Spin dynamics observed by Kerr rotation microscopy in GaAsBi epilayer

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The incorporation of only small concentrations of Bi into GaAs crystal induces a significant modulation of the electronic structure as a result of large differences in the sizes and chemical properties of Bi and As atoms. A rapid reduction of the energy band gap and an increase in spin splitting energy have been reported as a composition-dependent bowing of electronic properties [1]. This indicates the existence of a strong spin-orbit interaction in $GaAs_{1-x}Bi_x$, thus making it a candidate material for possible application to spin-based devices. Here, we investigated the dynamics of locally-injected spin polarization in an undoped $GaAs_{1-x}Bi_x$ (x = 0.019) epilayer with a Kerr rotation measurement based on pump-probe techniques. We found a discrepancy between the peak wavelengths of the Kerr rotation signal and the photoluminescence spectra observed in $GaAs_{0.981}Bi_{0.019}$. This implies the existence of a localized state at a lower energy level than the bottom of the conduction band. Therefore, our findings are beneficial as regards understanding the detailed electronic structure of diluted GaAsBi alloy as well as the spin dynamics.

The $GaAs_{0.981}Bi_{0.019}$ epilayers were grown on a (001)-oriented p-GaAs substrate by solid-source molecular beam epitaxy at a temperature of less than 400 ˚C. The samples consisted of, from the bottom, p-GaAs (substrate)/GaAs (buffer layer)/$GaAs_{0.981}Bi_{0.019}$ (43 nm)/GaAs (cap layer). The spin dynamics was measured using time-resolved Kerr rotation microscopy while changing the wavelength λ of a Ti:sapphire laser at T = 10 K.

Three Kerr rotation signal peaks at wavelengths of 833, 855, and 890 nm were observed in $GaAs_{0.981}Bi_{0.019}$ as shown in Fig. 1. The Kerr rotation signal at λ = 833 nm originates from the GaAs substrate, whereas the maximum peak at λ = 855 nm derives from the electrons in the GaAsBi conduction band. The wavelength of 855 nm is shorter than the peak of the photoluminescence spectra observed at λ = 960 nm. This fact indicates that localized states exist below the conduction band, and these states contribute mainly to the luminescence from GaAsBi. The peak of the Kerr rotation with a smaller intensity and a longer spin relaxation time at λ = 890 nm is thus attributed to the localized state. This work was supported by JSPS KAKENHI (No. 24686004 and 23310097).

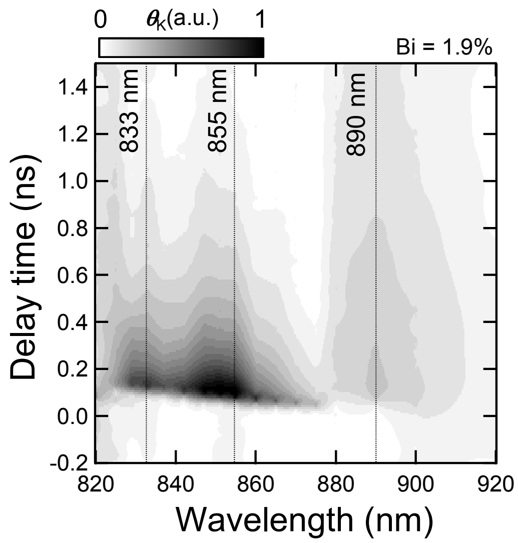

Fig. 1 Wavelength dependence of decaying Kerr rotation angle θ_K in $GaAs_{0.981}Bi_{0.019}$.

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