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Nonresonant optical properties of CdTe nanoparticles detected by nonlinear techniques

Lingyun *PAN* [a], Kenj *KAMADA* [b], *Atsushi ISHIKAWA* [a], *Junichi NAKAYAMA* [a], Naoto *TAMAI* [a]

a:*Kwansei Gakuin University;*

b:Natinoal Institute of Advanced Industrial Science

Introduction

Recently, much attention has been paid for nonlinear optical properties of semiconductor nanoparticles because of their potential applications [1]. In the present study, we have examined optical properties of CdTe nanoparticles by resonant and non-resonant time-resolved spectroscopy and laser trapping with near IR picosecond pulse laser. Unexpected anisotropy property of CdTe nanoparticles was detected with these experiments. TPA (two-photon absorption) induced fluorescence was used to confirm the laser trapping of nanoparticles.

Experiments

The CdTe nanoparticles (diameter 3.1~4.9nm) in aqueous solution with a concentration of ~10^{-6}M were used as samples. For laser trapping experiments, D_2O was used as a solvent. The sample was excited with SHG (420nm) of fundamental of fs Ti:sapphire laser and SHG (524nm) of fundamental of ps Nd:YLF laser (~4ps,80MHz). Polarization direction of excitation laser was adjusted by λ/2 plate to perpendicular one, and emission polarization ($I_{\parallel}$ and $I_{\perp}$) was selected by film polarizer. Luminescence decays were measured by picosecond single-photon timing spectroscopy with MCP-PMT. In laser trapping experiments, the fundamental of Nd:YLF laser was introduced into an inverted microscope with an oil immersion objective lens (60×, NA 1.25). TPA induced luminescence from trapped particles was detected with a CCD through the same objective lens. TPA cross-sections of CdTe nanoparticles were measured by a z-scan method as described previously [2].

Results and discussion

TPA cross sections of CdTe (~nm) was estimated to be ~10^4GM (GM=10^{-50} cm^4 s $photon^{-1}$ $particle^{-1}$). Polarization dependence of TPA induced luminescence intensity was detected in laser trapping experiments as shown in Fig. 1. The anisotropy behavior of CdTe nanoparticles is clearly detected although the value is smaller than that for typical dye molecule, rhodaming B. The steady state anisotropy, r, is 0.059, 0.085 for 4.2nm and

4.9nm diameter nanoparticles, respectively. This unexpected anisotropy for sphere CdTe nanoparticles is confirmed by time-resolved anisotropy decay experiments. A typical data is shown in Fig. 2. Two-photon anisotropy at the initial time, r(0), is 0.16 for 4.2nm diameter CdTe nanoparticles. One photon anisotropy decay measurement shows similar results. This is the first observation for anisotropy decay in semiconductor nanoparticles in our knowledge. This can be analyzed by the assumption that individual nanocrystals have a 2D fluorescence transition dipole, a so-called bright plane and dark axis [3,4]. The anisotropy decay time will be discussed in terms of volume and the interaction of CdTe nanoparticles with surrounding medium.

Reference

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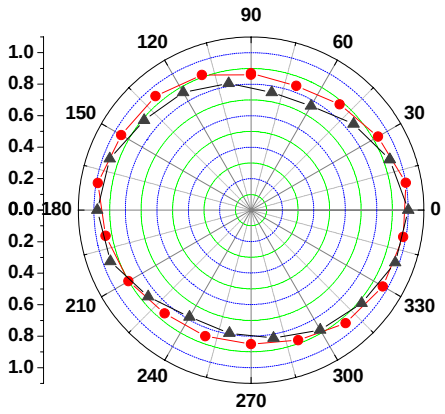

Fig.1 TPA induced luminescence intensity as a function of analyzer angle (polarization) in laser trapping experiments. Closed circles: CdTe nanoparticles (4.2nm diameter); triangle: rhodamine B.

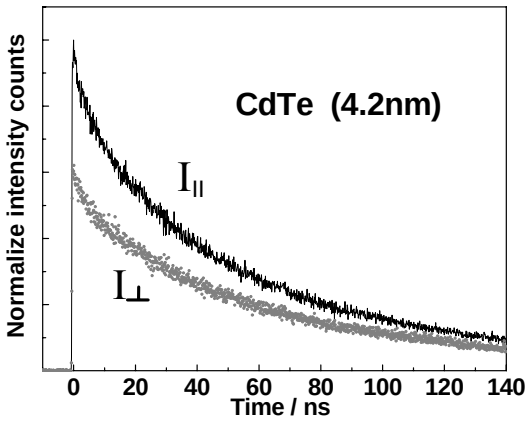

Fig.2 Two-photon anosoptropy decay for 4.2nm diameter CdTe nanoparticles.