Kerr rotation spectroscopy of electron spins in GaAsBi epilayer

○Yoji Kunihashi[1], Yusuke Tanaka[1], Haruki Sanada[1], Makoto Kohda[2], Junsaku Nitta[2], Sho Hasegawa[3], Hiroyuki Nishinaka[3], Masahiro Yoshimoto[3], Hideki Gotoh[1]

NTT Basic Research Laboratories[1], Tohoku University[2], Kyoto Institute of Techenology[3]

E-mail: yoji.kunihashi.kf@hco.ntt.co.jp

GaAsBi is a candidate material for spintronics applications in terms of spin control via spin-orbit effective magnetic fields because the addition of bismuth atoms to GaAs crystal significantly enhances the spin-splitting energy [1]. However, to date, the research on spin dynamics in such diluted bismide has been limited. Here, we investigate the electron spin dynamics in $GaAs_{1-x}Bi_x$ using Kerr rotation spectroscopy based on a pump-probe technique. A Kerr rotation signal was observed for a wide wavelength region of 840 to 906 nm, where the initial phase of the spin precession under an external magnetic field was changed continuously from 0 to π. This nontrivial dependence of the spin phase on the excitation wavelength implies that the spin properties are influenced by the energy band structures in $GaAs_{1-x}Bi_x$, and thus our findings are beneficial as regards understanding the spin properties of diluted $GaAs_{1-x}Bi_x$ alloy.

43-nm-thick $GaAs_{1-x}Bi_x$ (x = 1.9%) was grown on a *p*-GaAs substrate by molecular beam epitaxy at a temperature below 400 ˚C. The samples consisted of, from the bottom, *p*-GaAs (substrate) / GaAs (buffer layer) / GaAsBi / GaAs (cap layer). To investigate the spin dynamics, we performed time-resolved magneto-optic Kerr rotation measurements at 4 K. A mode-locked Ti:sapphire laser provided 150 fs pulses for injecting and detecting spins. The circularly-polarized pump beam excited spin polarized electrons, and the subsequent spin density dynamics were measured through the Kerr effect of the reflected linearly polarized probe beam. As shown in Fig. 1, we observed decaying and oscillating Kerr rotation signals under an in-plane external magnetic field of B = 400 mT for various laser wavelengths. This reflects the dynamics of optically-injected electron spins precessing around an external field in the GaAsBi layer. The *g*-factor estimated from the spin precession frequency was 0.651, which is about 1.5 times larger than the typical *g*-factor in GaAs, indicating the strong enhancement of the spin-orbit interaction in GaAsBi. We found that the initial phase of the spin precession became π/2 at a wavelength of λ = 886 nm whose energy corresponds to the band gap energy of GaAsBi. This appears to indicate that the in-plane spin components were generated by the circularly-polarized pump laser with band gap energy. The continuous modulation of the spin phase around the band edge as observed in the present experiment is incomprehensible behavior if we assume the same band structure with conventional GaAs, and it might originate from the complex structure of the valence band in $GaAs_{1-x}Bi_x$. This work was supported by JSPS KAKENHI (No. 24686004 and 23310097).

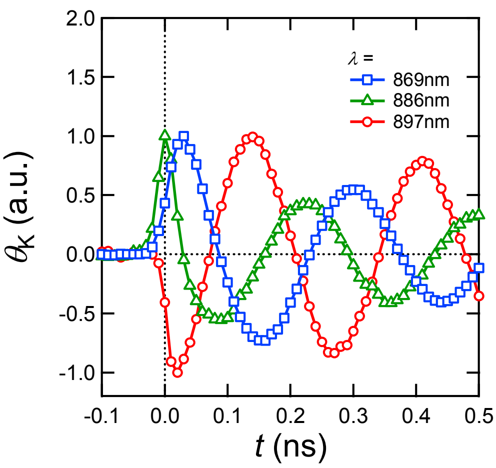

Fig. 1 Normalized Kerr rotation signal for various wavelengths under an external magnetic field of B = 400 mT.

[1] B. Fluegel *et al.*, PRL **97**, 067205 (2006).