Chapter 8

Conclusions and Future Prospects

Our main aim in the reaserch work is to synthesize good quality SnS nanocrystals as well as dopped SnS nanocrystals in simple and cost effective way. The grown nanoparticles have been studied structurally, optically and electrically by different tools and techniques. Finally, the as grown samples have been applied in the fabrication of various devices. Here we have grown different sizes of SnS nanoparticles by chemical reduction method, wet chemical precipitation method, solvothermal method as well as hydrothermal method. Also, Fe doped and Mn doped SnS nanocrystals were successfully synthesized. The SnS-Ag nanocomposite was prepared by cost effective solvothermal method. We have also synthesized the SnS nanoparticle using Gymnema Sylvestre leaf extract as a reaction medium and also a capping agent. Our main aim was to vary the size of the nanoparticles and we successfully get control over the size of the nanoparticles. The crystallite size of SnS nanoparticles increase with growth time as well as growth temperature. For doped samples it was observed that the grain size increase due to doping and the grain size is greater for Mn doped SnS nanoparticles. The as prepared SnS-Ag nanocomposite shows smaller sized (~7.5 nm) particles. The green method confirmed that the particle diameter of green synthesized SnS NPs is lower than the chemically synthesized SnS NPs.

The time varying (3h to 14h) SnS nanoparticles have been utilized to fabricate ethanol gas sensor. The gas sensing sensitivity was found to be maximum for sample grown for 7 hour at 300 ^{0}C and it was 61%. The selectivity to ethanol gas, higher sensitivity at moderate temperature as well as good stability over four weeks are shown by the fabricated gas sensor based on 7 hour grown SnS naoprticles. This is probably due to the chainlike shape, good stochiometry as well as moderate roughness. Therefore, the stochiometry, shape and roughness take an important role in sensing the gas.

The sizes dependent electrical properties of SnS nanostructured were studied. The SnS nanocrystals grown by varying temperature were p-type in nature. The electrical conductivities and carrier concentrations was higher for the higher temperature growth SnS sample. The carriers drift mobilities were found to be high for lower temperature growth sample. The decrease of mobility for the higher temperature grown SnS nanopartcles is due to the increase of defect concentration in the nanocrystals.

The as prepared SnS nanoparticles and SnS: Ag nancomposites are employed for the fabrication of low cost heterojunction solar cell with silicon. These nanoparticles are coated on n-Si wafer to fabricate heterojunction solar cell. The J-V plot of the fabricated heterojunction solar cells demonstrates that the power conversion efficiency of p-SnS: Ag/n-Si heterojunction is greater than the p-SnS/n-Si heterojunction. This increase in conversion efficiency of p-SnS:Ag/n-Si heterojunction is due to the scattering effect from Ag nanoparticles which leads to Surface Plasmon Resonance (SPR).

On the other hand, the fabrication of low cost and more efficient optoelectronic device is the dye sensitized solar cell (DSSC). Natural dye sensitized solar cell based on pure SnS as well as doped SnS have been fabricated in a simple way. Acalypha Wilkesiana leaf extract used as natural dye to enhance the power conversion efficiency of the fabricated solar cell. The power conversion efficiency corresponding to different samples with same natural dye is compared under the illumination of 100 mW/cm^2. The J-V study of DSSCs shows that the power conversion efficiency was highest for Mn doped SnS based DSSC. The increase in efficiency of Mn doped SnS is influenced by short circuit current density (J_{sc}). We have also fabricated dye sensitized solar cell (DSSCs) based on green synthesized SnS nanoparticles. The Acalypha Wilkesiana leaf extract used as a natural dye sensitizer in the fabrication of

DSSCs. The efficiency reaches maximum for green synthesized SnS nanoparticles based DSSC. This increase in efficiency is probably due to the better ability of carrier trapping in green synthesized SnS NPs.

The molecular interaction and the formation of biocomplex of BSA@ SnS nanoparticles are also studied. A spontaneous binding process has been observed between BSA and SnS NPs which were confirmed by UV–Vis absorption and fluorescence spectroscopic measurements. The PL decay lifetime of BSA with the addition of SnS NPs signifies that the quenching process follows static mechanism. Conformational changes of BSA under the association of SnS NPs have been observed. The HRTEM images demonstrate that SnS nanoparticles (NPs) facilitate the aggregation of BSA into nano fibrillar aggregates. Therefore, it is confirmed that the SnS NPs is capped.

Our future plan is to synthesize good quality quantum dot like SnS nanoparticles by changing the growth condition as well as growth process. The as prepared SnS will be utilized to fabricate another gas sensing devices like LPG, NH_3 sensor, enzymatic glucose sensor (biosensor). Also we look forward to improve the sensitivity as well as stability of the sensing devices. We will focus to improve the efficiency of solar cell based on SnS nanoparticles. Also we want to give more attention on the biosynthesis of SnS nanoparticles from others leaf extract as capping agent and want to apply these materials for the fabrication in different photovoltaic devices. Finally, we want to grow the good quality of SnS nanoparticles for Li-ion and Na-ion battery application.