Effect of two-pulse excitation on photo-excited precession of magnetization in (Ga,Mn)As in ultra-short time region

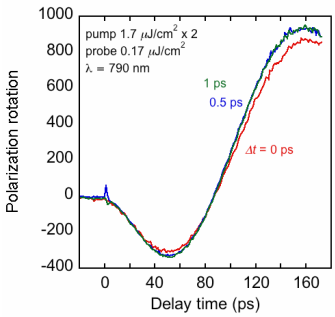
°宗片 比呂夫 [1]、松田 喬 [1] (1. 東工大像情報)

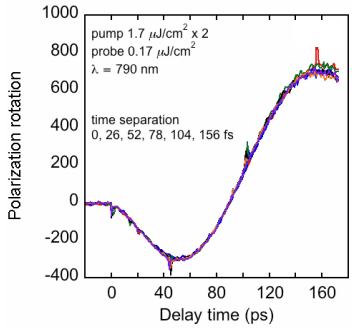
°Hiro Munekata [1] and Takashi Matsuda [2] (1. ISEL, TITech)

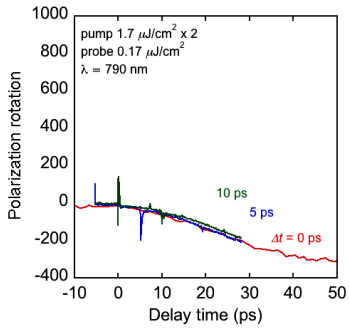
E-mail: hiro@isl.titech.ac.jp

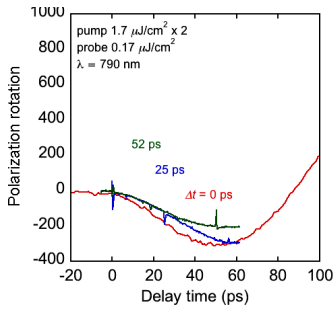
Studying the mechanism of fs-laser-excited precession of magnetization in ferromagnetic (Ga,Mn)As has given us the opportunity of pursuing the mechanism of ultrafast manipulation of ordered spins and new applications in spintronics. In general, photo-induced non-equilibrium states can be classified into three different stages: (i) strong non-equilibrium during the laser pulse width, (ii) thermalization with time scale governed by microscopic process (~ a few ps), and (iii) relaxation into an initial equilibrium with time scale rather governed by macroscopic process (~ ns or longer). This work aims at studying optically those stages by probing the response of ordered spins which are excited by the two pump pulses whose interval Δt is controlled for a wide range between 27 fs and 52 ps. See APL **93**, 202506 (2008) for data with Δt > 100 ps.

Two pump and one probe pulse trains of 150-fs pulse width and repetition of 76 MHz were impinged on a 100-nm thick $Ga_{0.98}Mn_{0.02}As$ sample cooled at 10 K. Temporal profiles obtained by pump-probe method exhibit clear photo-excited precession of magnetization (PEPM), as represented by red lines in Figs.1-4, the data obtained with Δt = 0. Delay up to Δt ~ 150 fs does not affect the profile, as seen in Fig.2. Interestingly, at Δt > 200 fs, slight but finite enhancement in the precession amplitude occurs in the time region of macroscopic relaxation (Fig.1). This trend vanishes as Δt is increased, as seen in Fig.3 for the data with Δt = 5 and 10 ps. Further increasing Δt gives rise to coherent control of precession as discussed in aforementioned APL paper. The enhanced precession amplitude found in Δt = 0.5 -5 ps implies that photo-induced torque increases non-linearly. This is possible if number of excited states per pulse is increased.









Temporal profiles of PEPM signals taken with different time intervals; in Fig.1 (upper, left), Δt = 0 (red), 0.5 (blue), and 1 ps (green); in Fig.2 (upper center), Δt = 0, 26, 52, 78, 104, and 156 fs; in Fig.3 (upper, right), Δt = 0 (red), 5 (blue), and 10 ps (green); in Fig. 4 (lower, right), Δt = 0 (red), 26 (blue), and 52 ps (green). Pump-probe photon energy, pulse width, fluence of pump and probe pulses are hν = 1.57 eV, Γ = 150 fs, F(pump) = 1.7 μJ/cm^2 and F(probe) = 0.17 μJ/cm^2, respectively. A GaMnAs sample (x = 0.02) was cooled at 10 K.

© 2015年 応用物理学会