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# Ultrafast exciton dynamics in GaAs crescent-shaped quantum wires

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## 1. Introduction

Semiconductor nanostructures are expected as materials for ultrafast devices because of it's high differential gain and optical nonlinearity. Nonlinear response of excitons confined in GaAs/AlGaAs quantum-wells has been extensively studied theoretically and experimentally[1]. We have developed high quality crescent-shaped quantum wires on a V-grooved substrate by the flow rate modulation epitaxy method (FME)[2,4,5]. However low density of conventional crescent-shaped quantum-wires limited an ultrafast nonlinear spectroscopy. In this paper, we have fabricated high density and high quality GaAs／AlGaAs crescent-shaped quantum wires specially designed for nonlinear spectroscopy. We have investigated ultrafast dynamics of excitons under resonant and non-resonant excitation by the high sensitive and the reflection type pump-probe nonlinear spectroscopy.

## 2. Experiments

We have used 15 periods of GaAs/AlGaAs quantum wires grown by the FME method on the V-grooves fabricated on the GaAs substrate[2]. The thickness and the width of a quantum wire are 11nm and 46nm respectively. The distance between each uncoupled quantum wires is 50nm. Fig.1 shows the PL and the PLE spectra of quantum wires measured at the low temperature of T=6K. In the PLE curves, the 1e−1hh exciton peak at 800 nm and the 1e−1lh exciton peak around 793 nm are each observed with polarizations of excitation laser parallel and vertical to them. This polarization dependences due to one-dimensional band mixing effect.

## 3. Results and Discussion

Fig.2 shows differential reflectivity spectra ΔR for the various delay times τ of -0.3ps to 100 ps under non-resonant excitation at 795nm. The arrows indicate the center position of FWHM in the spectra. They show the red shift from the excitation wavelength to the exciton absorption line 1e-1hh immediately following the pump pulse[3,4]. This is due to the relaxation from free carriers to excitons. Fig.3(a) shows the peak value of ΔR spectra under non-resonant excitation versus the delay time. The formation time[3,6] of excitons, which is defined as the time when the exciton can be formed from free electrons and holes, is about 5 ps in this quantum wires. From the decay rate of the peak value of ΔR spectra the decay time of excitons is found to be about 110 ps. Fig.3 (b) shows FWHM of ΔR spectra dependence on delay time under non-resonant and resonant excitation. In the case of non-resonant excitation, initial broad FWHM is caused by the mixture of two distribution components of free carriers and excitons. While in resonant case FWHM is increasing as exciton population increases. Fig.3 (c) indicates the shift wavelength of ΔR spectra under non-resonant and resonant excitation. Under resonant excitation, only the blue shift occurs within 0.3 ps and after that the red shift occurs until 100 ps. This blue shift is considered to be due to the mutual exciton-exciton interaction within coherent regime[1]. On the other hand spectrum movement occurs after 0.3ps which is due to the exciton relaxation.

## 4. Conclusion

We have investigated ultrafast carrier dynamics by resonant and non-resonant pump-probe spectroscopy. Under resonant excitation the blue shift occurred within 0.3ps and after that the red shift occurred. This blue shift and the red shift are considered to be respectively many-body effect due to exciton-exciton interaction and exciton relaxation. The formation time of exciton is found to be 5ps and the decay time of exciton is found to be about 110ps.

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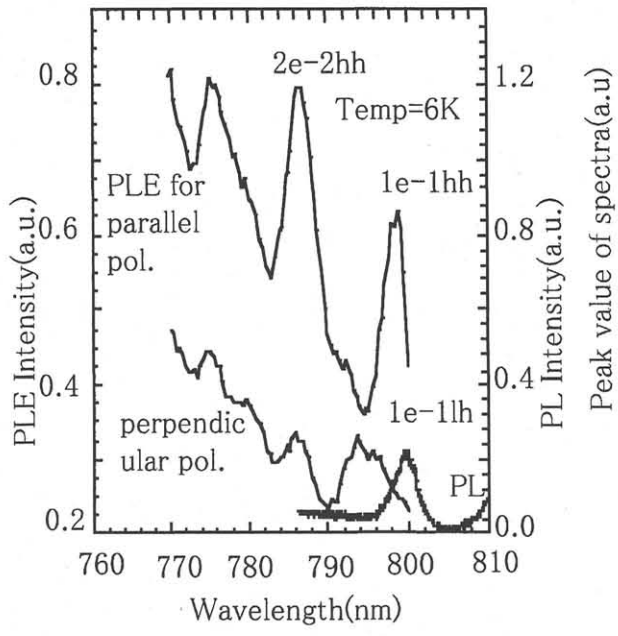


Fig.1 PL and PLE characteristic of the crescent shaped Quantum Wire

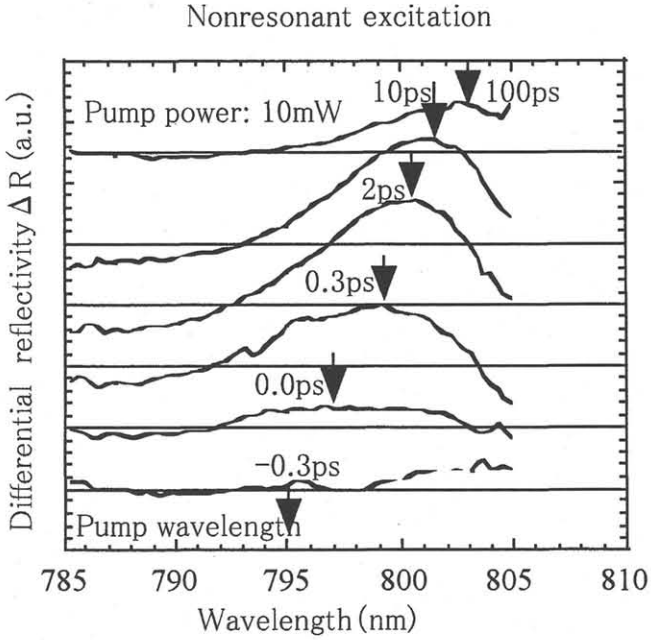


Fig.2 The ΔR spectra dependence on delay time under nonresonant excitation.

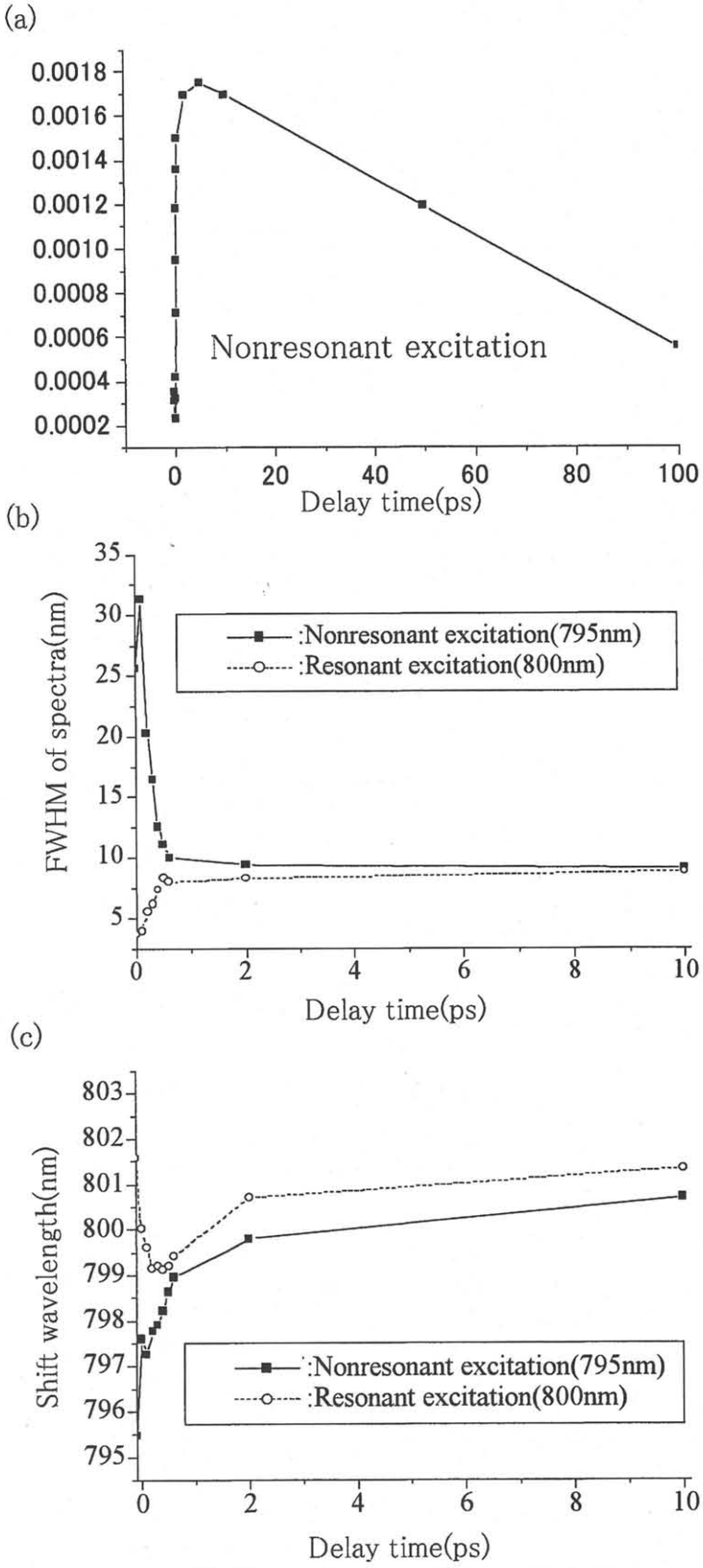


Fig.3 (a) The peak value, (b) the FWHM and (c)the shift of the center wavelengthes of the ΔR spectra dependence on delay time under nonresonant and resonant excitation.