Recent progress in fundamental studies on spin-photonics with magnets, semiconductors and insulators

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Digital information technology has great impact on our lives, which has strongly motivated scientists to look for faster and more energy-efficient ways to process streams of digital signals. This presentation reviews some works carried out recently in our group; namely, (i) devices for circular polarized light (CPL) technology and (ii) all-optical new functional devices.

Spin-LED as a monolithic CPL emitter (Fig. 1)

Compared with optics and photonics based on linearly polarized light, not so much research has been carried out for the development of technology based on CPL. We report bright electroluminescence of nearly pure circular polarization at room temperature with relatively high current density using lateral-type spin LEDs consisting of Fe stripe electrodes, 1-nm crystalline AlO_x tunnel barriers, and laser-quality AlGaAs/GaAs double hetero-structures (DH) [1,2]. Electrical helicity switching up to 100 kHz has been demonstrated using dual spin injection electrodes formed on the DH [3,4].

From photo-excited precession of magnetization to all-optical new functional devices (Fig. 2)

We found through the study of photo-excited precession of magnetization using ultrashort (10^{-13} sec) weak laser pulses of 1 μJ/cm^2 or less, that spins in ultra-thin Co/Pd multi-layer films are very susceptible to light; namely, a material that could be a candidate for photo-sensitive magnets [5]. This finding has been followed by the demonstration of polarization modulation of light signals in an optical waveguide with the same class of magnets, GdFe thin films [6]. In this work, we have emphasized the feasibility of the multiplexed transmission of polarization-modulated signals, controlled ultimately by photo-excitation of a class of light-sensitive magnetic layers.

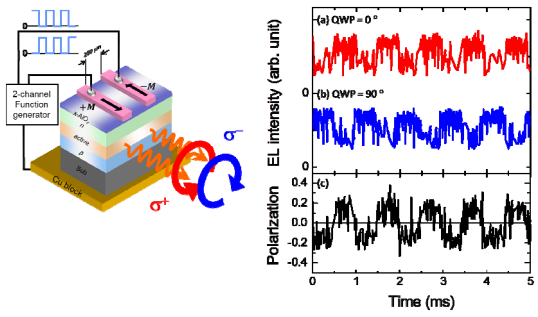

Fig. 1: (left) schematic device structure of dual-injection spin-LED, and (right) the data representing 1 kHz helicity switching at RT.

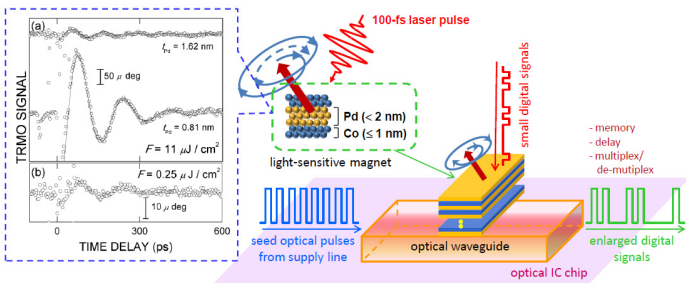

Fig. 2: Experimental data of photo-excited precession of magnetization (left), schematic illustration of Co/Pd ultra-thin multi-layers (upper center), and the concept of three-terminal photonic device utilizing photo-magnetic property (lower right).

Reference

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3) N. Nishizawa, *et al.*, APL **104**, 111102 (2014).
4) M. Aoyama, *et al.*, presented at JSAP Spring Meeting (March 19, 2016, Tokyo) 19p-P1-55 (Poster).
5) K. Yamamoto, *et al.*, IEEE Trans. Mag. **49**, 3155 (2013).
6) K. Nishibayashi, *et al.*, APL **106,** 151110 (2015).