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(Ga,Mn)As の長波長光 (λ > 820 nm) による光誘起 FMR の励起過程

Photo-induced FMR in (Ga,Mn)As with long wavelength (λ > 820 nm) excitation

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The issue of thermal[1] or non-thermal[2] influence in the ultra-short time scale (< 10 ps) has been debated in the study of photo-induced ferromagnetic resonance in a ferromagnetic semiconductor layer of (Ga,Mn)As. This problem is relevant to the excitation of spin-polarized electrons to non-equilibrium condition[3] and the ultra-fast demagnetization in metals. We have approached to the problem using relatively long excitation wavelength $\lambda \geq 830$ nm ($h\nu \leq 1.494$ eV), by which *phonon generation* via intraband inelastic carrier scattering is supposed to be less significant.

A 100-nm thick (Ga,Mn)As epilayer grown on a GaAs (001) substrate was used in this study. Mn contents and the Curie temperature are 2 % and T_c = 45 K, respectively. Single-color pump and probe technique was employed to measure transient reflectivity and polarization rotation. The former represents carrier dynamics, whereas the latter magnetization dynamics. Fluence of pump and probe beams were I_{pump} = 1.7 μJ/cm^2 and I_{probe} = 84 nJ/cm^2, respectively. The pulse width of the beams was 150 fs.

Temporal profiles of polarization rotation at 10 K for various λ are summarized in Fig. 1. Oscillatory signals were observed for λ = 830 ~ 880 nm. Signals due to demagnetization were hardly observed for both transient reflectivity and polarization rotation at the onset of the precession (Fig. 2). Analysis with gyromagnetic model[1] have revealed the λ-independent effective field $|H_{eff}|$ (= 2.0 kOe), effective Gilbert damping parameter α (= 0.25), and the H_{eff} tilt life time τ_2 (= 200 ps), suggesting that photo-induced precessions are not influenced by the after effect of lattice heating. The H_{eff} tilt rise time τ_1 (= 10 ps) is remarkably reduced from the case of λ = 750 ~ 810 nm (90 ~ 140 ps)[4]. Those experimental data suggest that photo-induced tilt of $\boldsymbol{H_{eff}}$ is attributed to excitation/relaxation of holes and spins but not to the heat generation.

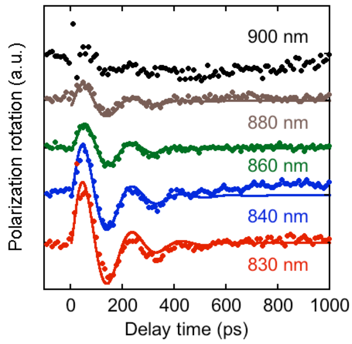

Fig. 1 Magnetization precession measured at λ > 820 nm. Dots are experimental data and lines are fitting curves.

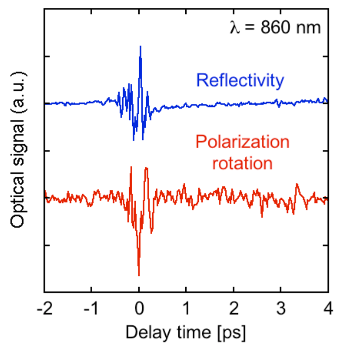

Fig. 2 Polarization rotation and reflectivity measured at 860 nm over few ps time period.

References: 1. E. Rozkotova *et al.*, APL, 92, 122507 (2008). 2. Y. Hashimoto *et al.*, PRL, 100, 067202 (2008). 3. K. Carva *et al.*, PRL, 107, 207201 (2011). 4. 松田　喬，宗片　比呂夫，第 37 回日本磁気学会学術講演会，北海道大学, 2013 年 9 月 6 日, 6aC-4