Zn ドープ InP バルクにおけるスピン緩和時間の観測

Observation of spin relaxation in Zn doped InP bulk

早大先進理工
○飯田 真之、谷川 詩馬、田中 大介、滝沢 将也、竹内 淳
Waseda Univ.
°M. Iida, S. Tanigawa, D. Tanaka, M. Takizawa, and A. Tackeuchi
E-mail address: beadaman@akane.waseda.jp

InP materials have found important applications, such as high-electron mobility transistors.[1] In this study, we investigated the carrier relaxation and spin relaxation in Zn doped InP bulk by time-resolved pump and probe reflection measurement. We also compared the results with those of our previous studies done on undoped and Fe doped InP bulk.[2, 3]

The sample investigated in this research was a 500 μm thick p-type Zn doped InP bulk (Wafer Technology Ltd.) grown by liquid encapsulated pulling method. The carrier concentration was between 6.5 – 7.5 × 10^{16} cm^{-3}. The carrier concentration of our previous samples were 7.8 – 7.9 × 10^{15} cm^{-3} (undoped, n-type) and 2.6 – 2.8 × 10^{8} cm^{-3} (Fe doped, semi-insulator). The carrier relaxation time at 10 K was 461 ps, whereas that of the previous samples were 840 ps (undoped), and 339 ps (Fe doped), each having no temperature dependence. The doping of Zn had similar impact on the carrier relaxation time as the doping of Fe.[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.[4] 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 shows the time evolutions of the reflection intensity. 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. The measured spin relaxation time is 813 ps, which is obtained from a single exponential fitting (black line). Figure 2 shows the summary of the spin relaxation time. The data of undoped and Fe doped InP bulk is also plotted for comparison.[2, 3] At 10 – 100 K, the spin relaxation time remained approximately the same as our previous samples. While the doping of Zn had a major effect on the carrier relaxation time, it had very little on the spin relaxation time.

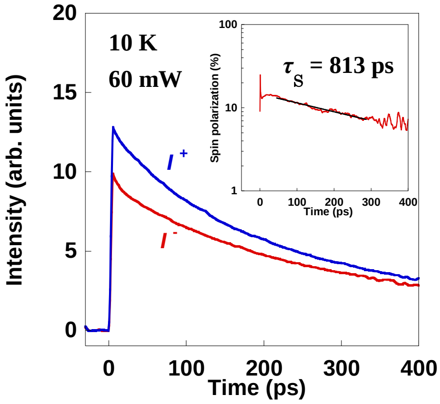

Fig. 1 Time evolutions of cocircular (I^+) and anticircular (I^-) polarization at 10 K for the excitation power of 60 mW. Inset shows time evolution of spin polarization. Black line shows single exponential fitting.

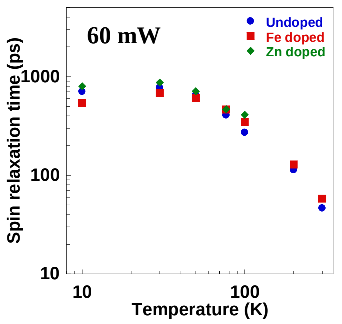

Fig. 2 Spin relaxation times of Zn doped, undoped and Fe doped InP bulk. Excitation power was set to 60 mW for all experiments.

[1] Y. Yamashita et al., IEEE Electron Device Lett. **23**, No. 10, 573-575, (2002).
[2] M. Iida et al., The 77th JSAP Autumn meeting, 14p-C41-10 (2016).
[3] M. Iida et al., The 64th JSAP Spring meeting, 14p-P10-8 (2017).
[4] A. Tackeuchi et al., Appl. Phys. Lett. **56**, 2213 (1990).