Co/Pd 多層膜における光励起磁化歳差運動の初期過程

Study on the onset of photo-excited precession of magnetization in Co/Pd multilayers

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Amplitude of photo-excited precession of magnetization (PEPM) in Co/Pd multilayers (MLs) has been found to increase by a factor 20 by changing the Pd layer thickness, making it possible to trigger the PEPM with fs-laser pulses as low as around 1 μJ/cm^2 [1]. This fact implies that the mechanism other than ultrafast demagnetization[2] may have significant influence on PEPM in Co/Pd MLs. We report here experimental data of PEPM in time regime of around 1ps, and discuss its mechanism under weak excitation condition.

[Co(0.78 nm) / Pd(0.81 nm)]$_5$ samples were deposited on *p*-Si(110) substrates by dc sputtering method at the substrate temperature of 150 °C. Magnetization dynamics were monitored by measuring magnetic polar Kerr rotation with one-color pump and probe technique. An external magnetic field was applied along 65° from the sample normal during measurement. Figures 1 (a) and (b) show temporal profile of PEPM with various pump fluences F. Amplitude of oscillation increases throughout the entire time region with increasing F. Sharp spikes, being attributed to the ultrafast demagnetization, also develops at t < 10 ps for relatively high F. Profiles in the region t > 20 ps are well fitted with the LLG (Landau- Lifshitz-Gilbert) equation, from which it is found that the sum of perpendicular anisotropy field H_{ani} and demagnetization field H_{dem} of opposite direction varies as $H(t) = \{1 + D \exp(-t / \tau)\}\cdot|H_{ani} - H_{dem}|$, with D the magnitude of a sudden change upon pulsed excitation and τ its lifetime. D varies linearly with F, whereas τ is independent on F, being $\tau \approx 400$ ps. The discrepancy between experiment and LLG at t < 20 ps indicates that the tip-off angle of a magnetization vector right at the re-magnetized state ($\tau \sim 5$ ps) is larger than that expected by precession motion. Adding the extra ultrafast demagnetization term on $H(t)$, $D'\exp(-t / \tau')\cdot|H_{dem}|$ with $\tau' = 1$ ps, does not help reproducing the observed discrepancy at t < 20 ps, as represented by the solid circles in Fig. 1 (b). Our analysis suggests that not only H_{dem} but also H_{ani} is influenced by the pulsed laser excitation, and furthermore, a transition region exists in the time domain (1 ~ 20 ps) between the ultrafast demagnetization state and the single precession state.

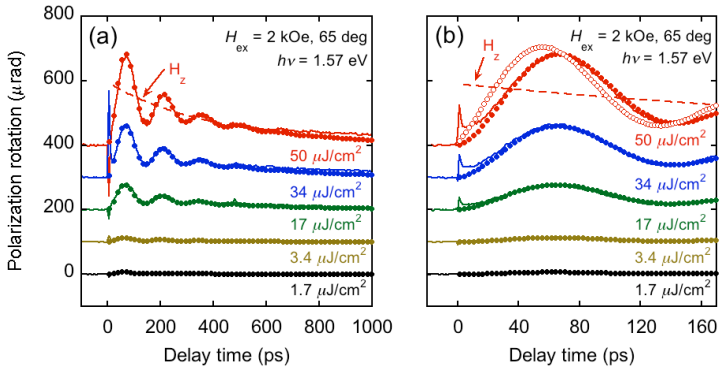

Fig. 1, Temporal profiles of PEPM data in Co/Pd multilayer (solid lines) and calculated values (dots) obtained with LLG equation in (a) the time region up to 1 ns and (b) 170 ps. Dashed line represents the temporal variation of out-of-plane component of $H(t)$ used in simulation of PEPM. Open circles represent the calculated values incorporating the extra ultrafast demagnetization. Data are vertically shifted for clarity.

[1] K. Yamamoto *et al.*, IEEE Trans. Magn. **49**, 3155 (2013). [2] M. van Kampen *et al.*, PRL **88**, 227201 (2002).