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Fe/AlO$_x$/GaAs 系 Spin-LED における円偏光極性の電気的切り替え

Electrical helicity switching on Fe/AlO$_x$/GaAs-based spin-LED

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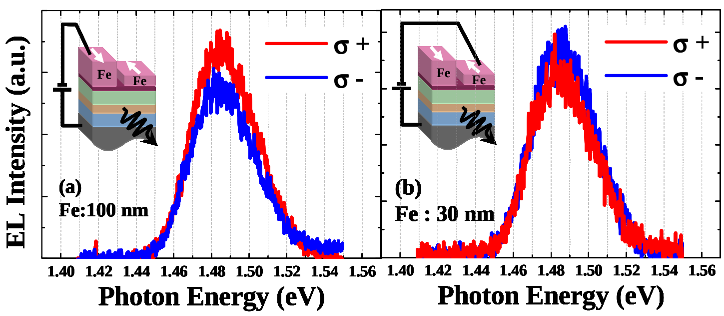
Spin light emitting diode (spin-LED), which was originally developed as a tool to detect spin polarization of carriers in semiconductors [1, 2], would be a device with great possibility in view of a new circular polarized light (CPL) source aiming at future applications associated with all-optical magnetic writing [3], 3-D display [4], chiral resolution [5], and advanced optical communication [6]. For practical application, realization of electrical helicity switching without using an external magnetic field is one of key issues. Electrical helicity switching using two spin-LEDs with antiparallel magnetization configuration was demonstrated in the past [7]. Reported here is the demonstration of electrical helicity switching using one spin-LED chip. Two ferromagnetic Fe electrodes with different thicknesses (30- and 100-nm) have been fabricated on one GaAs-based double heterostructure (DH) incorporating a 500-nm thick $In_{0.03}Ga_{0.97}As$ active layer. The DH had an AlO$_x$ barrier layer on top of it. Difference in coercive fields between the two Fe electrodes has allowed us to magnetize those with antiparallel magnetization configuration. Electrical helicity switching has been realized by electrically selecting the electrodes for spin-injecting into the DH, which has manifested itself in electroluminescence (EL) extracted from cleaved side-wall of spin-LED.

Figures 1 show EL spectra obtained at 5 K when a current was passed through (a) 30-nm and (b) 100-nm Fe electrode. The spectra exhibit opposite sign of circular polarization, reflecting antiparallel configuration. The magnitude of circular polarization is P_{circ} = +14 % and -7 %, for (a) and (b) respectively. These values correspond to spin polarized carriers of P_{ele} ~ (a) 29 % and (b) 14 %, respectively. CPL was observed up to around 70 K. Figure 2 shows experimental data for electrical helicity switching. From t = 0 to 200 sec., we switched between the two electrodes for every ten seconds. Clear helicity switching was demonstrated. Data after t = 200- sec. were obtained by passing current simultaneously through two electrodes, showing P_{circ} ~ 0. This fact can be understood in terms of mixing two opposite circular polarization, yielding linearly polarized light. Tuning the current ratio between two electrodes has yielded smooth conversion between circular and linear polarization.

[1] Y. Ohno *et al.*, Nature **402** 790 (1999).
[2] R. Fiederling *et al.* Nature **402** 787 (1999).
[3] C. D. Stanciu *et al.*, Phys. Rev. Lett. **99** 047601 (2007).
[4] S-C. Kim *et al*. 3D Research **1** 1 (2010).
[5] W.H. Porter, Pure and Appl. Chem. **63** 1119 (1991).
[6] M. Holub and P. Battacharya, J. Phys. D **40** R179 (2007).
[5] W. Terui *et al.*, phys. stat. sol. c **8** 396 (2011).



Figs.1 σ⁺ and σ⁻ EL spectra for samples with flowing a current through with a (a) 100 nm and (b) 30 nm thickness Fe electrode. Magnetization of electrodes is exhibits anti-parallel magnetization configuration.

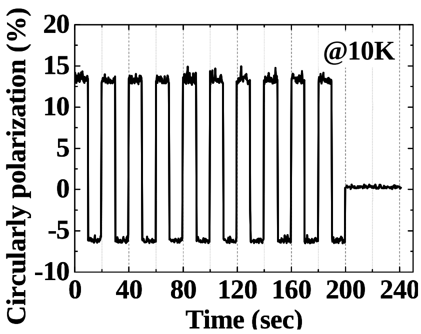


Fig. 2 Experimental data showing electrical helicity switching of circularly polarized light.