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GaAs 양자우물에서 흡수와 편광소멸의 결맞는 조절 : 시간과 에너지 영역 연구

Coherent Control of Absorption and Polarization Decay in GaAs Quantum Wells : Time and Spectral Domain Studies

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Recently, coherent control of exciton populations has been demonstrated through terahertz, reflection, and four-wave-mixing experiments. However, the most direct probe of exciton population control is the absorption, which has been lacking in previous studies. In this report, we probe the time evolution of exciton population directly through a transmission experiment. In particular, using upconversion technique with both narrow (spectrally broad) and long (spectrally narrow) pulses, we can obtain both the temporal and the spectral information. The main thrust of our report is that when phase controlled, the second pulse can be either greatly enhanced or completely destroyed by gaining energy from exciton (thus destroying the exciton population) or giving all of its energy to the system (thus greatly increasing the exciton population), respectively.

We probe upconverted pulse shapes and spectral characteristics of upconverted transmitted pulse when using a long pulse for upconversion. In Fig. 1(a), the transmitted pulse shape probed by upconversion is plotted for $\Delta\varphi = \pi$ or 0. We can see that for $\Delta\varphi = \pi$, the second pulse gains energy from the system, and the free induction decay is absent after the second pulse because little exciton population remains. For the zero phase, the second pulse lost much of its energy but the coherent exciton population thus enhanced gives out the free induction decay. A dramatic situation is seen in Fig. 1(b), where the incoming second pulse intensity relative to the first pulse intensity has been controlled such that for the zero phase, the second pulse is completely gone. In this case, the transmitted intensity is roughly equal to the transmitted intensity of the first pulse only! we also note the possibility of absolute amplification of the second pulse due to its energy exchange with the excited exciton system.

Taking advantage of a relatively narrow spectral width of a long upconverting pulse, we can demonstrate the enhancement of absorption (for zero phase) as well as the destruction of the exciton population and the resulting energy-gain experienced by the laser pulse (for π phase), as shown in Fig. 2. This is by far the most direct evidence for the coherent, linear gain of energy experienced by the pulse through the instantaneous destruction of the coherent exciton population.

In conclusion, we have demonstrated directly the interaction between the coherent exciton polarization and the controlling pulses by probing the linear propagation of pulses through a quantum well sample in both the time and spectral domain.

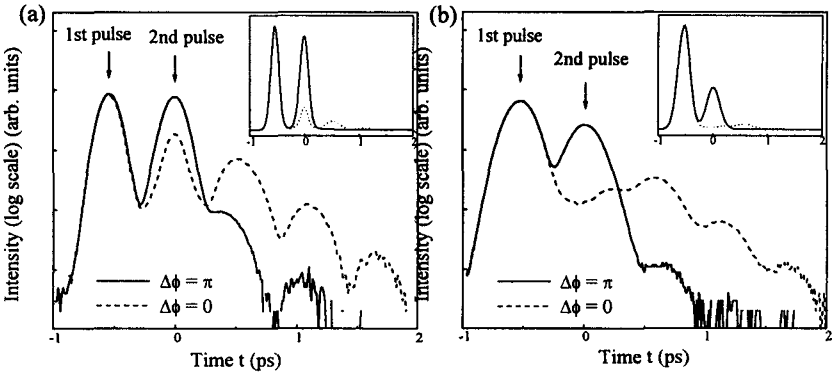

Fig. 1. For a time delay τ = 550 fs equal to the HH-LH beating period, transmitted pulse shapes probed by time-resolved upconversion are shown for $\Delta\varphi = \pi$ and 0 when the intensity ratio between two incident pulses (I_2 / I_1) is (a) 0.59 and (b) 0.12. They are plotted on a linear scale in the insets as well as a logarithmic scale.

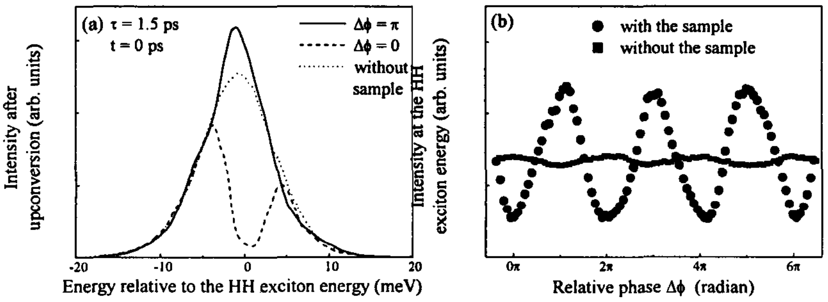

Fig. 2. (a) For a time delay (τ) of 1.5 ps, shown are the spectra of pulses not transmitted or transmitted through the sample with relative phase π or 0, probed by a long upconverting pulse with a relatively narrow spectral width when the time delay (t) of the long upconverting pulse is 0 ps. In each case of $\Delta\varphi = \pi$ or 0, a bump or dip is shown at the HH exciton energy respectively. (b) The intensity at the HH exciton energy versus relative phase under the same experimental condition as in figure (a).