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InGaAsP バルクのサブピコ秒スピン緩和時間の観測

Observation of the sub-picosecond spin relaxation in InGaAsP bulk

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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] Previously, we reported that the electron spin relaxation times in InGaAsP grown on InP substrate are 980 ps to 95 ps at 10 K to 300 K.[2] Here, we report sub-picoseconds spin relaxation in InGaAsP bulk grown on InP substrate.

The sample contains a 200-nm-thick undoped $In_{0.78}Ga_{0.22}As_{0.47}P_{0.53}$ grown by molecular beam epitaxy. To generate a smooth surface, a 50-nm-thick p-doped InP buffer layer was inserted between the InGaAsP and InP substrate. After InGaAsP growth, a 10-nm-thick InP cladding layer was grown. The spin relaxation times were measured by time-resolved spin-dependent pump and probe reflectance measurement.[3] A Ti-sapphire laser with an optical parametric oscillator was used as the optical source for the pump and probe experiment. In the spin-dependent pump and probe measurements, the laser energy was tuned to the photoluminescence peak. The time resolution in this system of 200 fs is determined only by the convolution of optical pulses.

Figure 1 shows the observed time evolutions of spin-dependent reflectance of cross-linear and anti-circular polarization at 10 K for the excitation power of 20 mW at the excitation wavelength of 1153 nm. Cross-linear polarization indicates the population change without spin polarization. Anti-circular polarization indicates the population change of up spin polarization. The observed time evolution of spin polarization at 10 K at 20 mW are shown in Fig. 2. The time evolution of spin polarization $(I_+ - I_-) / (I_+ + I_-)$ is derived from the difference of the cross-linear polarization $(I_+ + I_-) / 2$ and the anti-circular polarization I_- divided by the cross-linear polarization. The spin relaxation time τ_s, which is twice the relaxation time of the spin polarization, [3] is obtained to be 0.74 ps at 10 K by the double exponential fitting. This observed fast spin relaxation can be attributed to hole spin relaxation. As increasing temperature from 10 K to 300 K, the spin relaxation time decreases from 0.74 ps to 0.29 ps. This temperature dependence indicates that the Elliott-Yafet [4, 5] process due to spin-flip by scattering is effective in this sample.

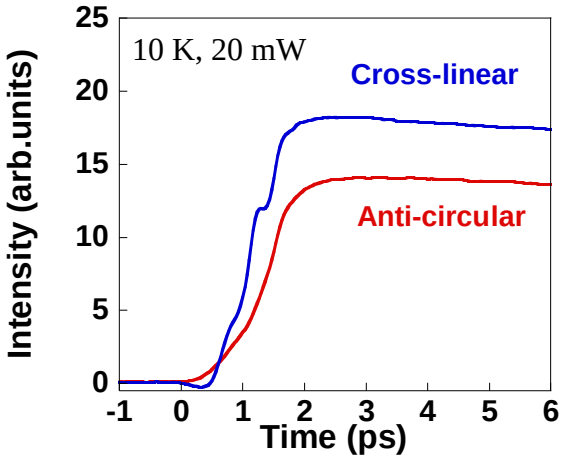

Fig.1 Time evolutions of spin-dependent reflectance at 10 K for the excitation power of 20 mW at 1153

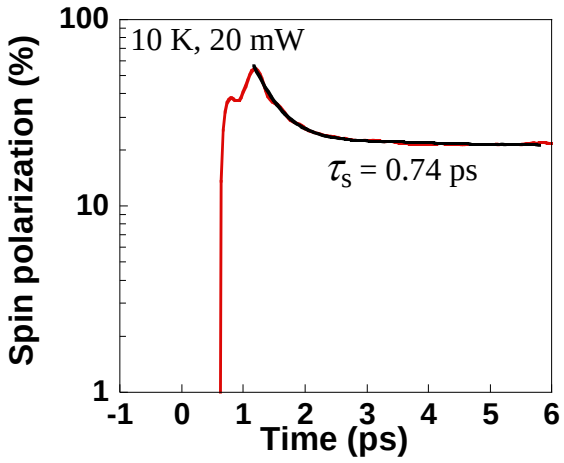

Fig.2 Time evolution of spin polarization at 10 K for the excitation power of 20 mW at 1153 m.

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