Photo excited precession of magnetization in Co/Pd multilayers grown on various substrates

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Aiming at studying novel functionality in optics and photonics with spin degree of freedom, we have been studying photo-excitation of ordered spins in weak excitation regime, and found recently that precession of magnetization could be induced in Co/Pd multilayers (MLs) grown on Si(110) with excitation power as low as 0.25 μJ/cm^2 at the wavelength λ = 790 nm [1]. Question concerning the use of a Si(110) substrate have been raised in view of substrate heating and physical property of the resultant MLs. We show here that Co/Pd MLs of similar kinds can be prepared on Si(100), GaAs(100), and GaAs(110), and discuss that the photo-excited precession of magnetization (PEPM) is not unique for samples on Si(110).

Samples consisting of $[Co/Pd]_5$ / Pd(6.81nm) / Ta(2.18nm) with different Co and Pd layer thicknesses, Co/Pd in the unit of nm, were prepared on various Si and GaAs substrates using DC magnetron sputtering at the substrate temperature of 150 °C. All samples have exhibited perpendicular magnetic anisotropy at room temperature (RT). PEPM experiments were carried out by time-resolved magneto-optical spectroscopy on the basis of pump and probe technique using a mode-locked Ti:sapphire laser of 150-fs pulse width at the wavelengths λ = 790 ~ 895 nm.

Temporal profiles of magneto-optical (MO) signals obtained at λ = 790 nm (P_{pump} = 1.5 μJ/cm^2) are shown in Fig.1 (a) for samples grown on four different substrates. Oscillations due to PEPM are observed in all samples. Shown in Fig.1 (b) is a MO temporal profile for the sample grown on GaAs(100) obtained at λ = 890 nm (P_{pump} = 18 μJ/cm^2) which is longer than the fundamental absorption edge (λ_{GaAs} = 872 nm) of the substrate. This fact indicates that PEPM is attributed solely to light absorption in MLs. Shown in Figs.2(a)-(c) are static optical data for the 0.45/0.57 MLs sample grown on GaAs(100), from which we are able to derive complex refractive index $n = 2.7 + 3.8i$, together with dielectric tensor $\varepsilon_{xx} = -7.15 + 20.52i$ and $\varepsilon_{xy} = 0.0836 - 0.0362i$. Magnitudes of real and imaginary parts of the off-diagonal term appear to be, respectively, five times smaller and six times larger than those of representative MO materials [2].

[1] K.Yamamoto *et al.*, IEEE Trans Mag. **49**, 7 (2013). [2] M. Mansuripur, JAP **67**, 6466 (1990).

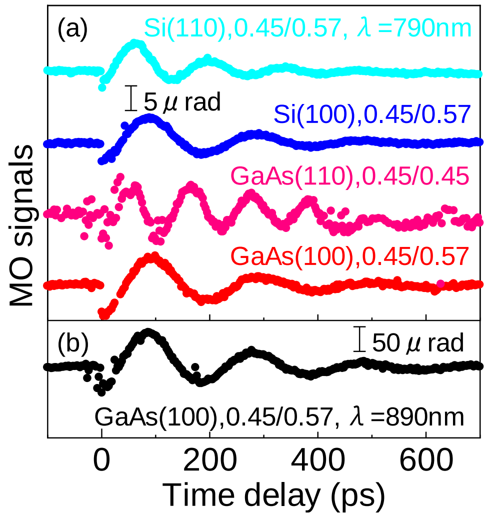

Fig.1: (a) Four temporal profiles obtained at RT with λ = 790nm and P_{probe} = 0.3 μJ/cm^2 from the samples grown on, from the top, Si(110), Si(100), GaAs(110), GaAs(100).
(b) A temporal profile obtained at RT with λ = 890nm and P_{probe} = 0.3 μJ/cm^2 from the samples grown on GaAs(100). Non-oscillatory backgrounds are subtracted from the data.

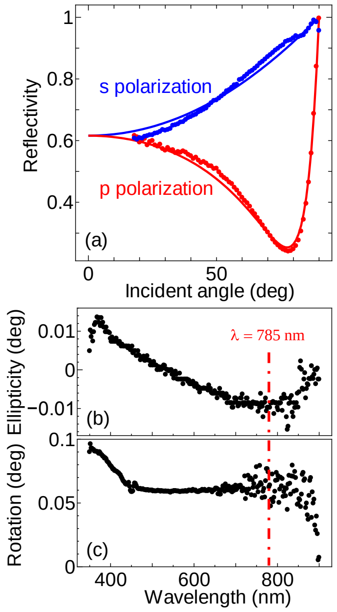

Fig.2: Three static optical data at RT: (a) dependence of incidence angle of light on reflectivity measured at λ = 785 nm. Lines represent calculated curves using Fresnel equation. (b) ellipticity and (c) polar Kerr spectra measured with $H_\perp$ = 10 kOe.