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Strong coupling of defect levels in In_2S_3 nanoclusters due to plasmonic interactions

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1. Introduction

Surface plasmon incorporated in semiconductors lead to local field amplification which can cause enhancement in absorption and emission properties [1]. This phenomenon finds application in photonic devices [2]. In this work we report on the strong coupling of the defects levels of indium sulfide (In_2S_3) nanoparticles due to plasmonic interactions by Ag nanospheres.

2. Experimental details

In_2S_3 nanoparticles are synthesized by homogeneous precipitation method using equimolar solution of indium chloride ($InCl_3$) and thioacetamide (TAA) as precursors. The resultant mixture obtained by adding TAA to $InCl_3$ at room temperature is allowed to precipitate for 24 hours. The In_2S_3 nano powder is separated by centrifuging the solution at 4000 rpm and by washing it with ethanol to remove impurities. Ag nanospheres are synthesized by a simple chemical method [3] using $AgNo_3$ as precursor. $AgNo_3$ (2 gm) dissolved in 6 ml of ethylene glycol is added slowly to PVP (2 gm) dissolved in ethylene glycol (34 ml) which is heated in prior at 160 ^{0}C. The pH of the PVP solution is maintained at 9 by adding Na_2Co_3. The colloidal solution Ag nanospheres thus obtained is added to In_2S_3 nanoparticles dispersed in water and sonicated for 30 minutes at room temperature. The mixture is deposited on micro glass slide by solvent evaporation method at 60^{0}C. The obtained films are characterized using FESEM, optical absorption spectroscopy and photoluminescence studies.

3. Results and discussion

Figure 1a and 1 b shows the FESEM image of In_2S_3 particles and Ag nanospheres synthesized by simple chemical methods. The In_2S_3 nanoparticles agglomerate to form nanoclusters of size ~ 300 nm. The synthesised Ag nanospheres are of size ~ 100 nm.

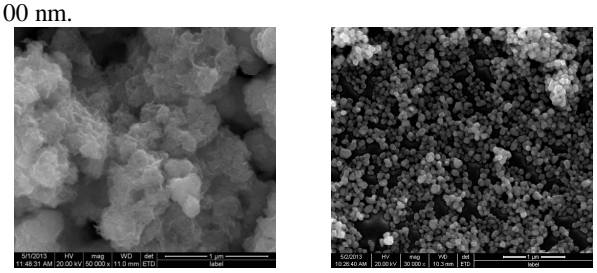

Figure 1(a) In_2S_3 nanoclusters (b) Ag nanospheres

The extinction spectra of pure In_2S_3 nanoclusters and hybrid nanostructure shown in figure 2 clearly depict a blue shift. The incorporation of Ag plasmonic structure with plasmonic peak at around 455 nm to the semiconductor nanocluster has shifted the absorption onset on In_2S_3 by 10 nm and the change in the spectrum profile is because in the presence of plasmonic structure the density states of conduction band is strongly enhanced thus supressing the absorption due to various defect levels in In_2S_3.

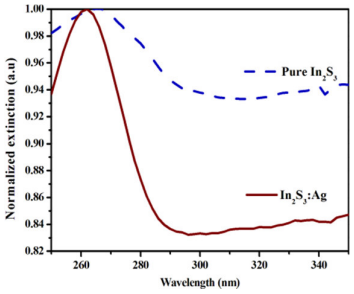

Figure 2 Extinction spectrum of pure In_2S_3 and Ag: In_2S_3

The emission spectrum for excitation at 488 nm of the pure In_2S_3 nanocluster and Ag: In_2S_3 hybrid structure is shown in figure 3. The spectrum corresponding to pure In_2S_3 shows emission at ~ 650 nm (red region), which is reported of In_2S_3 as due to various defect levels in the material. Upon addition of Ag plasmonic structure the emission shifts to green region (559 nm). This indicates that in the presence of plasmonic structures there is strong coupling between the defect levels capable of emitting in the green region.

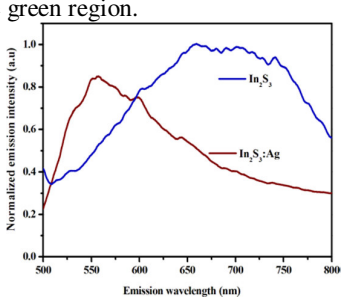

Figure 3 Photoluminescence of pure In_2S_3 and Ag: In_2S_3

4 Conclusions

In_2S_3 nanoparticles and Ag nanospheres synthesized by simple chemical methods are combined to form a hybrid nanostructure. Strong coupling of defect levels in In_2S_3 nanoclusters is observed when Ag plasmonic structures are incorporated. The blue shift of 10 nm is observed the extinction spectrum. The defects in In_2S_3 nanoparticles responsible for red emission are over powered by the strong coupling of excitons causing emission in green region.

Reference

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