Plasmon assisted switching of emission in β - In_2S_3 /Ag nanohybrid Structures

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1. INTRODUCTION

Photonic devices require material whose optical properties are tunable over a wide range of wavelength with faster switching rate. Semiconductor quantum dots have wide range applications in such devices. To enhance their optical properties, semiconductors are coupled with plasmonic nanostructures. Such hybrid structures exhibits tunable absorption, fluorescence and scattering with fast radiative and non radiative decay rates. In this work we demonstrate quenching and enhancement of emission of β -In_2S_3 quantum dots in the proximity of Ag nanoparticles. Thus making these nanohybrids highly suitable for photonic device fabrication.

2. EXPERIMENTAL DETAILS

In_2S_3 quantum dots were synthesized by homogenous precipitation method using Indium chloride (0.1 M) and TAA (0.1M) as precursors. Ag nanoparticles were synthesized using silver nitrate (0.45 mg) and Polyvinyl pyrolidene (100 ml) (as surfactant) by heating the mixture 60 ^{0}C for 3 hours. The In_2S_3 / Ag nanohybrids were synthesized by growing Ag nanoparticles over In_2S_3 quantum dots dispersed in PVP solution.

3 RESULTS AND DISCUSSIONS

The XRD pattern indicates the formation of is β-In_2S_3 with cubic crystalline structure having orientation along (611), (440), (400), (222), (311) and (211) respectively (JCPDS file no 32.0456). TEM Images of Ag nanoparticle and In_2S_3/Ag nanohybrid structures is shown in figure 1a and b. The average size of the Ag nanoparticle is ~ 30 nm. The Raman Spectra of pure In_2S_3 and In_2S_3/Ag nanohybrid structures (Figure 2a) shows intense and broad band at ~150 cm^{-1} (In-In stretching mode), 219cm^{-1} (In-S bending mode) and 300 cm^{-1}. The peaks at 179 cm^{-1}, 247 cm^{-1}, 150/369 cm^{-1} corresponds to F_{2g}, E_g and A_{g1} vibrational modes and peaks at 438 $cm^{-1}$and 474 cm^{-1} is due to S-S bond of elemental S .

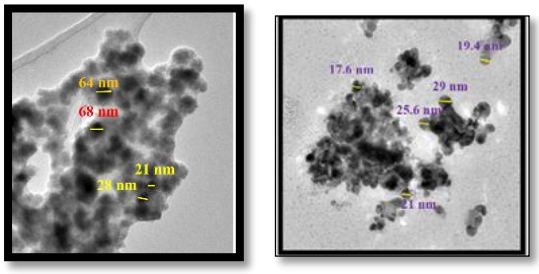

Figure 1 (a) TEM images of Ag nanoparticle and β-In_2S_3 and (b) β-In_2S_3 / Ag nanohybrid structures

The excitonic absorption and emission rates of pure In_2S_3 nanoclusters can be modified by the presence of the strong field produced by the plasmons. The extinction spectra of pure In_2S_3 nanoclusters and hybrid nanostructure shown in figure 2b clearly depict a blue shift ~ 500 meV.The bandgap of the β-In_2S_3 microflowers is ~ 3.1 eV which exhibits blue shift when compared to the bulk β-In_2S_3 due to the quantum confinement effect. With incorporation of Ag nanostructures with plasmonic peak at around 463 nm to the β-In_2S_3 microflower structures, bandgap shift by ~ 500 meV, which may be due to the strong interfacial electronic coupling between the neighbouring β-In_2S_3 and Ag nanoparticles. The coupling of the electronic states of β-In_2S_3 also leads to shift in the emission wavelength from red (670 nm) to blue region (494 nm) of the electromagnetic spectrum (figure 3).

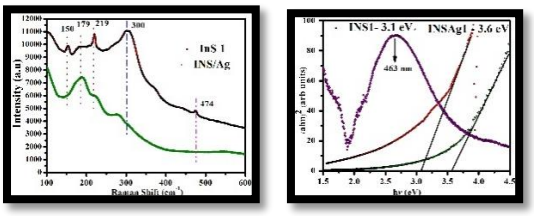

Figure 2 (a) Raman Spectra of Pure β-In_2S_3 and β-In_2S_3 / Ag . (b) Excitation Spectra for β-In_2S_3 and β-In_2S_3 / Ag

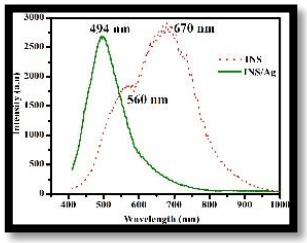

Figure 3. Emission spectra for Pure β-In_2S_3 and β-In_2S_3 / Ag

4 Conclusion

β-In_2S_3 / Ag nanohybrid structures were synthesized by simple chemical method. Incorporation of Ag nanostructures ~ 30 nm exhibited strong coupling of defect levels in In_2S_3 microflowers leading to the blue shift of ~ 500 meV is in the extinction spectrum and switching of emission from red to blue region of electromagnetic spectrum.

Reference

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