Observation of spin relaxation in 800-°C-annealed Be-doped $In_{0.8}Ga_{0.2}As_{0.45}P_{0.55}$ at 10-300 K

早大先進理工 [1], SINANO-CAS [2]
○ショウ サンウ [1], 原澤 遼 [1], 安江 雄也 [1], H. Wu [1], 有竹 貴紀 [1], S. L. Lu [2], L. Ji [2], 竹内 淳 [1]
Waseda Univ. [1], SINANO-CAS [2]
○C. Jiang [1], R. Harasawa [1], Y. Yasue [1], H. Wu [1], T. Aritake [1], S. L. Lu [2], L. Ji [2] and A. Tackeuchi [1]
E-mail address: s112804036@akane.waseda.jp

InGaAsP grown on InP substrate is a promising candidate of four junction solar cells which can achieve the ideal efficiency of 55%.[1] Here, we report the spin relaxation time of 800-°C-annealed Be-doped $In_{0.8}Ga_{0.2}As_{0.45}P_{0.55}$ grown on an InP substrate observed by time-resolved pump and probe measurement at 10-300 K.

The sample contains a 1000-nm-thick Be-doped $In_{0.8}Ga_{0.2}As_{0.45}P_{0.55}$ grown on an InP substrate by molecular beam epitaxy. The Be concentration is 2×10^{17} cm^{-3}. After the growth, the sample was annealed at 800 °C. The spin relaxation process was observed by pump and probe measurement at 10-300 K.[2]

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 wavelength was tuned to 1117 nm at 10 K, and 1167 nm at 300 K.

The time evolution of spin-dependent reflection intensity for the excitation power of 30 mW at 300 K 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 114 ps. Figure 2 shows spin relaxation times for different excitation powers at 10-300 K. In Fig.2, the spin relaxation time becomes faster as increasing excitation power at 10-77 K. The temperature dependence evaluated to be $\tau_s \propto T^{-1.9}$ is observed at 77-300 K.

At 10-77 K, spin relaxation time decreases as the carrier intensity increases. This result shows that Bir-Aronov-Pikus process[3] is related at 10-77 K. At 77-300 K, the spin relaxation time decreases with increasing temperature. Therefore, this result implies that Elliott-Yafet process[4] and D'yakonov-Perel' process[5] are effective at 77-300 K.

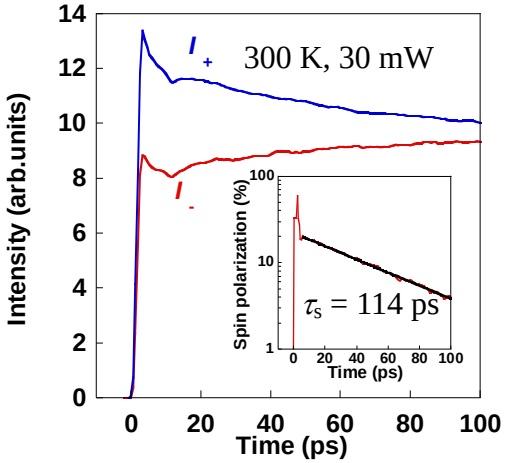

Fig.1 Time evolution of spin-dependent reflection intensity and (inset) spin polarization for the excitation power of 30 mW at 300 K.

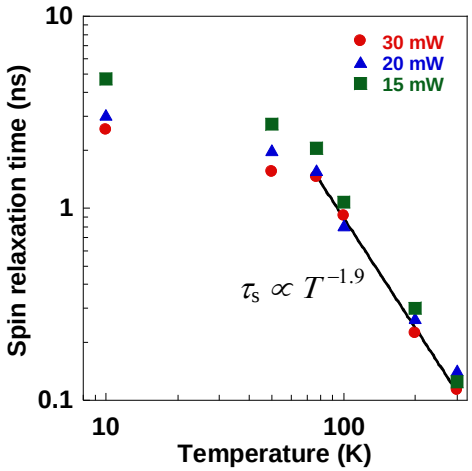

Fig.2 Spin relaxation times for different excitation powers at 10-300 K. The solid line shows the temperature dependence of the spin relaxation time fitted at 77-300 K for 30 mW-pump.

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