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Ultrafast Degenerate Transient Lens Spectroscopy in Semiconductor Nanosctructures

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Abstract. We report the non-resonant excitation and probing of the nonlinear refractive index change in bulk semiconductors and semiconductor quantum dots through degenerate transient lens spectroscopy. The signal oscillates at the center laser field frequency, and the envelope of the former in quantum dots is distinctly different from the one in bulk sample. We discuss the applicability of this technique for polarization state probing in semiconductor media with femtosecond temporal resolution.

Keywords: transient lens, quantum dots, nanocomposites, transient polarization

In this paper we test the capabilities of transient lens spectroscopy using non-resonant excitation. Transient lens technique utilizes a variation of pump-probe scheme. Gaussian-type laser beam has the highest intensity at its center so the photoinduced refractive index works like a lens element focusing or defocusing the probe radiation [1]. We can detect the amount of (de)focusing by placing a pinhole before the photodetector. Controlling the probe delay allows one to detect transient lens dynamics in time domain with femtosecond accuracy.

There are a variety of mechanisms for a photoinduced refractive index change: non-uniform heat distribution form temperature lenses [2], lenses are due to optical Kerr effect [3], there is a thermal lens spectroscopy [4], the population lenses [5], etc. Mostly, when photoinduced refractive index change is being probed, the pump pulse frequency is within the absorption region of the sample, and the probe frequency is not. We have used an Yb-doped femtosecond solid-state laser as a source for both pump and probe pulses, and CdS/CdSe nanoparticles as a sample. In our case both pump and probe radiation were non-resonant.

The experiment showed that the detected signal manifests interferometric-like fringes at the central laser frequency. This fact points out that the effective refractive index is determined by the phase difference between the probe field and pump-induced dipoles. Thus, the signal envelope directly reflects the current polarization state of the medium.

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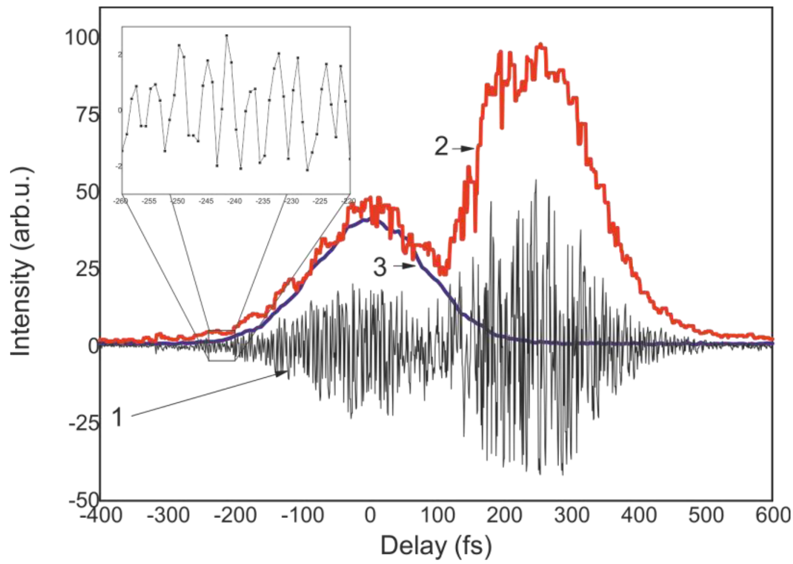

Figure 1. 1 – transient lens signal in CdSe/CdS quantum dots. 2 – amplitudes of the oscillations of 1. 3 – cross-correlation function of pump and probe pulses

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