Manipulation of ordered spins with light

– new photonic materials with magnetism –

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Owing to its high-speed, selective, non-linear, contactless, and quantum characteristics, light has the latent power of producing new functionality and paradigm, when combined with novel materials. This presentation reviews the frontier of research concerning a study of interaction between light and ordered spin (magnetization) with ultra-short light pulses and magnetic materials. A personal perspective as to new applications in the field of information processing and transmission is also discussed in view of photonics materials.

At the present stage, it is very important to establish reliable techniques for manipulating spins in magnetic materials with photons, and demonstrate prototype devices for mutual conversion between photons and ordered-spins. To this end, author, with his colleagues, studies experimentally the photo-excited precession of magnetization (PEPM) with various III-V ferromagnetic semiconductors [1,2] and metals [3] (Fig. 1), a concept of new photonic device consisting of those materials and existing optical components [4], and circularly polarized light emitters/detectors [5] (Fig.2). At the time of presentation, I plan to review experimental results on PEPM with Co/Pd ultra-thin multi-layers in the regime of weak excitation (< 1 μJ/cm^2) and a concept of all-optical signal modulation, added with experimental demonstration of electrical helicity switching.

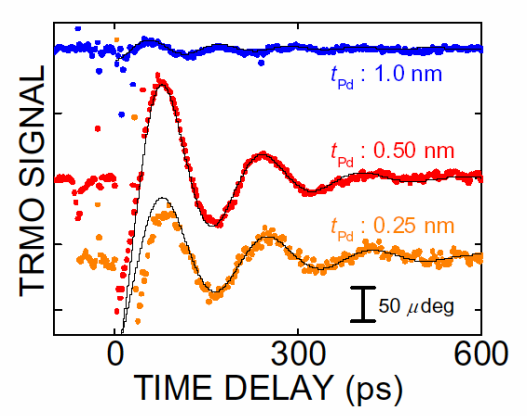

Fig. 1: Temporal profiles of PEPM data for three samples with different Pd layer thicknesses. Pump fluence 11 μJ / cm². The Co layer thickness was fixed at t_{Co} = 0.78 nm. Solid lines are fit to the experimental data.

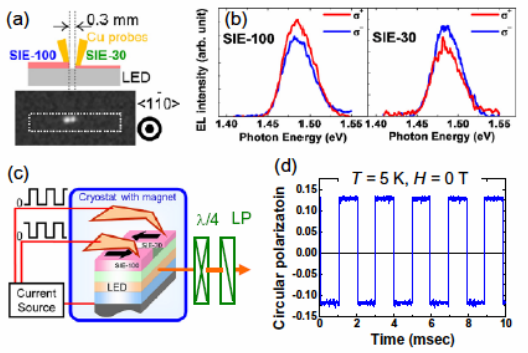

Fig.2: (a) a diagram of the spin LED with dual spin-injection electrodes (SIE) and its far-field image of EL emission, (b) EL spectra with current sent through each SIE, (c) a diagram of experimental setup, and (d) demonstration of electrical helicity switching at 1 kHz.

Reference

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3) K. Yamamoto, *et al.*, IEEE Trans. Mag. **49**, 3155 (2013).
4) H. Munekata, (Japanese) Oyobutsuri, July issue, 2014, in print.
5) N. Nishizawa *et al.*, Appl. Phys. Lett. **104**, 111102 (2014) ; N. Nishizawa and H. Munekata, J. Appl. Phys. **114**, 033507 (2013).