Investigation on X-ray diffraction of CdS Thin Films Prepared by Sol-Gel Dip Coating Method

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Abstract

In the present work, conventional chemical sol-gel dip coating method was employed for the preparation of CdS nanoparticles. XRD studies reveal that CdS crystallizes in single phase hexagonal structure. The particle size of CdS nanoparticles is obtained as 13nm.In recent decades innovative nanomaterials have been broadly studied, aiming at both investigating the structure-property relationship and discovering new properties, in order to achieve pertinent improvements in current state-of-the art materials. Recently, controlled growth and assembly of nanostructures into hierarchical and complex architectures have played a key role in engineering novel functionalized materials. Since the structural characterization of such CdS nanomaterials is a fundamental step, here we discuss X-ray scattering/diffraction techniques to analyze CdS nanomaterials under different annealing temperature.

Keywords: ***CdS nanoparticles, Sol-Gel Dip Coating, XRD, Thermal annealing***

1. Introduction

Nanostructure sulfides (CdS and ZnS) have been widely studied with a view to launch a relationship between structure, size and optical properties [1]. II-VI semiconductor nanoparticles are currently of enormous interest for their practical applications such as zero-dimensional quantum confined materials in optoelectronics and photonics. Among these, CdS has been considered due to its potential technological applications in field effect transistors, solar cells, photovoltaic, light emitting diodes, photocatalysis, photoluminescence, infrared photodetector, environmental sensors and biological sensors [2-8]. There are various methods reported in the literature to fabricate nanoparticles by physical [9, 10], chemical methods [11] and ion implantation [12]. In the present study we have synthesized CdS nanoparticles through sol-gel dip coating technique. CdS nanoparticles are extensively characterized using X-Ray diffractometer.

2. Experimental Details

2.1 Substrate cleaning method

CdS thin films were synthesized on glass substrate. Started by glass substrate with distilled water, then surface rubbed with acetone socked cotton. Substrate immersed into chromic acid solution takes 30 minutes then again cleaned with Distilled water and acetone. Thereafter put into sodium hydroxide solution for another 30 minutes. Then immersed into 2-proponal in the ultrasonic agitation for 15 min. Finally glass substrate is dried in hot air oven at 70ºC.

2.2 Sol-Gel Dip coating method

In this method allows the deposition thin films in order to few nanometers and easy, inexpensive preparation technique. Physical properties of the CdS films are depend on the parameters of bath temperature, material concentrations, pH value and substrate.

Precursors used for the preparation of CdS solutions are Cadmium chloride ($CdCl_2$ –Cadmium source), thiourea (Sulphur source), Sodium citrate (catalyst), Distilled water and liquid ammonia (pH variation). Initially 0.2 M of ($CdCl_2$) Cadmium chloride was mixed with 0.05M of thiourea and Sodium citrate. 60ml of Distilled water was added under constant stirring time for 3Hrs.On the mean time liquid ammonia was added drop by drop using syringe. Liquid ammonia was used for pH measurement and controlled to obtain the value of pH -11.0. The substrate was immersed in the prepared solution on dipping time for 10 minutes and drying time for 10 minutes. Sol-Gel dipping coating process was done by 5 times with the dried temperature of 80ºC. As prepared CdS thin films are annealed with various temperatures of 400ºC and 500ºC.

3. Result and Discussion

3.1 X-ray diffraction XRD

The nanostructural properties of the dip coated CdS thin films have been investigated by X-ray diffraction (XRD) technique as the shown in Fig.1a and 1b prepared by sol-gel dip coating technique annealed at 400°C and 500°C for one hour. XRD pattern provided information about crystalline phase of the nanoparticles as well as the crystallite size. Figure 1a shows the X-ray diffraction pattern of the as synthesized CdS nanoparticles. Peaks are observed at 24.35°and 27.91° corresponding to JCPDS card 47-1179, the (400) and (420) planes of the cubic and hexagonal phases of CdS thin film annealed at 400°C, while Figure 1b shows the CdS thin film annealed at 500°C, appeared one peak at 24.86° corresponding to the (400) plane of the hexagonal phase with reference to JCPDS card 47-1179. The intensity of the peak is observed at thin film annealed at 500°C is higher than the film annealed at 400°C. The observed sharp peak compared to bulk CdS sample indicates the presence of good crystalline nature, which is good for photocatalytic reaction.

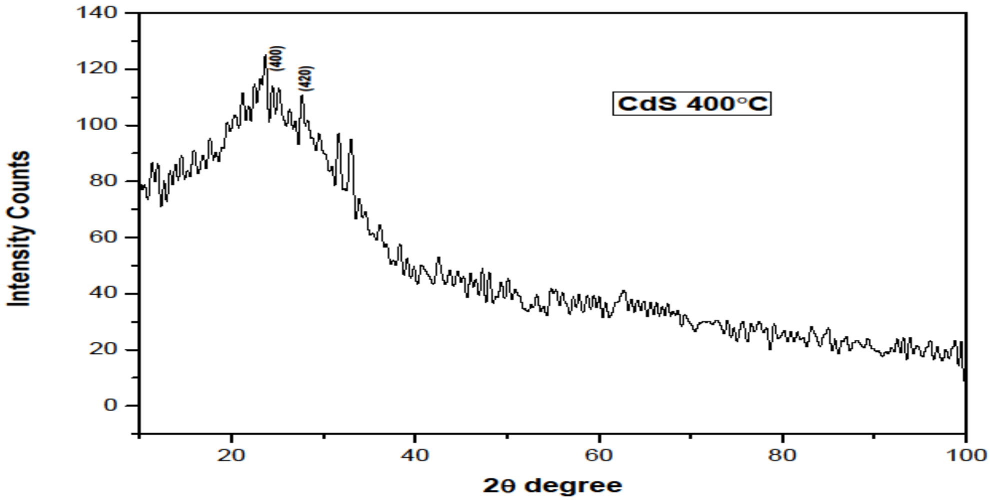

Figure 1a: XRD pattern of CdS thin film annealed at 400°C

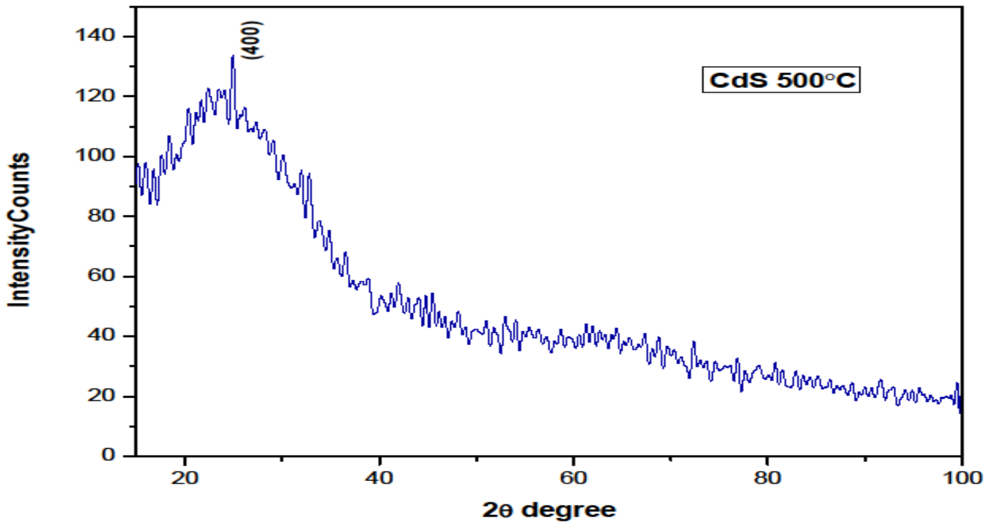

Figure 1b: XRD pattern of CdS thin film annealed at 500°C

4. Conclusion

Sol-gel dip coating method has been successfully developed to synthesize CdS nanostructures without using any capping agent at different annealing temperature. XRD pattern shows diffraction lines due to CdS X-ray diffraction patterns, revealed that the synthesized CdS nanostructures have hexagonal structure we found that the grain size increase with increasing the annealing temperature respectively. CdS nanomaterials are today combined with biomaterials, proteins, and polymers to create multi-function hierarchically ordered complex systems. Therefore, X-ray scattering based techniques are showing, more and more, their great potential and effectiveness for the multiple-length-scale structural analysis of CdS nanomaterials.

5. References

[1] V.I. Klimov, J. Phys. Chem. B 110, 16827(2006).

[2] A.Fukoka, Y.Sakamoto, S.Guan, S.Inagaki. N.Sugimoto, Y.Fukushima, K.Hirahara, S.Iijima, M.Ichikawa, J.Am.Chem.Soc. 123, 3373(2001)

[3] A.Henglein, Chem.Rev.89, 1861(1989).

[4] C.Petit, M.P.Pilleni, J.Phys.Chem. 92, 2282(1988).

[5] A.P.Alivisatos, Science 271, 933 (1996).

[6] V.L.Kolvin, M.C.Schlamp, A.P.Ailivisatos, Nature 370, 354(1994).

[7] D.L. Klein, R.Roth, A.K.L. Lim, A.P.Ailivisatos, Nature 389, 699(1997).

[8] C.Yang, X.Zhou, L.Wang, X.Tian, Y.Wang, Z.Pi, J.Mater.Sci. 44,3015(2009).

[9] F.Antolini, A.Ghezelbash, C.Esposito, E.Trave, L.Tapfer, B.A.Korge, Mater.Letter. 60, 1095(2006).

[10] J.S.Jie, W.J.Zhang, Y.Jiang, X.M.Meng, Y.Q.Li, S.T.Lee, Nano Lett. 6, 1887(2006).

[11] N.V.Deshmukh, T.M.Bhave, A.S.Ethiraj, S.R.Sainkar, V.Ganesan, S.V.Bhoraskar, S.K.Kulkarni, Nanotechnology 12,290-294(2001).

[12] U.V.Denisca, O.Gamulin, A.Tonej, M.Ivanda, C.W.White, E.Sonder, R.A.Zuhr, Mater.Sci.Eng.C 15,105(2001).

[13] Balram Tripathi, Y.K.Vijay, F.Sing, D.K.Avasthi, S.Wate, Journal of Alloys and Compounds 459, 118(2008).

[14] B.D Cullity, Elements of X-Ray Diffraction, Addison-Wesley, Reading, MA, (1977).

[15] E.Wu, POWD, An interactive powder diffraction data interpretation and indexing program Ver2.1, School of Physical Science, Flinders University of South Australia, Bedford Park S.A. 5O42 AU.

[16] M.Thambidurai, N.Muthukumarasamy, S.Agilan, N.Murugan, N.Sabari Arul, S.Vasantha and R. Balasundaraprabhu, Solid State Sciences 12, 1554-1559 (2010).

[17] L.E.Brus, J.Chem.Phys.79, 5566(1983).

[18] J.Tauc (Ed.), Amorphous and Liquid Semiconductors, Plenum Press, New York, 159 (1974).

[19] C.W.Litton, D.C.Reynolds, Phys.Rev. A 133, 536 (1964).

[20] J.I.Pankove, Optical Process in Semiconductors, New Jersey, USA 34 (1971).