ドープ濃度の異なる Zn ドープ InP バルクのスピン緩和

Observation of spin relaxation in Zn doped InP bulk with different doping concentrations

早大先進理工
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The spin relaxation of semiconductors has attracted considerable attention owing to the enormous potential of spin-based devices, the so-called "spintronic devices".[1] Particularly, InP materials have found important applications, such as high-electron mobility transistors or optoelectric devices.[2] However, the effect of doping on spin relaxation has not yet been clarified. In this study, we have investigated the carrier relaxation and spin relaxation in Zn doped InP bulk with different doping concentrations by time-resolved pump and probe reflection measurement.

The samples investigated in this research were a 500-µm-thick Zn doped InP bulk (sample A) and a 350-µm-thick Zn doped InP bulk (sample B) grown by liquid encapsulated Czochralski method. Both samples were grown by Wafer Technology Ltd. Sample A showed a p-type characteristic with carrier concentration between 6.5 - 7.5 × 10^{16} cm^{-3}. Sample B showed a p-type characteristic with carrier concentration between 1.40 × 10^{17} cm^{-3}.

In the time-resolved pump and probe reflection measurement, spin-aligned carriers were excited by a circularly polarized optical pulse generated from a Ti-sapphire laser.[3] The photon energy was tuned to the bandgap energy for resonant excitation. The time resolution of the measurement system was about 300 fs, which originates from the pulse width being slightly widened by an EO modulator.

Figure 1 and Figure 2 shows the time evolutions of the reflection intensity in sample A and sample B, respectively. I^+ and I^- indicate the cocircular and anticircular polarizations, respectively. The time evolution of the spin polarization is plotted in the inset of Fig. 1 and Fig. 2. At 10 K, for the excitation power of 60 mW, the carrier relaxation times of sample A (sample B) are obtained to be 54 ps (65 ps) and 715 ps (452 ps) by a double exponential fitting. The measured spin relaxation time of sample A is 318 ps and that of sample B is 502 ps, which is obtained from a single exponential fitting (black line). The spin relaxation time of sample A is shorter than that of sample B. These results indicate that the doping concentration affects the spin relaxation mechanism.

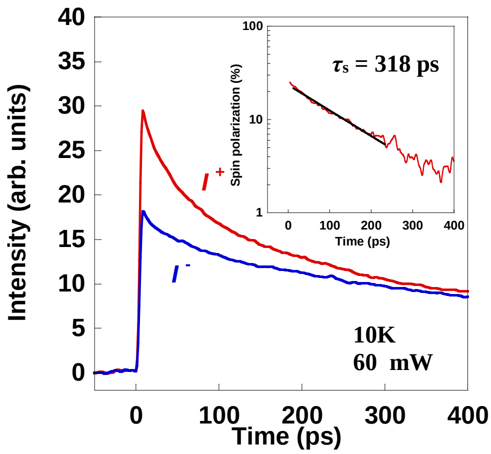

Fig. 1 Time evolutions of cocircular (I^+) and anticircular (I^-) polarization in sample A at 10 K for the excitation power of 60 mW. The inset shows time evolution of spin polarization. Black line shows single exponential fitting.

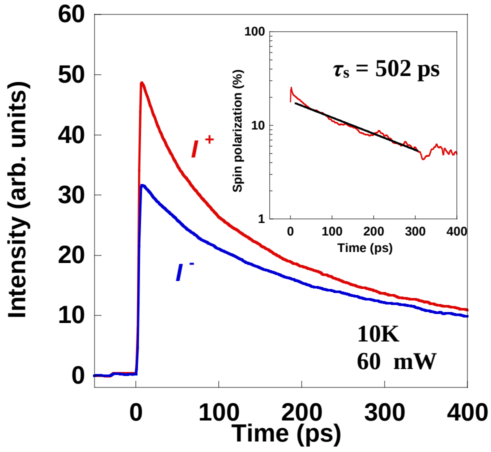

Fig. 2 Time evolutions of cocircular (I^+) and anticircular (I^-) polarization in sample B at 10 K for the excitation power of 60 mW. The inset shows time evolution of spin polarization. Black line shows single exponential fitting.

[1] Y. Yamashita et al., IEEE Electron Device Lett. **23**, 573 (2002).
[2] N. Dharmarasu., et al., Appl. Phys. Lett. **79**, 2399 (2001).
[3] A. Tackeuchi et al., Appl. Phys.Lett. **56**, 2213 (1990).