Optical structure modification induced by lattice strain in Mn-doped CdSe QDs

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ABSTRACT

Narrow size distribution manganese-doped cadmium selenide quantum dots (Mn-doped CdSe QDs) successfully synthesized using inverse Micelle technique with organic solvent and surfactant possesses zinc blende structure with physical size ranging from 3 to 14 nm and crystallite size 2.46–5.46 nm. Mn-doped CdSe QDs observed to growth larger QDs compared to pure CdSe QDs at significantly same reaction times. The lattice parameter compressed with QDs sizes growth due to the introduction of lattice strain provoked by the incorporation of Mn atoms into CdSe QDs lattice. The Mn-doped CdSe QDs shows a slight blue-shift on absorption and emission spectra’s compared to pure CdSe even though is possessed larger QDs. The band gap structure modification prominently affected by the lattice strain were transition of Stoke’s, Rayleigh to anti-Stoke`s shifts observed as the Mn-doped CdSe QDs size growth. The typical red-shift of absorption and emission wavelength observed with growth of QDs sizes. The role of oleic acid as a surfactant and capping agent shows in FTIR spectra. The lattice strain tailored the binding energy between the ion prominently on the surface of the QDs with growth of QDs sizes.

1. Introduction

Doping is the intention of introduction of impurities into a material that is a fundamental step to controlling the properties of bulk semiconductors. This stimulated similar efforts to dope semiconductor nanocrystals [1]. Despite some successes, many of this effort have failed for reason that remain unclear [2]. For example, Mn can be incorporated into nanocrystals of cadmium sulphide (CdS) and zinc selenide (ZnSe), but not into CdSe [3]. Recent studies have been made to overcome this doping problem [4], by introducing Mn into CdSe QDs with different crystal structure compared to the previous study by Mikulec et al. (2000) [5]. Mikulec et al. (2000) successfully synthesized true Mn-doped CdSe nanocrystals by organometallic decomposition by synthesizing complicated organic compound, that is Mn2(u-Se-Me)2(CO)8 and CdMe2 [5]. Erwin et al. (2005) proposed that the binding energy of the (100) facets in zinc blende CdSe is much higher than that of any facets in wurzite CdSe. Erwin et al. (2005) also claimed that the wurzite CdSe cannot be doped with Mn due to self-purification [1,6].

Mn-doped CdSe QDs (zinc blende) was significant to the semiconductor research since Mn incorporation into CdSe QDs promised a high-density diluted semiconductor for spintronic application and provide good traps for excitation electrons which is significant for electronic and optoelectronic devices [7].

The semiconductor researchers around the world are challenged to improve the synthesis line in effort to achieve greener, less intricate, size tunable and high yield synthesis of Mn-doped CdSe QDs. As a counter to this, we are here reporting on the Mn-doped CdSe QDs synthesized using inverse micelle technique and the size dependent properties compared to the un-doped CdSe QDs [8].

2. Experimental

Mn-doped CdSe QDs were prepared using Mn–Cd and Se as precursors. 0.5 g of Mn acetate and 0.5 g of CdO, 25 ml of para inflammation and 15 ml of oleic acid were loaded in a three neck round bottom flask. The mixture was placed into glove box in vacuum condition. The solution was heated to 160 °C and stirred until the CdO was completely dissolved. The mixture was heated to 210 °C immediately after the injection, then rose to 220 °C. The temperature dropped to wine red. Then about 5 ml of Mn–Cd solution was swiftly injected into the Se solution during rapid stirring. The temperature dropped to 210 °C immediately after the injection, then rose to 220 °C. The temperature was maintained at 220 °C for the growth of CdSe QDs at...