Quantum-rod sensitized four-dimensional optical data storage

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Abstract: Quantum rods (QRs) are incorporated into polymers that are doped with azo dyes via an energy transfer process. The polarization-dependent refractive-index change allows four-dimensional optical data storage as well as other polarization-controlled photonic applications.
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Azo dyes are known to align themselves to the impinging light field. Recently, such polarization sensitivity has been also demonstrated under two-photon (2P) excitation, paving a new way for multi-dimensional optical recording. The 2P sensitivity of azo-dye-doped polymers can be greatly enhanced by incorporating quantum dots (QDs) as 2P energy transfer donors [1]. While the large 2P absorption cross-sections of QDs are beneficial to efficient nonlinear absorption, the lack of polarization sensitivity reduces the efficiency in polarization encoding. Quantum rods (QRs), however, possess the polarization selective excitation property [2] as well as the efficient 2P excitation that could fully benefit in multi-dimensional recording. In this paper, we report the development of QR sensitized dye-doped polymer for four dimensional optical data storage.

Fig. 1a shows the TEM images of prepared CdS QRs. Their absorption and emission spectral as well as the overlapping with the absorption spectra of azo dye 2-{ethyl-[4-(4-nitro-phenylazo)-phenyl]-amino}-ethyl ester (DR1-EH) are shown in Fig. 1b. The 2P absorption cross-section of QRs was measured to be $20.9*10^{-46} cm^4 \cdot s \cdot photon^{-1}$, which is four orders of magnitude higher than that of DR1-EH. Therefore QRs are potential to be used as 2P energy transfer donors. In particular, a pronounced angular-dependent 2P excitation property has been observed for our as-prepared QRs on glass slide as shown in Fig. 1c, which establishes the possibility of polarization modulated refractive-index change. To demonstrate the polarization-encoded 4D optical data storage, QRs were dispersed into polystyrene (PS) contained 9.1wt.% of DR1-EH. A Ti:sapphire ultrashort pulsed laser beam of pulse width 100 fs (Spectra-Physics Tsunami) at a wavelength of 720 nm was employed as a 2P excitation source. Figs. 1d to g demonstrate 2P induced two-state polarization encoding in such a medium. Four letters were encoded in the polarization state of the writing beam at 0 and 45 degree respectively in each of two layers and read out distinctly using reading beams with corresponding polarization states.

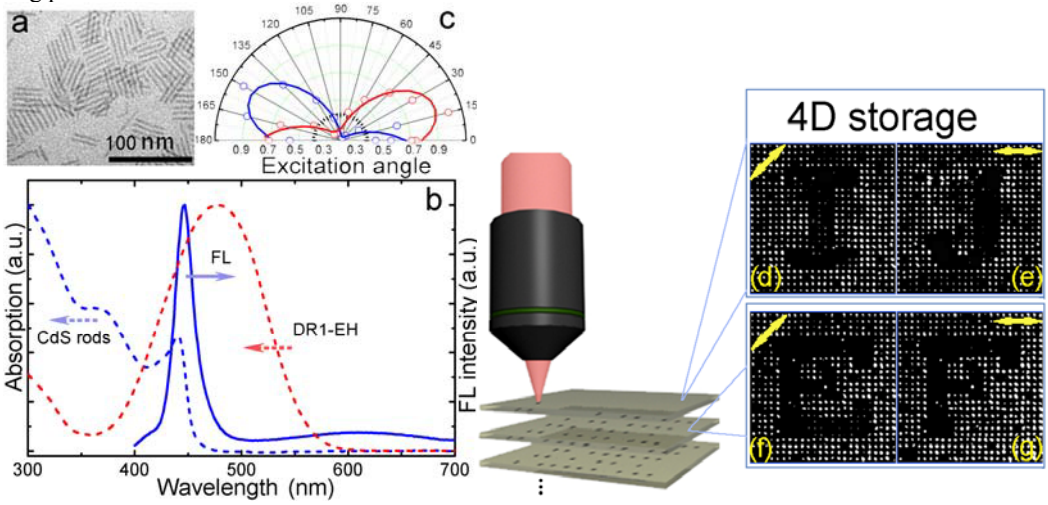

Fig.1 a, TEM images of prepared CdS QRs. b, Absorption and emission spectra of CdS QRs as well as absorption spectra of DR1-EH. c, The normalized fluorescence intensity of two emission spots of QRs prepared on the glass slide is plotted as a function of excitation polarization angles. d to g, Demonstration of polarization-encoded 4D optical memory. Letters I/J (d/e) and E/F (f/g) were recorded in the first and second layers, respectively, in the polarization direction of 0 and 45 degrees and retrieved back using corresponding polarized reading beams.

References

[1] X. Li, J. W. M. Chon, R. A. Evans, and M. Gu, "Two-photon energy transfer enhanced three-dimensional optical memory in quantum-dot and azo-dye doped polymers," Appl. Phys. Lett. **92**, 063309 (2008).
[2] E. Rothenberg, Y. Ebenstein, M. Kazes, and U. Banin, "Two-photon fluorescence microscopy of single semiconductor quantum rods: Direct observation of highly polarized nonlinear absorption dipole," J. Phys. Chem. B. **108**, 2797-2800 (2004).

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