Photoluminescence and Boosting Electron-phonon Coupling in CdS Nanowires With Variable Sn(IV) Dopant Concentration

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Abstract

High-quality Sn(IV) doped CdS nanowires were synthesized by a thermal evaporation route. Both XRD and Raman scattering spectrum confirmed the doping effect. The room temperature photoluminescence (PL) demonstrated that both near bandgap emission and discrete trapped-state emission appeared simultaneously and significantly, which were attributed to the strong exciton trapping by impurities and electron-phonon coupling during the light transportation. The PL intensity ratio of near bandgap emission to trapped-state emission could be tune via doped Sn(IV) concentration in the CdS nanowires. It is interesting that the trapped-state emission shows well separated peaks with the assistance of 1LO, 2LO, 4LO phonons, demonstrating the boosting electron-phonon coupling in these doped CdS nanowires. The influence of Sn(IV) dopant is further revealed by PL lifetime decay profile. The optical micro-cavity also plays an important role on this emission process. Our results will be helpful to the understanding of doping modulated carrier interaction, trapping and recombination in one-dimensional (1D) nanostructures.

Full Text

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Figures
Figure 1

(a,b) SEM of Sn doped CdS nanowires formed at early stage and after 60 min growth. Inset of (a) is amplified magnification of a representative nanowire. (c,d) EDS of the ball at the tip and the backbone in the nanowire, respectively.
Figure 2

X-ray diffraction patterns of Sn-doped CdS nanowires.
Figure 3

Micro-Raman scattering spectrum of single Sn doped CdS nanowire by using He-Ne laser (632.8 nm) as excitation light source.

Figure 4
(a) Far-field emission image of single Sn doped CdS nanowire. Inset is the bright-field optical image of corresponding single nanowire. Scale bars are 20 μm. (b) Far-field PL spectra under increasing excitation power. Inset is the local scale-up of impurities emission bands.

Figure 5

(a) Far-field emission image of single Sn(IV) heavy slightly doped CdS nanowire. Inset is optical morphology image. Scale bars are 20 μm. (b) The corresponding far-field PL spectra under increasing excitation power.
Figure 6

(a,c) Far-field emission and optical (inset) images of CdS nanowires with higher doping concentration. Scale bars is 20 μm; (b,d) The corresponding far-field PL spectra.
Figure 7

(a) PL of Sn CdS nanowires under excitation of pulse laser with wavelength of 400 nm (b c The corresponding PL lifetime decay profiles of 520 nm and 609 nm. (d) The schematic diagram for the carrier with different lifetime decay processes.