Room temperature spontaneous emission with pure circular polarization on spin-LEDs

Institute of Innovative Research, Tokyo Institute of Technology.
°N. Nishizawa, K. Nishibayashi and H. Munekata
E-mail: nishizawa.n.ab@m.titech.ac.jp

We have reported electroluminescence (EL) with almost pure circular polarization (CP) [1] and electrical helicity switching at room temperature [2], which is a breakthrough in the field of semiconductor-based spintronics device and is also attractive as a new monolithic CP light source. The pure CP emission is achieved although the maximum CP value obtained through radiative recombination of spin-polarized carriers is restricted to be 0.5 by optical selection rules in a degenerated GaAs layer. Also, it is achieved in the regime of moderately high current density (J > 100 A/cm^2) which is far less than that for stimulated emission of conventional stripe lasers. We report here the experimental data as a clue to the emission mechanism.

The tested device consists of a GaAs-based double heterostructure with a 500-nm *p*-GaAs active region, 1-nm crystalline AlO_x [3], and stripe-type Au/Ti/Fe electrodes. EL at RT from the side-wall was detected by multi-channel spectrometer through a quarter wave plate and a linear polarizer. Figure 1 shows helicity-dependent EL spectra obtained at three different current density J values. The difference in intensity between the right- and left-handed EL components (I^+ and I^-) becomes larger with increasing J. The CP values, $P \equiv (I^+ - I^-)/(I^+ + I^-)$, increases steeply and reaches close to the pure CP when J > 100 A/cm^2 (inset in Fig. 1). These experimental facts suggest a sort of optical non-linear effects are induced by highly spin injection and it enhances CP significantly. Shown in Fig. 2 is the horizontal line profile of the integrated EL intensity. The point x = 0 is the position right under the Fe strip electrode. Measurements were carried out by laterally moving the 0.1-mm wide optical slit (x = 0 → 0.8). With increases J from 75 to 125 A/cm^2, the EL intensity becomes narrower, together with CP value increases at x = 0. The concentration of EL emission energy indicates that the non-linear optical effects, such as spin-induced birefringence, work effectively in the highly injected GaAs region right under the Fe electrodes.

[1] N. Nishizawa *et al.*, SSDM2015. A-2-5 (Late News), 2015. [2] M. Aoyama *et al.*, 63rd JSAP Spring Meeting, 19p-P1-55 19p-P1-55 (2016). [3] N. Nishizawa *et al.*, J. Appl. Phys. **114**, 033507 (2013).

This research and development work was supported from Advanced Photon Science Alliance Project from MEXT, Grant-in-Aid for Scientific Research (No. 22226002) from JSPS and the MIC/SCOPE #162103004

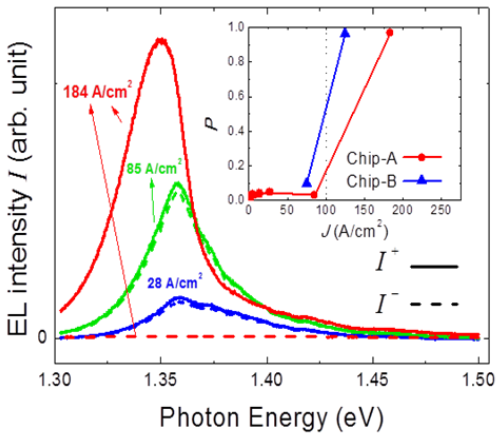

Fig. 1: Helicity-dependent EL spectra from the side wall of the device (chip-A) with J = 28, 85 and 184 A/cm^2. The inset shows J dependence of CP values for two chips, chip-B is shown in Fig. 2.

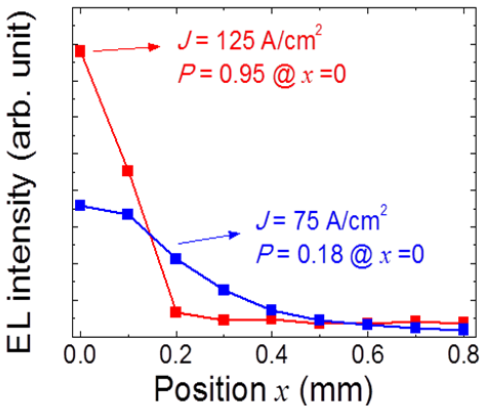

Fig. 2: Horizontal line profiles of the integrated EL intensity obtained from chip-B at J = 75 and 125 A/cm^2.