Optical spin-torque observed in FeCo / Pt bilayers

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Manipulation of magnetization precession, namely magnon, with circularly-polarized light has attracted much attention, to date. Many of relevant studies have focused on magnon driven by the inverse Faraday effect in magnetic insulators or semiconductors. However, there have been few reports on metals. Recently Choi *et al.* reported magnetization precession driven by the circularly-polarized light in ferromagnet/heavy metals bilayers [1]. Then, they proposed new physics, optical spin-torque which is distinct from the traditional inverse Faraday effect. However, the physics of optical spin-torque is not clearly understood yet; thus, it is demanded to deeply understand the physics of this torque toward photo-spintronic applications. As a first step to further research, we study helicity dependence of laser-induced magnetization precession in FeCo / Pt bilayers. Thin film samples were prepared by magnetron sputtering. MgO / FeCo / Pt thin film layer were deposited on thermally oxidized Si substrate. The pulse width, wavelength, and repetition rate of the femtosecond laser pulse used were 120 fs, 800 nm, and 1 kHz, respectively. Figure 1 (a) shows magnetization precession in FeCo (2) / Pt (3) (thickness is in nm) bilayer with different light helicities, where 2 T in-plane magnetic field is applied. The helicity dependent magnetization precession was clearly observed. The solid curves in Fig. 1(a) shows the fitting of sinusoidal function to the data. This fitting indicated that circularly-polarized laser makes magnetization initially tilt away from the film surface. This result is consistent with the previous observation and optical spin-torque proposed, as shown in Fig. 1(b). Optical spin-torque is believed to be regarded as a damping-like torque, which is induced by a current of the spin-angular momentum in a nonmagnetic layer transferred from the circularly-polarized light. The spin polarization vector of this spin current is parallel to the photon spin vector, $\pm\sigma$ determined by the light helicity σ. Therefore, the vector of the optical spin-torque is parallel to the film plane and magnetization is initially driven perpendicular to the film plane. Indeed, we also observed the remarkable dependence of this torque on the FeCo and Pt layer thicknesses, which will be discussed in detail. This work was partially supported by KAKENHI (19K15430), Advanced Technology Institute Research Grants, and CSRN.

[1] G. -M. Choi *et al.* Nat. Commun. **8**, 15085 (2017), G. -M. Choi *et al.* Nat. Commun. **11**, 1482 (2020).
[2] S. Iihama and S. Mizukami, manuscript in-preparation.

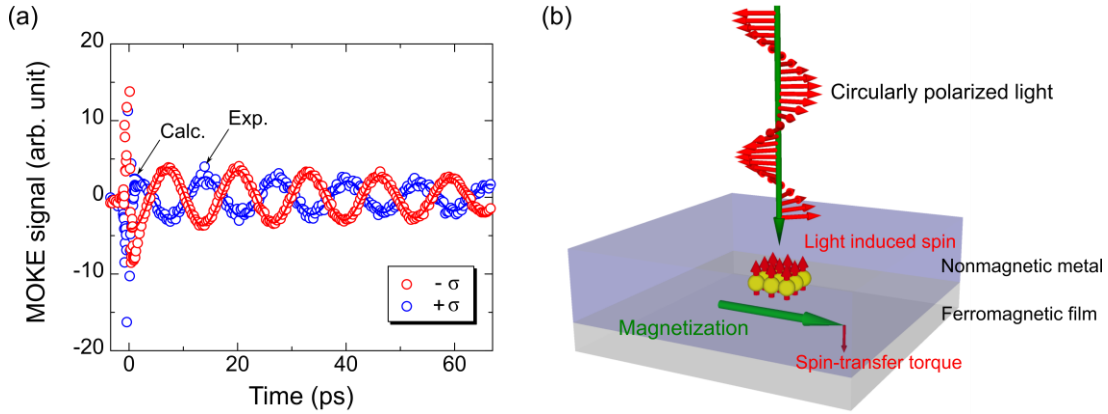

Fig. 1 (a) Magnetization precession dynamics in FeCo / Pt bilayer excited by left circularly polarized and right circularly polarized light pulse. (b) Schematic illustration of optical spin-torque.