InGaAs 量子井戸と GaInNAs 量子井戸のスピン緩和の観測

The observation of the spin relaxation in InGaAs quantum well and GaInNAs quantum well

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In present optical fiber communications, laser diodes are used in the 1.3 or 1.55-μm wavelength ranges to minimize loss at the optical fiber windows.[1] GaInNAs QW semiconductor alloys grown on a GaAs substrate have attracted a lot of attention due to their unusual physical properties and potential applications in long wavelength optoelectronic devices.[1] Previously, we have reported the spin relaxation time of $GaIn_{0.425}N_xAs$/GaAs QWs (x = 0, 0.6 %) measured by the time-resolved spin-dependent pump and probe reflectance measurements.[2] In this paper, we report the spin relaxation time of $Ga_{0.6}In_{0.4}N_{0.01}As_{0.99}$ QW and $In_{0.4}Ga_{0.6}As$ QW measured by the time-resolved spin-dependent pump and probe reflectance measurements.

The sample consists of a 7-nm-thick $Ga_{0.6}In_{0.4}N_{0.01}As_{0.99}$ well and 7-nm-thick $In_{0.4}Ga_{0.6}As$ well sandwiched between GaAs barrier layers grown by molecular beam epitaxy on a GaAs substrate. A Ti-sapphire laser with an optical parametric oscillator was used as the optical source. Initially, spin-aligned carriers were generated in the sample by a circularly polarized pump pulse and the circularly polarized time-delayed probe pulse was irradiated.[3] Consequently, the population change of the spin polarized carriers was measured through the change in intensity of the reflected probe. The time resolution of this measurement system was 200 fs.

Figure 1 (a) and Figure 2 (a) show the observed time evolutions of spin-dependent reflection intensity of $Ga_{0.6}In_{0.4}N_{0.01}As_{0.99}$ QW and $In_{0.4}Ga_{0.6}As$ QW for an excitation power of 40 mW at 10 K. I^+ indicates a right circularly polarized excitation and a right circularly polarized probe. I^- indicates a right circularly polarized excitation and a left circularly polarized probe. The difference between I^+ and I^- corresponding to the spin polarization can be clearly observed. Figure 1 (b) and Figure 2 (b) show the time evolutions of the spin polarization for an excitation power of 40 mW at 10 K. The spin relaxation times are evaluated to be 387 ps and 23.8 ps by a single-exponential fitting at 10 K.

In $In_{0.4}Ga_{0.6}As$ QW, we didn't observe excitation power dependence of the spin relaxation time at 10 K. This result suggests that Bir-Aronov-Pikus (BAP) mechanism[4] is not effective at 10 K. In $Ga_{0.6}In_{0.4}N_{0.01}As_{0.99}$ QW, however, we observed excitation power dependence showing that the spin relaxation is mainly governed by BAP mechanism at 10 K.

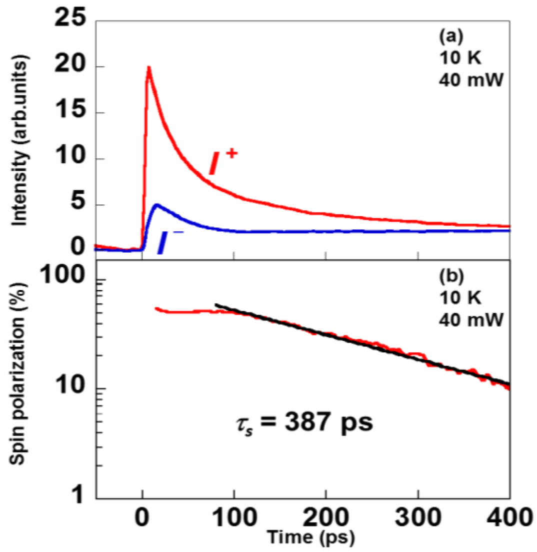

Fig.1 Time evolutions of (a) spin-dependent reflection intensity and (b) spin polarization in $Ga_{0.6}In_{0.4}N_{0.01}As_{0.99}$ QW for the excitation power of 40 mW at 10 K.

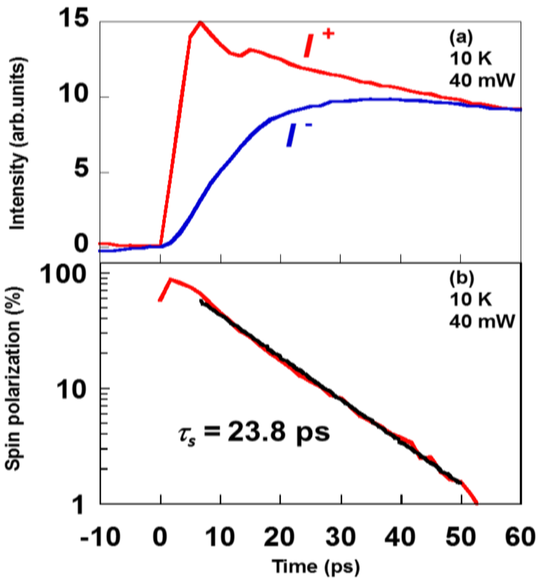

Fig.2 Time evolutions of (a) spin-dependent reflection intensity and (b) spin polarization in $In_{0.4}Ga_{0.6}As$ QW for the excitation power of 40 mW at 10 K.

1 M. Kondow et al., Jpn. J. Appl. Phys. **35,** 1273-1275 (1996).
2 中田他、第 72 回応用物理学会学術講演会 1p-S-4 (2011).
3 A. Tackeuchi et al., Appl. Phys. Lett. **56**, 2213 (1990).
4 G. L. Bir et al., Sov. Phys. JETP. **42**, 705 (1976).