CdSe Nanoparticles in Silica matrix by Sol Gel method

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ABSTRACT

'Quantum dots' or nanoparticles of diverse semiconductor materials are extensively studied because of their interesting size dependent properties. It is further interesting to organize the quantum dots in the form of superlattices thin films, monolithics, ordered arrays for fruitful applications. Various applications such as sensors, displays, recordings, communications etc. require condensed organic or inorganic tunable material in the ultra violet to visible range. This work discusses the synthesis of CdSe nanoparticles in a silica matrix. The UV absorption measurements of CdSe nanoparticles indicated sharp absorption at 272 nm, with the energy gap of 4.54eV. Silica gel containing the CdSe nanoparticles was spin coated onto substrates to form thin film samples. Scanning Electron Microscope (SEM) measurements revealed formation of CdSe nanoparticles within the gel-network. The paper discusses the single size distribution of CdSe nanoparticles in the silica gel matrix. The matrix consisting of monodispersed CdSe nanoparticles in a silica gel has potential applications in sensors, tunable waveguides, and sensitive photon counting systems, luminescent displays, and laser micro cavities.

Keywords: CdSe nanoparticles, Sol-Gel, core-shell

1 INTRODUCTION

Semiconductor nanocrystallites embedded in dielectrics are fascinating due to their electrical and optical properties associated to the quantum confinement effects. Various synthesis routes are adopted by different scientists. Nevertheless, sol–gel method has become one of the fabrication methods for combining II–VI semiconductors and dielectrics [1] like SiO_2. This method has tremendous advantages over classical solid-state synthetic routes, like the simple synthetic conditions, high homogeneity, purity of the final material and versatility, which are basis for the development of new advanced materials.

Because silica is optically transparent and chemically inert, it can be used as a good coating material. Thickness of the silica shell can be controlled. Thus, the distance between neighboring particles can be regulated [2]. The surface of silica can be modified with different functional groups by amines, thiols, carboxyls, etc.The synthesis of monodisperse spherical silica nanoparticles from aqueous alcohol solutions of silicon alkoxides and ammonia as a catalyst was first reported by Stöber et al [3]. The narrow size distribution of silica particles could be size tuned by controlling the reactants composition, pH and temperature. The Stöber method, with a few modifications is broadly used for coating inorganic nanoparticles [4]. The silane coupling method, where a surface primer (a silane coupling agent) was needed for the surface with silanol anchor groups was adopted by few researchers.The water-in-oil (W/O) microemulsion system has also been used for the preparation of silica coated nanoparticles, where, micelles or inverse micelles are used to control the size and confine nanoparticles [5]. CdSe is a II–VI band gap semiconductor having a band gap energy of 1.84 2.2 for CdSe Wurtzite and 1,67 for Zinc blende.

In this work, we have used sol-gel method in combination with top down approach for synthesizing CdSe nanoparticles embedded in silica matrix.

2 EXPERIMENTAL

The synthesis of CdSe nanoparticles within the gel were carried out by adding cadmium selenide micro particles (~10 micrometer) during hydrolysis and polycondensation reactions of tetraethyl-ortho-silicate (TEOS) in double distilled water. The complete reaction was carried out under continuous rigorous stirring. Ethanol (C_2H_5OH) was used as a solvent and hydrochloric acid (HCl) as a catalyst to obtain SiO_2 sol and finally gel containing CdSe nanoparticles. Finally, entire solution was stirred continuously until gel formation.

Optical absorption spectra were recorded using Shimadzu 3600 double beam spectrometer model. Propanol was used as the reference liquid. Spectra were recorded over a range of 200 to 600 nm. Field emission scanning electron microscopy (FE-SEM) was carried out to study surface morphology.

3 RESULTS AND DISCUSSION

The CdSe nanoparticles synthesized by sol-gel method in SiO_2 matrix were dried in 1 inch diameter holders at room temperature atmospheric conditions.

3.1 UV Absorption Spectroscopic Studies

The UV absorption measurements (**Figure 1**.) of CdSe nanoparticles indicated sharp absorption at 272 nm, with the energy gap of 4.54eV. The resolved lowest exciton transition of the CdSe nanoparticles locates at 272 nm, shows blue shifts from 716 nm of bulk CdSe band gap.

SiO_2 without CdSe nanoparticles has absorption at 220 nm. Thus, the peaks observed at 220nm are due to the solvent.

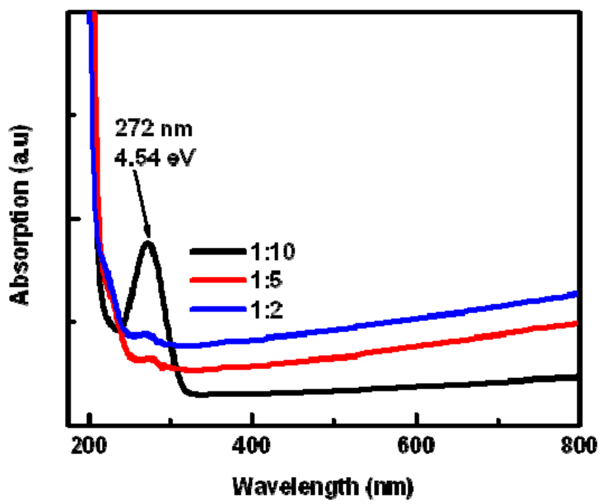

Figure 1. *UV absorption spectra for CdSe nanoparticles synthesized using sol-gel method.*

3.2 High Resolution Scanning Electron Microscopy

Field emission high resolution scanning electron microscopy of the CdSe nanoparticles embedded dried gel samples was carried as seen in **Figure 2**.

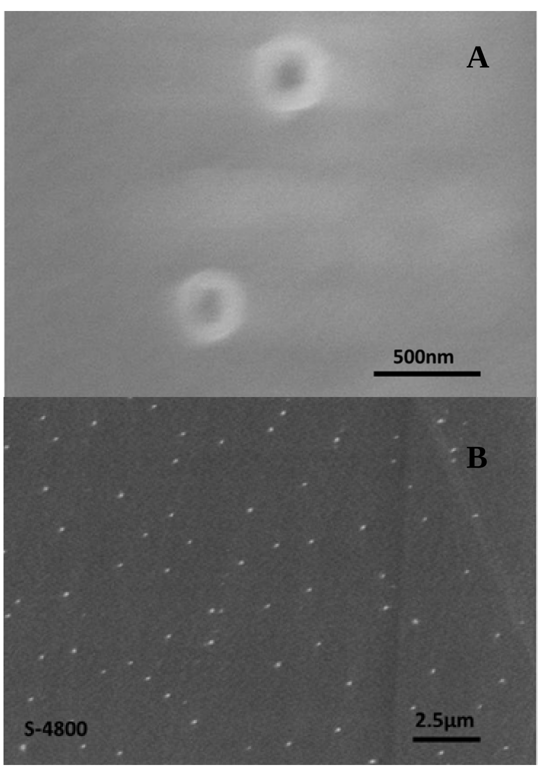

Figure 2. *FE-SEM of CdSe in SiO2 matrix (A) magnified image, (B) Overview of sample*

Interestingly, the synthesis led to the formation of CdSe-core/silica-shell nanoparticles. The original particle size of CdSe particles used in the synthsis was ~10 micrometers. From SEM image, **Figure 2(A)**, it is clear that the particle size of the core/shell nanoparticles is in the range of ~ 280 nm for core+ shell, whereas around ~140nm for only core. **Figure 2(B)** shows the overview of sample. The core-shell nanoparticles having narrow-size distribution or monodispere are almost equally spaced all over the sample.

4 CONCLUSION

The synthesis led to the formation of CdSe-core/silica-shell nanoparticles. The optical absorption spectra of CdSe-core/silica-shell nanoparticles indicated sharp absorption at 272 nm, with the energy gap of 4.54eV. The original particle size of CdSe particles used in the synthsis was ~10 micrometers. From SEM imgaes, the formation of CdSe-core/silica-shell nanoparticles was observed with the particle size of the core/shell nanoparticles in the range of ~ 280 nm for core+ shell and around ~140nm for only core.

This study indicates that the CdSe microparticles when mixed with the combination of acid, base and silicate reduce to smaller particles in the range of nano-sizes.\

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