Photo-excited precession of magnetization in ultra-thin Co/Pd multilayers at low laser fluence regime

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We present femtosecond-pulse-induced precession of magnetization at low laser fluence (P < 5 μJ/cm2) regime as a function of magnetic field and laser fluence in three Co/Pd multilayer (ML) systems. These systems belong to three different regimes of magnetic anisotropy that vary with Co thickness (t_{Co}): in-plane (sample 1, t_{Co} = 0.74 nm), weakly out-of-plane (sample 2, t_{Co} = 0.6 nm), and out-of-plane (sample 3, t_{Co} = 0.40 nm) with t_{Pd} < 0.5 nm for all samples. Interestingly, the precession amplitudes A_0 have been increased significantly with decreasing the t_{Co} values. The influence of various spin dynamics and static magneto-optical parameters on precession amplitude is examined critically and compared with a previously proposed analytical expression that connects those quantities. The expression has been expressed as:

$$A_0 = \frac{c\gamma_{eff}\theta_{Kerr}\sin(\theta_m)}{4\pi f\left(1+\alpha_{eff}^2\right)}P$$

Here, c is *the efficiency of energy transfer from orbital to spin subsystems*, γ_{eff} the effective gyromagnetic ratio, θ_{kerr} the Kerr angle, θ_m the equilibrium angle of the magnetization vector before precession, f the frequency of precession, P the excitation power of the pump pulse, and, finally, α_{eff} is the effective Gilbert damping constant. It has been found that the enhancement of structural-dependent energy transfer efficiency between charge and spin subsystems is indeed responsible for the observed variations in precession amplitudes. The results of the analyses are summarized in **Table 1**.

Based on this fact, we discuss that the spin–orbit interaction that yields perpendicularly spin-polarized electrons in the MLs through the Co/Pd interface is responsible for the observed increase in precession amplitudes of locally excited magnetization. Our approach of employing low-fluence laser excitation of magnetization precession could be practical for developing a non-thermal, all-optical magnetic switching toward photonic memory applications. An article concerning this work has been accepted in JAP (https://doi.org/10.1063/5.0131045) and will be available at the time of this presentation.

Extracted parameters	Sample 1	Sample 2	Sample 3
A_0 (μrads)	0.06–0.22	0.2–0.9	0.5–3.0
f (GHz)	4.9	3.3	2.2
τ (ps)	950	640	260
α_{eff}	0.069	0.082	0.29
c (rad Oe/erg)	82	170	380

TABLE 1: Summary of spin dynamics parameters extracted from time-resolved magneto-optical Kerr effect signals with an external field of 2000 Oe.