

ノンドープ InP バルクにおけるスピン緩和時間の観測

Observation of spin relaxation in undoped InP bulk

早大先進理工

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InP materials have found important applications, such as high-electron mobility transistors.¹ However, the amount of research done on their behavior, involving electron spin dynamics, is still limited. In this study, we investigated the spin relaxation in undoped InP bulk by time-resolved pump and probe measurement.

The sample investigated in this research was an 1100 μm thick undoped InP bulk (Wafer Technology Ltd.) grown by liquid encapsulated pulling method. The sample showed n-type behavior with carrier concentration between $7.8 - 7.9 \times 10^{15} \text{ cm}^{-3}$. This is due to phosphorus vacancies, and is a typical characteristic of undoped InP.² Figure 1 shows the PL spectra of the sample at 10 K. Two peaks are observed. These peaks are named peak 1 and peak 2, from the shorter wavelength, respectively. Peak 1 originates from the band-to-band transition and the recombination of free excitons. Peak 2 originates from transitions involving unintentionally doped residual zinc impurities.³

In the pump and probe measurement, spin-aligned carriers were excited by a circularly polarized optical pulse generated from a Ti-sapphire laser.⁴ The photon energy was tuned slightly above that of peak 1. The time resolution of the system was about 300 fs, which originates from the pulse width.

Figure 2 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. 2. The measured spin relaxation time is 705 ps, which is obtained from a single exponential fitting (black line). Figure 3 shows the temperature and excitation power dependence of the spin relaxation time. At 10 – 50 K, no clear temperature dependence is observed. At 77 K – RT, a clear negative temperature dependence and a negative excitation power dependence are observed. The negative temperature dependence suggests the effect of the DP mechanism.⁵

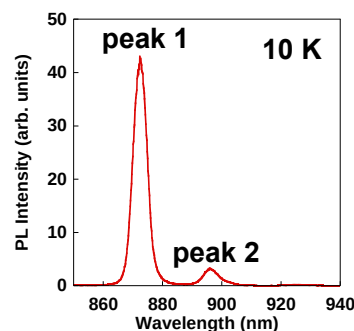


Fig. 1 PL spectra of undoped InP bulk at 10 K.

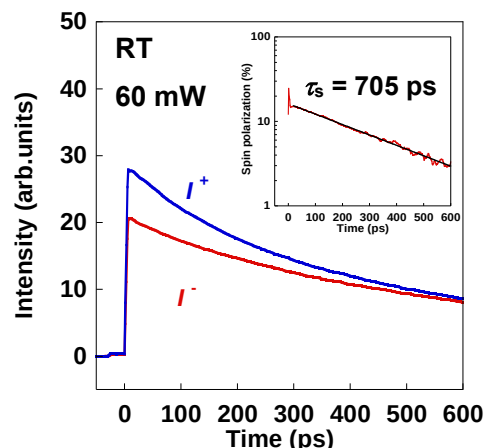


Fig. 2 Time evolutions of cocircular (I^+) and anticircular (I^-) polarization at 10 K for the excitation power of 60 mW. Inset shows time evolution of spin polarization. Black line shows single exponential fit.

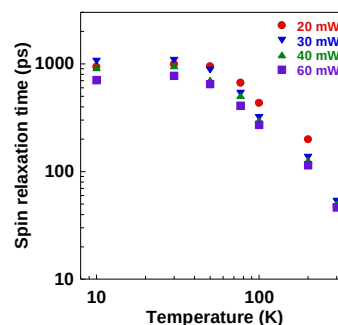


Fig. 3 Spin relaxation times of undoped InP bulk at 10 K – RT.

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³ T. Inoue et al., J. Electrochem. Soc. **137**, No. 4, 1283 (1990).

⁴ A. Tackeuchi et al., Appl. Phys. Lett. **56**, 2213 (1990).

⁵ M. I. D'yakonov et al., Sov. Phys. Semicond. **20**, 110 (1986).