Be ドープ InGaAsP バルクにおける スピン緩和時間のキャリア濃度依存性(10-300 K)

Carrier density dependence of spin relaxation time in Be-doped InGaAsP bulk (10-300 K)

早大先進理工 [1], SINANO-CAS [2]
○山田 築 [1], 大木 俊介 [1], 石川 友樹 [1], 亀崎 拓也 [1], S. L. Lu [2], L. Ji [2] and 竹内 淳 [1]
○K. Yamada [1], S. Ohki [1], T. Ishikawa [1], T. Kamezaki [1], S. L. Lu [2], L. Ji [2] and A. Tackeuchi [1]
E-mail address: kizuccoo3361@ruri.waseda.jp

Experiments and analyses of spin relaxation of InGaAsP have attracted intense interest with the continuous development of solar cells and other solar energy materials.[1] Previously, we observed the spin relaxation in Be-doped InGaAsP bulk with different carrier density (sample B).[2] Here, we report the carrier density dependence of spin relaxation time in Be-doped InGaAsP grown on an InP substrate observed by time-resolved pump and probe reflectance measurements.[3]

The samples contain a Be-doped InGaAsP grown on an InP substrate by molecular beam epitaxy. The carrier densities are 1×10^{18} cm^{-3} (sample A) and 1×10^{17} cm^{-3} (sample B). The spin relaxation times were measured by pump and probe reflectance measurement at 10-300 K. A Ti-sapphire laser with an optical parametric oscillator was used as the optical source. The pump beam was chopped by an electro-optic modulator at 1.9 MHz to avoid optical noise in the low-frequency region. The excitation laser wavelengths were tuned to 1101 nm at 10 K, and 1117 nm at 300 K.

As for sample A, the time evolution of the reflectance at 10 K for 30 mW is shown in Fig. 1, where I^+ indicates a right circularly polarized excitation with a right circularly polarized probe, while I^- indicates a right circularly polarized excitation with a left circularly polarized probe. Note that the spin polarization was clearly observed. The time evolution of spin polarization $(I^+ - I^-)/(I^+ + I^-)$ is shown in the inset of Fig. 1. The spin relaxation time τ_s, which is twice the relaxation time of the spin polarization, is evaluated to be 1.08 ns.

The obtained spin relaxation times for sample A and sample B are shown in Fig. 2. Over the entire temperature range, the spin relaxation time of sample A, which has a higher carrier density, is shorter than that of sample B. In addition, at 10-77 K, sample A has a weaker temperature dependence. Although it is reported that higher carrier density samples have shorter carrier relaxation times,[4] the obtained fact indicates that the difference of carrier density affects not only carrier relaxation but also spin relaxation.

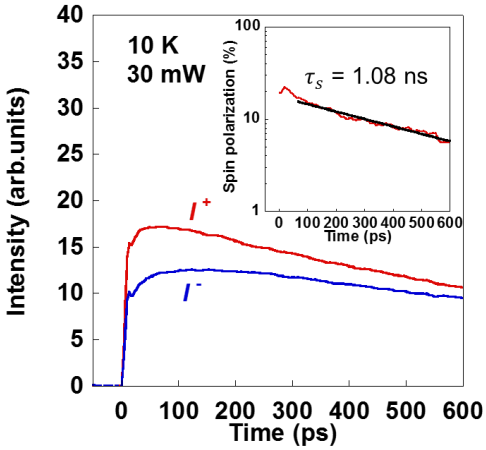

Fig.1 Time evolutions of spin-dependent reflectance and (inset) spin polarization for the excitation power of 30 mW at 10 K (sample A).

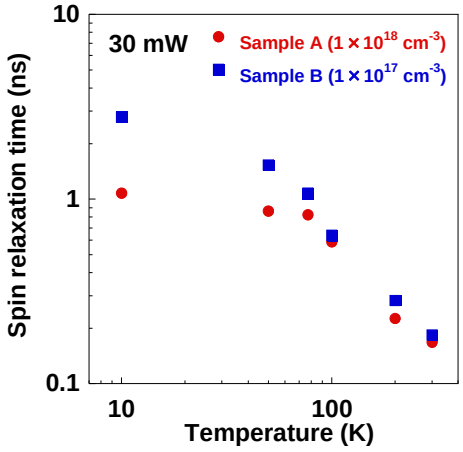

Fig.2 The summary of spin relaxation times of sample A (1×10^{18} cm^{-3}) and sample B (1×10^{17} cm^{-3}).

[1] L. Ji et al., Solar Energy Materials & Solar Cell. **127**, 1, (2014).
[2] 呉 他, 第 75 回応用物理学会秋季学術講演会 19p-S2-5 (2014).
[3] A. Tackeuchi et al., Appl. Phys. Lett. **56**, 2213 (1990).
[4] T. Beechem et al., J. Appl. Phys. **103**, 093507 (2008).