Indian J. Phys. **78A** (1), 121-124 (2004)

Nanomaterials–2003

AN INTERNATIONAL JOURNAL IJP

Synthesis and characterization of nanocrystalline zinc sulphide by wet chemical route

R Maity, S Kundoo, P K Ghosh and K K Chattopadhyay*

Department of Physics, Jadavpur University,
Kolkata-700 032, India

E-mail : kkc@juphys.ernet.in

Abstract Nanometer-sized ZnS crystallites were synthesized by a wet chemical synthesis process Thin films of these nanocrystallites were also prepared on glass substrates and annealed in vacuum at various temperatures. The nanocrystalline powders were characterized by X-ray diffraction (XRD) and transmission electron microscopy (TEM) studies. The thin films were characterized by UV-visible optical absorption spectroscopy XRD and TEM data confirmed the nano sizes of the crystallites. Also they showed the typical interplanar spacings (d value) corresponding to the cubic phase of ZnS Band gap value increased in the nanomaterial than the bulk value Sizes of the nanocrystallites were also determined from the band gap shift Annealing of the thin films modified the band structure and particle sizes were increased.

Keywords · Zinc sulphide, nanocrystalline, wet chemical process

PACS Nos. · 81 07.Bc, 68.37 Lp

1. Introduction

Nanometer-sized semiconductor particles have attracted much attention over the past few years because of their novel electrical and optical properties originating from quantum confinement. The emphasis has been mainly given on the synthesis of semiconductor particles belonging to II-VI and III-V groups, which show significant quantum confinement effects. Semiconductor nanoparticles exhibit size-dependent electronic band gap energies [1], melting temperatures [2], solid-solid phase transition temperatures [3] and pressures [4]. In addition to these, doped semiconductor nanoparticles have tremendous potential for use in light emitting applications. These properties of nanocrystals make them an interesting category of materials for optoelectronic applications. For example, ZnS is an important material for a variety of applications such as, electroluminescent devices, solar cells and other optoelectronic devices. Also manganese doped ZnS nanoparticles have photoluminescent efficiency, higher than that of bulk ZnS : Mn [5]. Hence, there has been growing interest in developing techniques for preparing semiconductor nanoparticle films. The wet chemical synthesis method is a simple and inexpensive alternative to more complex chemical vapor deposition (CVD) and physical techniques. The physical methods [6] that are commonly used for the fabrication of low-dimensional solids have some resolution limits that restrict these techniques from reaching to nanometer scale. On the other hand, colloid chemistry route offers a simple means to synthesize such particles with good control of size and size distribution. In the past few years there have been various reports [7,8] for synthesizing nanometer-sized ZnS particles by wet chemical process using a suitable capping or surface-passivating agents to control the size of the particles. To date, there have been a very few reports [9] on the systematic studies of how the structural and optical properties change when these nanoparticles are annealed.

In this article, we report the synthesis of nanometer-sized ZnS particles by a wet chemical synthesis process without using any capping agent/surfactant and also we have prepared thin films of these nanoparticles. We have studied the changes in structural and optical properties of these films with the variation of annealing temperature.

2. Experimental

We have synthesized ZnS nanocrystallites by a chemical process without using any capping agent. Our synthetic root followed was a modification of the method adopted by Nanda *et al* [7]. To prepare ZnS nanocrystallite powders, we have taken two types of solution. Solution-I was prepared by dissolving zinc acetate dihydrate (6.6 mmol) in 150 ml of dimethyl formamide

* Corresponding Author

200°C, 300°C) films respectively. From these results, it is clear that particle size increased with annealing temperature.

4. Conclusions

ZnS nanocrystallites have been successfully synthesized by a wet chemical synthesis process without using any capping agent. Also the thin films of these were prepared on glass substrates. X-ray diffraction and transmission electron microscopy studies revealed that the synthesized particles have cubic zinc blende structure. Band gap values were determined from the optical transmission studies of the as-deposited and annealed films. From the shift of the band gap with respect to the bulk value, sizes of the nanocrystallites were determined.

Acknowledgments

Two of us (R M and S K) wish to thank CSIR, Govt. of India, for awarding them junior research fellowship during the execution of the work.

References

[1] L E Brus *J. Chem. Phys.* **80** 4403 (1984)

[2] A N Goldstein, C M Echer and A P Alivisatos *Science* **356** 142 (1992)

[3] S B Qadri, E F Skelton, D Hsu, A D Dinsmore, J Yang, H F Gra and B R Ratna *Phys. Rev.* **B60** 9191 (1999)

[4] C C Chen, A B Herhold, C S Johnson and A P Alivisatos *Scienc* **276** 398 (1997)

[5] R N Bhargava, D Gallagher, X Hong and A Nurmikko *Phys. Re Lett.* **72** 416 (1994)

[6] A P Alivisatos *MRS Bull* **23** 18 (1998)

[7] J Nanda, S Sapra and D D Sarma *Chem. Mater.* **12** 1018 (2000)

[8] B Bhattacharjee, D Ganguli, K Iakoubovskii, A Stesmans and S Chaudhuri *MRS Bull.* **25** 175 (2002)

[9] A D Dinsmore, D S Hsu, S B Qadri, J O Cross, T A Kennedy, H J Gray and B R Ratna *J. Appl. Phys.* **88** 4985 (2000)

[10] J C Manifacier, M De Murcia, J P Fillard and E Vicario *Thin Soli Films* **41** 127 (1997)

[11] J I Pankove *Optical Processes in Semiconductors* (New Jersey Prentice-Hall) (1971)

[12] Y S Yuang, Y F Chen, Y Y Lee and L C Liu *Jpn J. Appl Phys* 7 3041(1994)