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QThG2 **10:45 am**

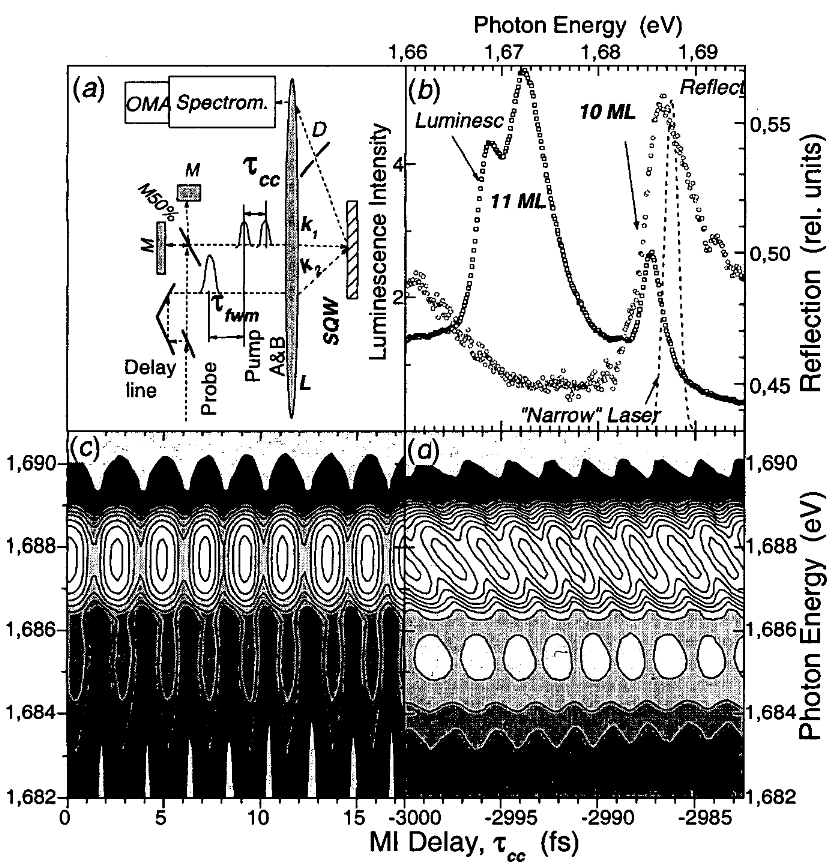
Optical coherent control in semiconductors

John Erland, Vadim G. Lyssenko, and Jørn M. Hvam, *Research Center COM, Technical University of Denmark, Oersteds Plads 349, Dk-2800 Kgs. Lyngby, Denmark Email: jeo@com.dtu.dk*

The developments with coherent control (CC) techniques in optical spectroscopy have recently demonstrated population control and coherence manipulations when the induced optical phase is explored with phase-locked laser pulses. Fascinating demonstrations were first obtained with atoms and molecules such as localization of electronic wavepackets in atomic sodium and control of molecular chemical reactions.[1,2] These and other developments have been guiding the new research field of quantum control including the recent applications to semiconductors and nanostructures. Examples include population control of excitons in GaAs quantum wells and quantum dots as well as control of electron-phonon scattering is GaAs that have provided new advancements in ultrafast spectroscopy of semiconductors.[3–5]

We study the influence of inhomogeneous broadening in semiconductors on CC results. Photoluminescence (PL) and the coherent emission in four-wave mixing (FWM) is recorded after resonant excitation with phase-locked laser pulses with wave vector k_1. For the FWM, a second beam with wave vector k_2 is incident on the sample resulting in the coherent scattering of the emission in the direction $2k_2 - k_1$, see Fig. 1a. The sample is a narrow 28 Å GaAs single quantum well (SQW), surrounded by 250 Å $Al_{0.3}Ga_{0.7}As$ barriers, grown by molecular-beam-epitaxy with growth-interruptions on the barrier-well interfaces. This leads to formation of large monolayer-plane islands with 11 monolayers (ML) thickness; see sample characterization in Fig. 1b. Our main experimental results are shown in Fig. 1c and Fig. 1d with the spectrally resolved FWM. In the direction of observation for the FWM signal, we simultaneously record PL from the sample on the low-energy side. The strong fringes, corresponding to the optical period, of these optical signals are caused by the interference between the two polarizations excited by the phase-locked CC laser pulses. The striking difference in the time-delay dependence is evident from Fig. 1c at zero delay with no spectral variation of the PL and FWM signals, whereas for longer phase delay in Fig. 1(d), the fringes in the FWM acquires a phase, dependent on the detected photon energy ω. For the latter, the PL signal appears to be proportional to the spectrally integrated FWM signal i.e. without any spectral variation.

Calculations of the FWM signal in the two-level approximation using CC pulses give an explanation of the spectral behavior of CC experiments in inhomogeneously broadened semiconductors. For large inhomogeneous broadening ($\Gamma \gg \gamma_{21}$), we show in Fig. 2(a) that the different spectral components have different phase within the chosen spectral window. In the other limit ($\Gamma \sim \gamma_{21}$), the FWM CC fringes have no spectral variation as shown in Fig. 2(f). However, in-between these two limits we find that the spectral wings of the FWM spectra have the same phase whereas an increasing part of the center acquires the phase change. This occurs as a result of the mixing of the Lorentzian part due to the homogeneous broadening, with constant phase $\omega_{21}\tau_{CC}$ and the Gaussian part with phase $\omega\tau_{CC}$ due to the inhomogeneous broadening. This explains how inhomogeneous broadening influences CC experiments and in particular how the fringe contrast decay change with inhomogeneous broadening.



QThG2 Fig. 1. a) Experimental setup with a Michelson interferometer for phase-locked pulse pair generation with time-delay τ_{CC}. The FWM, generated by a time-delayed (τ_{fwm}) third pulse, is spectrally resolved and detected with an optical multichannel analyzer (OMA). b) Luminescence (squares) and reflection (circles) of the GaAs SQW revealing two regions with thickness of 11 and 10 monolayers. The pump laser spectrum is snown dashed. c,d) FWM-spectra at 12 K with PL ($\nabla\omega < 1.686$ eV) for different phase delay $\tau_{CC} = 0$ and $\tau_{CC} = -3$ ps with $\tau_{fwm} = 0.5$ ps.

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QThG3 **(Invited)** **11.00 am**

Signatures of carrier-wave Rabi flopping in GaAs

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Illuminating a semiconductor with a constant light intensity can lead to a periodic oscillation of the inversion, a phenomenon which is known as Rabi flopping. Using pulsed excitation, Rabi flopping has been observed on semiconductors[1–3] and exhibited periods in the range from 100 fs to 1 ps. *What happens if the light intensity becomes so*

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