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Manipulation of Coherent Exciton towards Novel Ultrafast Devices

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Summaries

The development of both the growth-technique of high quality nano-structures and the ultrafast laser technology enables us to control the quantum dynamics in semiconductor by a coherent control[1]. These technology also gives us the possibility to apply the coherent phenomena to novel devices such as ultrafast optical switch, terahertz wave generator and quantum computer. The ultrafast coherent control of excitons in semiconductors have been reported using Michelson interferometer[2]. In order to realize the more sophisticated control, the pulse shaping technique is more attractive candidate. In this paper, we report ultrafast manipulation of coherent excitons in single and coupled quantum well structures using phase-locked femtosecond pulse sequence generated by pulse shaping technique.

The pulse shaping system with phase and amplitude liquid crystal (L.C.) spatial light modulator (SLM) and a Ti^{3+}-sapphire laser with pulse width of around 120fs is used to generate the phase-locked pulse sequences for excitation control. The phase relations between the pulse are controlled in the frequency domain by LC modulator. Fig.1 show the spectra and the cross correlation waveform of the shaped control pulse sequence. The solid and dotted curves in (a) show the spectra of the triple pulse with relative phase of 0, 0, 0 (0-0-0 pulse), and 0, π,0 (0-π-0- pulse), respectively. As an example, the symmetric triple and five pulses with the interval (T) of 490 fs were generated in (b) and (c), respectively.

In the following experiment, high quality single period 10nm thick GaAs/AlGaAs quantum well and 10 period asymmetric coupled quantum well structures (10nm and 13nm thick wells and 2.5nm barrier) are used.

Ultrafast manipulation of coherent excitons in single quantum well is demonstrated by observation of reflectivity change ΔR in the pump-probe measurement (Fig.2). The phase-locked twin (0-π: T=500fs) and triple (0-π-0 : T=390fs) pulse are used as control pulse and corresponding results are shown in Fig. 3. The first pulse arrives at t = 0 and after the arrival of the second one at t = T the decrease of the reflectivity change are observed for twin (0-π) pulse. Also, the increase of the reflectivity change is observed for the triple (0-π-0) pulse after the arrival of the third pulse at t = 2 T (=780fs). Ultrafast (< 500fs) control of reflectivity change with good coherent carrier destruction (87%) is demonstrated. Also, the preliminary on-off-on manipulation of the exciton populations is achieved.

The manipulation of coherent excitons in quasi-three level system in coupled quantum well is also demonstrated by observation of quantum-beats. As a result both the exciton population and polarization (quantum-beats) are controlled in femtosecond time domain by phase locked pulse sequence.

References

[1] W. S. Warrent, ,H. Rabitz, and M. Dahleh, Science, 259, 1581 (1993)
[2] A. P. Heberle, and J.J. Baumberg, and K. Kohler, Phys. Rev. Lett., 75, 2598, (1995)

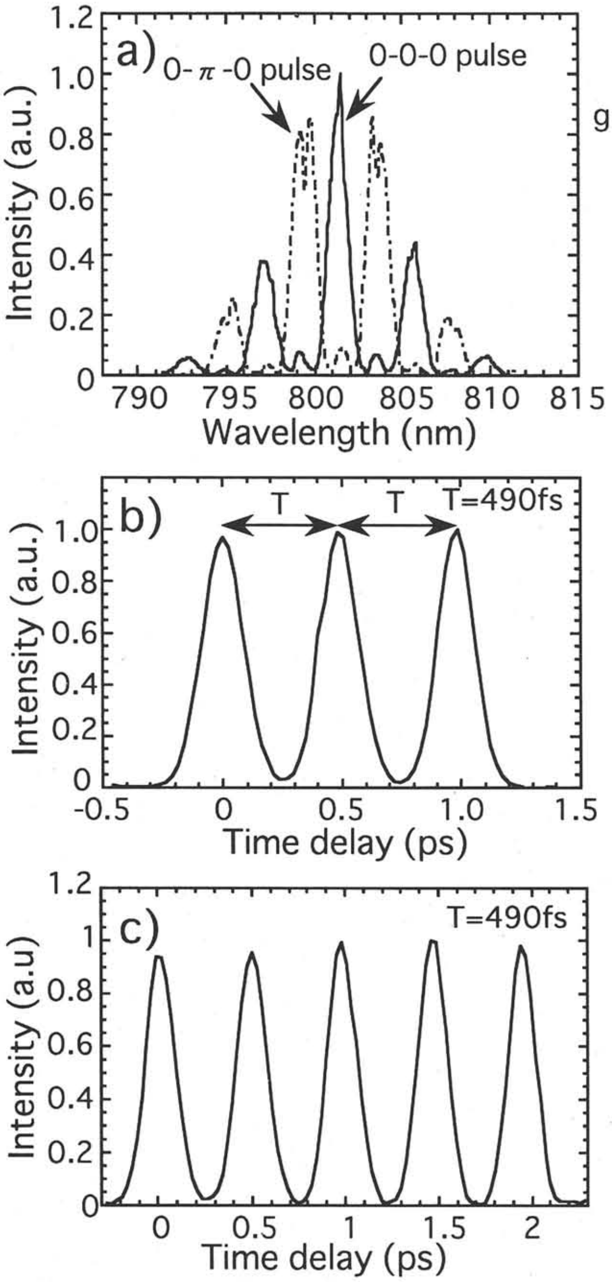

Fig. 1 Phase locked control pulse sequence generated by pulse shaping technique.
a) Spectra of triple pulse with phase relation of 0-0-0 (solid curve) and 0-π-0 (dotted curve).
b) Cross correlation waveform of phase locked triple pulse.
c) Cross correlation waveform of phase locked five pulses.

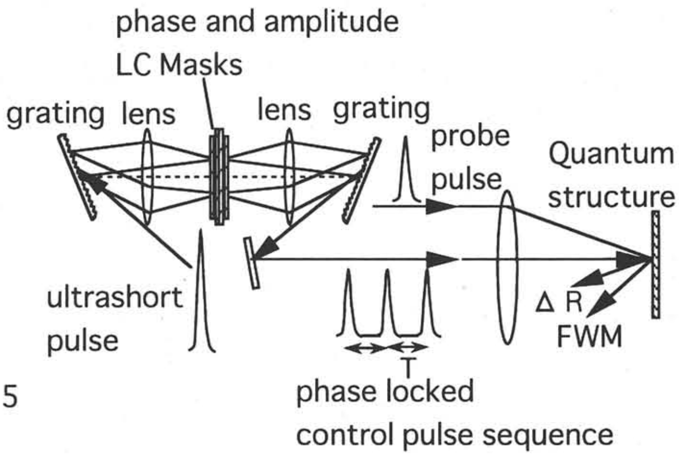

Fig 2. Experimental setup for the manipulation of coherent exciton in single and coupled quatum wells. The phase locked control pulse sequence is generated by pulse shaping system.

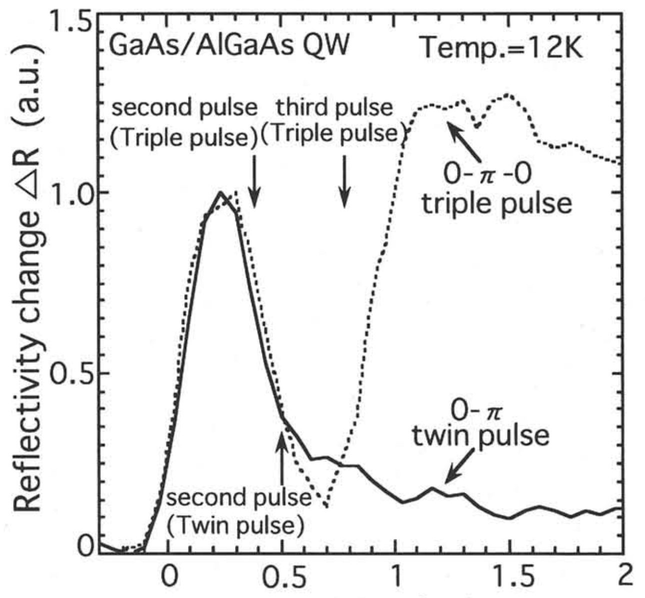

Fig. 3 Ultrafast control of reflectivity change in quantum well by the manipulation of exciton population. Solid and dotted curve shows the reflectivity change for phase locked twin (0-π) and triple (0-π-0) pulse sequence, respectively.