OPTOELECTRONICS AND ADVANCED MATERIALS – RAPID COMMUNICATIONS Vol. 4, No. 10, October 2010, p. 1445 - 1447

NLO properties of tin sulfide nanoparticle by precipitation method

D. NITHYAPRAKASH*, J. CHANDRASEKARAN
PG and Research, Department of Physics, Sri Ramakrishna Mission Vidyalaya College of Arts and Science, Coimbatore – 641 020, Tamil nadu, India

SnS nanoparticles were successfully synthesized by precipitation method. The as-prepared samples were characterized by X-ray diffraction and scanning electron microscopy. The SEM measurements show the aggregates of small nanocrystals in which size of 15 nm were estimated by Scherrer's formula. The chemical composition of the prepared sample was analyzed by an EDS. The optical properties were obtained from UV-VIS spectra and the optical bandgap was calculated. The SnS nanoparticles were also studied by NLO properties.

(Received July 19, 2010; accepted October 14, 2010)

Keywords: SnS Nanoparticles, X – ray diffraction, Optical properties, NLO

1. Introduction

In recent years, semiconductor nanostructures such as nanoparticles, nanorods, nanotubes, nanowires and nanobelts have attracted intensive interest due to their novel physiochemical properties that differ greatly from their bulk counterparts [1]. Nanomaterials have been extensively studied due to their unique physical and chemical properties and potential applications in diverse areas [2]. IV-VI semiconductor compounds such as PbSe, SnSe and SnS have been important role in different areas of materials science for several decades [3].

Tin sulfide is one of the most important chalcogenides showing a variety of phases, such as SnS, SnS_2, Sn_2S_3 and Sn_3S_4 due to the versatile coordinating characteristics of tin and sulfur. Tin monosulfide [SnS] is a narrow bandgap semiconductors with an optical bandgap 1.33 eV [4]. It belongs to the layered semiconductors having orthorhombic structures, where the Sn and S are tightly bonded in a layer and the layers are bonded by weak Vander Waals force [5]. Especially, SnS had attracted more attention of researchers owing to its interesting properties and potential application in photoconductors [6], near-infrared detector [7], holographic recording system [8], photovoltaic materials with high conversion efficiency [9], a solar absorber a thin film solar cell [10], commercial semiconductors sensors in environmental industrial and biomedical monitoring [8].

In this paper, we report the structural, optical and NLO properties of synthesized SnS nanoparticles.

2. Experimental

2.1 Preparation of tin sulfide nanoparticles

The $SnCl_2.2H_2O$ and Na_2S were used in this experiment analytical grade. $SnCl_2.2H_2O$ and Na_2S were taken in deionized water individually. Both solutions were stirrered continuously until dissolved well. Then the solutions were mixed together and stirred vigorously. After precipitation, the formed SnS was filtered and washed with methanol and deionized water. Then the product was dried at room temperature and grained.

2.2 Characterization

The as-synthesized samples were characterized using a combination of the following techniques. X-Ray diffraction (XRD), scanning electron microscope (SEM), Energy Dispersive analysis by X-rays (EDS), UV-VIS spectrophotometer and NLO properties.

3. Results and discussion

Fig. 1 shows the XRD pattern of the SnS nanoparticles. From this figure it is clear that, the XRD of the SnS exhibits prominent peaks when the scattering angles (2θ) were: 27.05°, 34.33°, 38.17° and 51.88°, which could be indexed to scattering from the (112), (022), (005) and (116) plane respectively. All the diffraction peaks can be indexed to orthorhombic crystalline phase of SnS with lattice parameters a= 5.69 Å, b = 5.78 Å, c = 11.77 Å, which is in good agreement with literature value (JCPDS: 79-2193). In the XRD spectrum, no characteristic peak was observed for other impurities such as SnS_2, Sn_2S_3, Sn_3S_4 etc., implying the formation of the single phase tin monosulfide. The strong and sharp diffraction peaks indicate that the product is well crystallized. The intensity of (112) peak is very strong; revealing the as-prepared nanoparticles have high preferential orientation along the Scherrer equation [11] is about 15 nm.

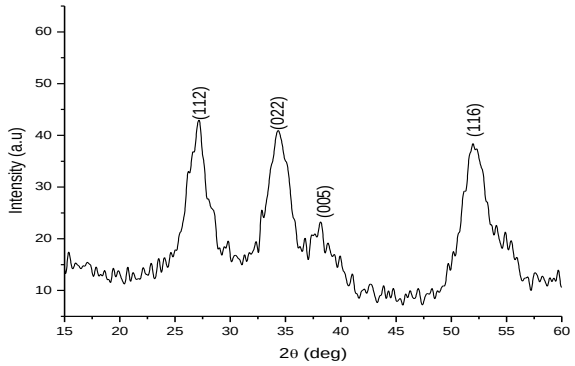

Fig. 1. XRD pattern of SnS nanoparticles.

Mean while, from the XRD pattern it can be seen that no impurities are detected in the sample, which was further confirmed by the EDS analysis, which illustrates that only Sn and S were detected and the atomic ratio of Sn: S was stoichiometric 1:1, in agreement with the expected value. The EDS spectrum of SnS nanoparticles as shown in Fig. 2.

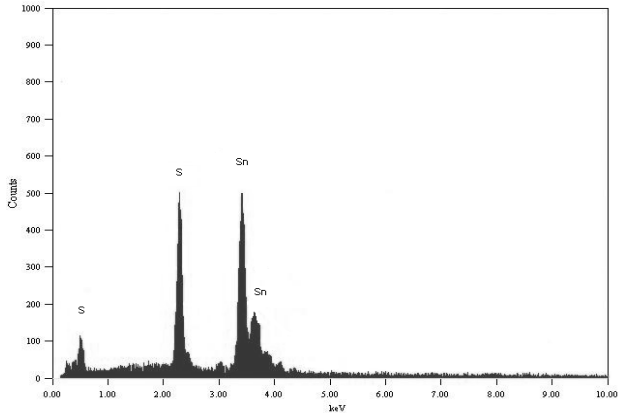

Fig. 2. EDS spectrum of SnS nanoparticles.

Fig. 3 shows the SEM image of SnS nanoparticles. This SEM image reveals that the particles are in aggregation state due to their extremely small dimensions and high surface energy.

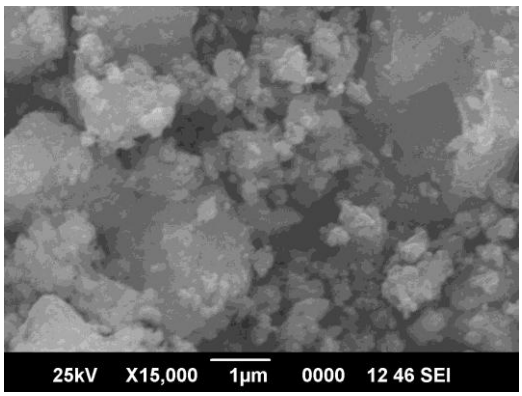

Fig. 3. SEM image of SnS nanoparticles.

The UV-VIS absorption spectra of SnS nanoparticles as shown in Fig. 4. It is clearly observed that the nanoparticles have a wide absorption range from UV-VIS region, which means it is good for absorption of the sunlight [12]. $(\alpha h\nu)^n$ verus hν plot for n = 2,1/2,1/3 shows linear behavior for n = 2 direct optical bandgap in the particles (Fig. 5), the optical bandgap is calculated as 1.48 eV.

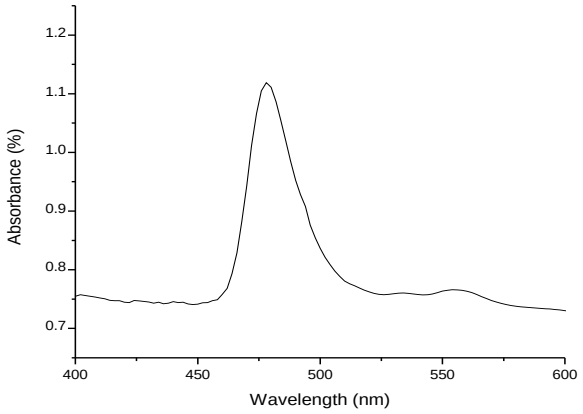

Fig. 4. UV-VIS absorption spectrum of SnS nanoparticles.

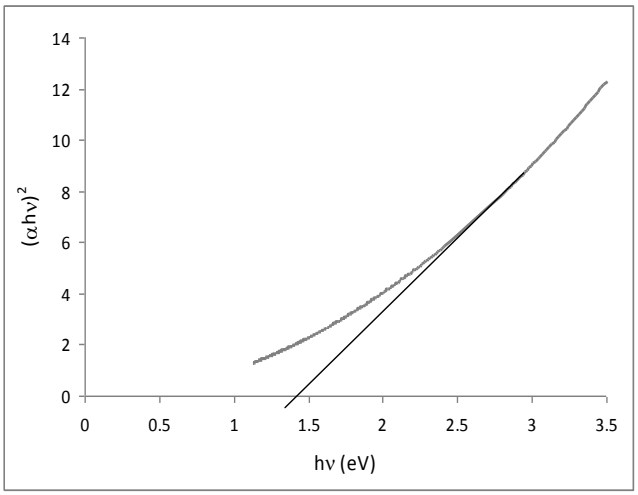

Fig. 5. Plot $(\alpha h\nu)^2$ versus hν of SnS nanoparticles.

The SHG intensity of the SnS nanoparticles was measured using the Kurtz and Perry powder technique [13]. The particles were grained into fine powder and packed in the micro capillary tube. A Q – switched Nd: YAG laser (1064 nm) has been used. The input pulse energy 3.1 mJ/pulse and pulse width 8 ns were incident on the SnS powder. The generation of the second harmonics was confirmed by the emission of green radiation. The present result shows SHG conversion efficiency of KDP is 20 mV and for SnS nanoparticles is 33 mV. Therefore efficiency of the SnS nanoparticles was high compared to KDP.

4. Conclusion

In summary, SnS nanoparticles are successfully synthesized by precipitation method. The XRD pattern reveals that crystallinity of the SnS nanoparticles appeared as an orthorhombic structures. SEM micrograph shows the aggregation state of SnS nanoparticles. The EDS spectrum reveals that the stoichiometric is maintained. In UV-VIS absorption spectrum shows that the nanoparticles have a wide absorption range and 1.48 eV direct allowed transition energy gap. NLO property gives information of the second harmonic which may be due to emission of green radiation. SHG conversion efficiency of SnS nanoparticles is 33 mV, which is high compared to KDP. These results shows that the SnS nanoparticles are promising materials for application in optoelectronic devices.

Acknowledgement

The two of us (J.C and D.N) gratefully acknowledge the financial support from the UGC, Govt. of India for the major research project (F-33-19/2007(SR)).

References

[1] A. P. Alivisatos, Semiconductor clusters, nanocrystals and quantum dots, Science **271**, 933 (1996).
[2] U. Simon, R. Flesch, H. Wiggers, G. Schon, G. Schmid, J. Mater. Chem. **8**, 517 (1998).
[3] K. Unger, Verbindungshalbletier, Akademische Verlagsanstalt, Leipzing, (1986).
[4] L. S. Price, I. P. Parkin, A. M. E. Hardy, R. J. H. Clark, Chem. Mater. **11**, 1792 (1999).
[5] H. Zhu, D. Yang, Y. Ji, H. Zhang, X. Shen, J. Mater. Sci. **40**, 591 (2005).
[6] J. B. Johnson, H. Jones, B. S. Latham, J. D. Parker, R. D. Engelken, C. Barber, Semicond. Sci. Technol. **14**, 501 (1999).
[7] N. K. Reddy, K. T. Reddy, Thin Solid Films **325**, 4 (1998).
[8] M. Radot, Rev. Phys. Appl. **18**, 345 (1977).
[9] J. P. Singh, P. K. Bedi, Thin Solid Films **199**, 9 (1991).
[10] N. K. Reddy, K. T. R. Reddy, Rec. IEEE Photovolt. Spec. Conf. **26**, 515 (1997).
[11] H. P. Klugg, L. E. Alexander, X – Ray Diffraction Procedures, Wiley, Newyork, (1954).
[12] J. R. S. Brownson, C. Georges, C. Clement, Chem. Mater. **18**, 6397 (2006).
[13] S. K. Kurtz, T. T. Perry, J. Appl. Phys., **39**, 3798 (1968).

*Corresponding author: nithip12@gmail.com