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Si quantum dot with large absorption coefficient: 40-times enhancement established by laser ablation synthesis

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Quantum dots (QDs) exhibit various interesting optical properties when their size is reduced to a nanometer order. For example, their band gap energy, luminescence wavelength, and transition probability can be tuned by varying their size. Such optical properties have been observed in CdSe, CdS, ZnSe, GaAs, and Si QDs. Another property, efficient multi-exciton generation (MEG) has been found in PbSe, PbS, PbTe, and Si QD systems. MEG has been extensively researched as it is very promising for developing new-generation photovoltaic. Since MEG has been discovered in silicon (Si) QD, the absorption process of Si-QD is another crucial topic. Si-QDs have been synthesized by various methods. However, the extinction coefficient of Si-QDs has not been quantitatively clarified yet.

Several recent studies have investigated the large extinction coefficients of Si-QDs dispersed in liquids because their dispersion solutions are useful for preparing photovoltaic via wet processes. Rosso et al. produced alkyl[1], amine and Ru complex[2] terminated Si-QDs by chemical synthesis and found that the molar extinction coefficient is significantly affected by attaching amine alkene groups to Si-QDs. Reipa et al.[3] produced size-selected octyl-terminated Si nanocrystals and reported that the extinction coefficient increases with increasing Si nanocrystal size.

Here, we produce Si-QDs with sizes in the range 1–3 nm by Pulsed Laser Ablation in organic solvents and measure the Si-QD concentration and their ultraviolet (UV), visible (Vis), near infrared (NIR), and infrared (IR) absorption spectra. The absorption coefficient and molar extinction coefficient were obtained and their magnitudes were compared with previously reported values. The absorption coefficient of the Si-QDs was found to be 30 and 260 times greater than those of crystal and amorphous Si, respectively. The molar extinction coefficient of Si-QDs was up to 750 times larger than those of previously reported Si-QDs. Such large extinction coefficients were achieved by Si-QDs with a size of 1–3 nm, whose surfaces were passivated by carbon chains. It was also ensured that the Si-QDs were stably dispersed in hydrocarbon and alcohol solvents for over 10 months.

References:

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