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低温成長 GaAs の伝導帯-カーボンアクセプター間遷移でのスピン緩和

Picosecond spin relaxation of band to carbon acceptor transition in low-temperature grown GaAs

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Low-temperature grown GaAs (LT-GaAs) has unique properties such as the very short carrier lifetime 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 which contribute to the ultrafast nonradiative recombination of photoexcited carriers.[3] Previously, we reported the spin relaxation of exciton–related transition of LT-GaAs.[4] In this study we have investigated the spin relaxation attributed to the transition from the conduction band to the carbon acceptor level of LT-GaAs by time-resolved pump and probe measurements.

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 near the photoluminescence peak wavelength attributed to the transition from the conduction band to the carbon acceptor level. The time resolution of this measurement system is 200 fs, which is determined by the convolution of the optical pulses.

Figure 1 shows the time evolutions 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 single exponential decay with time constants of 82 ps. In contrast, the spin relaxation time of high temperature grown GaAs bulk was measured to be 1.8 ns.[6] The observed fast spin relaxation of the transition from the conduction band to the carbon acceptor level indicates the relevance of Elliott-Yafet (EY) process.[7,8] The EY process causes spin flip by impurity scattering which carbon acceptors may involve.

Figure 2 shows the excitation power dependence of the spin relaxation time at 10 K. The spin relaxation time shows no change with excitation power indicating that the Bir-Arnov-Pikus (BAP) processs[9] is not effective at 10 K. This result is in contrast to the previous result that the BAP process and EY process are effective between 10 K and 77 K for exciton-related transition.[4] At temperatures over 50 K, we have observed the strong temperature dependence showing that the spin relaxation is mainly governed by EY or D'yakonov-Perel process[10] over 50 K.

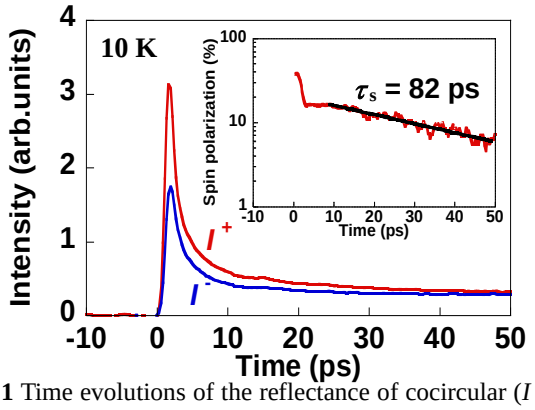

Fig.1 Time evolutions of the reflectance of cocircular (I^+) and anticircular (I^-) polarization at 10 K for the excitation power of 70 mW. The inset shows the time evolution of spin polarization.

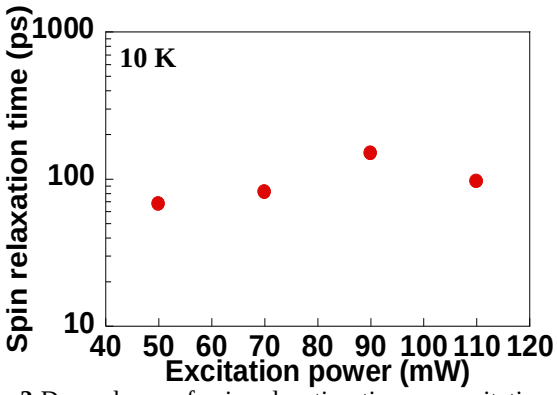

Fig.2 Dependence of spin relaxation time on excitation power for the transition from the conduction band to the carbon acceptor level at 10 K.

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