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低温成長 GaAs のキャリア及びスピン緩和の観測

Observation of carrier and spin relaxation in low-temperature grown GaAs

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Low-temperature grown GaAs (LT-GaAs) has unique properties such as the very short carrier life time and large resistivity. Therefore, LT-GaAs is expected to be used for the photoconductive emitter and detector, and ultrafast all-optical switching devices.[1,2] LT-GaAs was found to be highly strained, containing roughly 1-2% excess arsenic being incorporated during growth as As antisite defects. These As-related defects contribute to the ultrafast nonradiative recombination of photoexcited carriers.[3] Previously, we reported the electron spin relaxation times of LT-GaAs at 10-200 K.[4] In this study we have investigated the temperature dependence of carrier and spin relaxation time in LT-GaAs by time-resolved pump and probe measurements, and revealed these relaxation mechanisms.

The sample is 1-μm-thick LT-GaAs which was grown at 260 °C by molecular beam epitaxy. After growth, this sample was annealed at about 600 °C for 10 minutes. In the pump and probe measurements, spin-aligned carriers were created when electrons were excited by a circularly polarized optical pulse generated from a Ti-sapphire laser.[5] The photon energy was tuned to the resonant excitation of the lowest electron-heavy-hole exciton. The time resolution of this measurement system is 200 fs, which is determined by convolution of the optical pulse width.

Figure 1 shows the time evolution of the reflectance in short time range of 23 ps at 10 K for the excitation power of 30 mW at 822 nm. The inset shows the time evolution in long time range of 700 ps. In this measurement, we used the linear orthogonal polarization for the pump and probe beams to avoid the observation of coherent artifact. We observed the triple exponential decay with time constants of 2.0 ps, 28 ps and 158 ps. Two fast relaxation components of 2.0 ps and 28 ps can be attributed to the non-radiative recombination related to defects induced by low temperature growth.

We also measured the temperature dependence of the carrier life time. The carrier life time of the first and the second relaxation components become faster as increasing temperature. However, the carrier life time of the third relaxation component becomes slower as increasing temperature. This indicates that third relaxation component is attributed to the radiative recombination. [6]

Figure 2 shows the time evolution of the reflectance of cocircular (I^+) and anticircular (I^-) polarization at 10 K for the excitation power of 70 mW. The inset shows the time evolution of spin polarization. We observed the double exponential decay with time constants of 46.2 ps and 509 ps. The observed fast spin relaxation which is considerably shorter than that of conventional GaAs[7] indicates the relevance of Elliott-Yafet process[8,9] as spin relaxation mechanism, where spin flip is caused by impurity scattering.

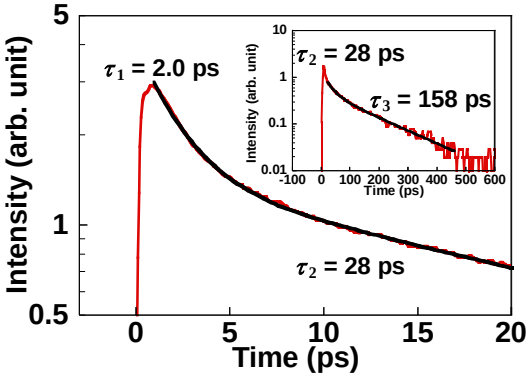

Fig.1 Time evolution of the reflectance at 10 K for the excitation power of 30 mW at 822 nm.

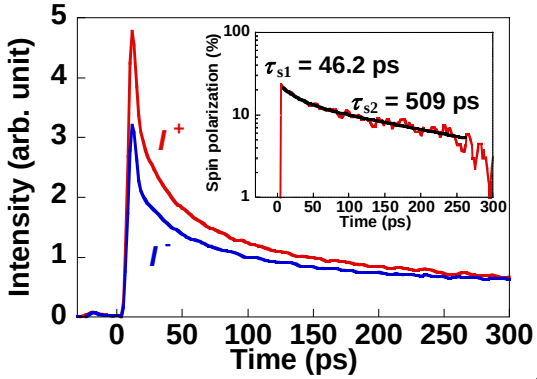

Fig.2 Time evolution of the reflectance of cocircular (I^+) and anticircular (I^-) polarization at 10 K for the excitation power of 70 mW. The inset shows the time evolution of spin polarization.

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