nu}$ is also shown in figure 3. From this plot band gap of different CdS samples are determined. Thus with the increase of temperature the band gap shifts to higher energy as shown in table 2.

Figure 4 shows the photo luminescence spectrum of as prepared CdS samples.

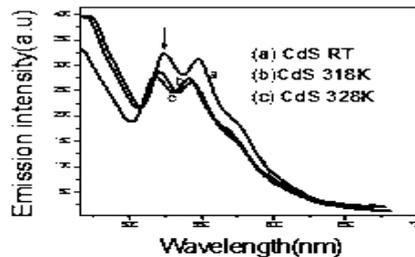


Figure 4: Photoluminescence Spectra of as Prepared CdS Nanoparticles

Photoluminescence spectrum displays peak around 525 nm due to presence of surface states (18-19). Also the peak of the photoluminescence spectra is shifted towards higher energy for higher growth temperature which is shown in table 2.

Table 2: Characteristics of as Prepared CdS Nanoparticles

Growth Temperature	Particle Size(nm) from TEM	Band Gap(ev)	Emission Peak (nm)
298K	11	2.90	527.21
318K	8.2	3.41	525.5
328K	6	3.57	522.82

The decrease of particle size with increase of temperature is possibly due to higher kinetic energy of the particles in the medium. Thus the particles try to be separated out instead of agglomeration. As a result the probability of formation of larger size particle is reduced with increase of temperature. Hence there is a shift of band gap towards higher energy with increase of temperature as the sizes of the nanoparticles are reduced. Therefore more and more quantum confinement is possible with increase of temperature.

CONCLUSIONS

CdS nanoparticles have been grown by a simple hazard free chemical route. Nanoparticle of different size and nearly spherical shape is obtained by a simple route. Therefore the process is cost effective. The grown CdS nanoparticle of different size can be used to fabricate in various devices like solar cell.

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REFERENCES

1. Alivisatos, A.P. (1996). *Science*, 271, 933
2. Peng, X.G., Manna, L., Yang, W.D., Wickham, J., Scher, E., Kadavanich, A., Alivisatos, A.P. (2000). *Nature*, 404, 59
3. Bawendi, M. G., Steigerwald, M. L., Brus, L. E. (1990). *Annu. Rev. Phys. Chem.*, 41, 477
4. Trindade, T., O'Brien, P., Pickett, N.L. (2001). *Chem. Mater.*, 13, 3843
5. Hullavarad, N.V., Hullavarad S.S. (2007). *Photo. Nano. Fund. Appl.*, 5 (4), 156
6. Colvin, V.L., Schlamp, M.C. Alivisatos, A.P. (1994). *Nature* 370, 354
7. Huynh, W.U., Dittmer, J.J., Alivisatos, A.P. (2002). *Science*, 295, 2425
8. Tessler, N., Medvedev, Kazes, V. M., Banin, U. (2002). *Science*, 295, 1506
9. Mattoussi, H., Radzilowski, L.H., Dabbousi, B.O., Thomas, E.L., Bawendi, M.G., Rubner, M.F. (1998). *J. Appl. Phys.*, 83, 7965
10. (Taguchi, T., Endoh, Y., Nozue, Y. (1991). *Appl. Phys. Lett.*, 56, 342
11. Sun, S.H., Murray, C.B. (1999). *J. Appl. Phys.*, 85, 4325
12. Towey, T.F. Khan –Lodi, A., Robinson, B.H. (1990). *J. Chem. Soc. Faraday Trans.*, 86, 3757
13. Gautam, U.K., Seshadri, R. Rao, C.N.R. (2003). *Chem. Phys. Lett.*, 375, 560
14. Wang, W., Zhihui, L., Changlin, Z., Congkang, X. (2003) *Mater. Lett.*, 57(18), 2755
15. Pickett, N.L., O'Brien, P. (2001). *The Chem. Rec.*, 1, 467
16. Crouch, D., Norager, F., O'Brien, P., Park, J., Pickett, N. *Phil. Trans. A.*, (2003). 361, 297
17. Wang, W., Germanenko, I., El-Shall, M.S. (2002). *Chem. Matter*, 14, 3028
18. Alivisatos, A.P. (1996). *J. Phys. Chem.*, 100, 13226
19. Okamoto, S., Y. Kanemitsu, Hosokawa, H., Murakoshi, K., Yanagida, S. (1998). *Solid. State. Commun.*, 10, 1, 7