

Blue shift in band gap and enhanced emission in SnS nanostructures with high Sn concentration

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1. Introduction

Among the IV-VI group semiconductor nanostructures, GeS, SnS and PbS are important functional materials. SnS has been attracting wide attention due to its layered property and low toxicity. SnS has a narrow band gap and belongs to the layered semiconductors having orthorhombic structures, where Sn and S are tightly bonded in a layer and layers are bonded by weak Vanderwaals force [1]. In this work we report on the shift in band gap and enhanced photoluminescence in SnS nanostructures by increasing the Sn concentration. We study the effect of metal ions on the nanostructures as highly degenerate structures with plasmonic properties. It has potential application in photoconductors, near IR detectors, holographic recordings, photovoltaic materials, commercial sensors and biomedical monitoring [2]

2. Experimental details

The precursors tin chloride (SnCl_2) and thioacetamide ($\text{C}_2\text{H}_5\text{NS}$) are commercially obtained from Sigma Aldrich and used as received without any purification. Equimolar concentration (0.1 M) of SnCl_2 and $\text{C}_2\text{H}_5\text{NS}$ are dissolved separately in 100 ml doubly distilled water under continuous stirring for 10 minutes. Thioacetamide solution is gradually injected into SnCl_2 solution and stirred continuously for two hours at room temperature. Initially, the solution remains transparent and colorless. The reaction mixture is allowed to undergo slow precipitation at a constant temperature of 30°C in a thermally insulated container. $\text{C}_2\text{H}_5\text{NS}$ is a slow releaser of sulfur and its reaction with SnCl_2 is a gradual process. After an ageing time of 24 hours, the solution appears brown in color, indicating the formation of SnS particles. The precipitate can be separated by centrifuging at 4000 rpm for 30 minutes. The precipitate is then washed twice with ethanol to remove impurities and is well dried before storage. The pH of the solution is maintained as 1. The concentration of Sn in SnS is increased by changing the molarity of SnCl_2 from 0.1 M to 0.6 M. Hence the ratio Sn and S is varied from 1 to 6 [3]. The obtained powder is characterized using FESEM, X-Ray diffraction studies, optical absorption spectroscopy and photoluminescence studies.

3. Results and discussion

Figure 1 shows the FESEM image of SnS particles synthesized by homogenous precipitation method. The SnS nanoparticles cluster together to form structures of size ~ 100 nm.



Figure 1 SnS nanoclusters of size ~ 100 nm

The absorption spectra of SnS nanoclusters shown in figure 2a shows that the onset varies with increase in concentration of SnS from 1 to 6. From the Tauc plot (Figure 2b) it is clear that the band gap of SnS varied from 3.1 eV to 3.6 eV when the Sn/S is varied from 1 to 6.

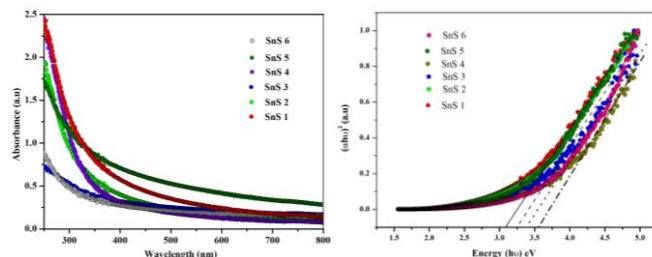


Figure 2 (a) Variation in absorption onset with increase in Sn concentration (b) Tauc plot showing the shift in band gap with increase in Sn concentration

With increase in concentration of Sn, we observe that photoluminescence of SnS at wavelength ~ 600 nm increases. The enhancement of emission and blue shift in band gap is attributed to the plasmonic nature of Sn particles present in the SnS nanostructures.

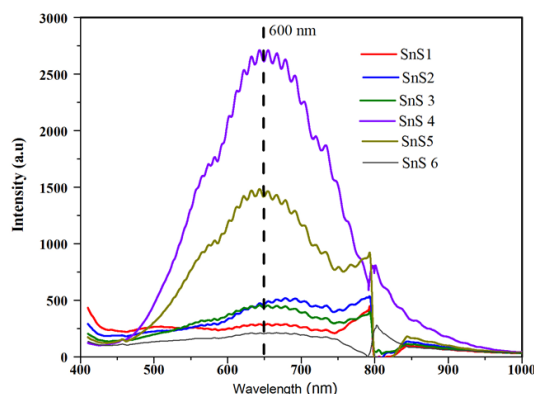


Figure 3 Photoluminescence of SnS nanostructures

4 Conclusions

Sn metal ions present in SnS nanoparticles lead to blue shift in the band gap of SnS nanoparticles due to plasmon assisted interaction between the excitons. The influence of the plasmonic particles also assist in enhancing the photoluminescence (600 nm) by modifying the radiative states of SnS nanoparticles.

Reference

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2. J. B. Johnson, H. Jones, B.S. Latham, J.D. Parker, R.D. Engelken, C.Barber, 1999 *Semicond. Sci. Technol.* 14,501.
3. Anita R Warriar and R Gandhimathi 2018 *Methods Appl. Fluoresc.* 6 035009