Room temperature operation of helicity switching using dual-electrode spin-LED


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Recently, we have reported electroluminescence (EL) of nearly 100% circularly polarization at room temperature (RT), which is a breakthrough in the field of semiconductor-based spintronics device as well as in optics/photonics [1]. We report here the room-temperature demonstration of helicity switching, as the natural extension towards practical applications.

Figure 1 shows (a) the measurement set-up for helicity switching and (b) a schematic illustration of the cross section of tested devices. The device consists of a GaAs-based double heterostructure with the 500-nm p-GaAs active region, 1-nm crystalline (x-) AlOx [2], and a pair of stripe-type Au/Ti/Fe electrodes having different switching fields, the dual spin injection contacts [3,4]. In detail, thickness of Fe layers are 100 nm and 30 nm, with the spatial separation of 250 μm. Anti-parallel magnetization configuration was achieved by carefully adjusting the magnetizing field. No external fields were applied during EL measurements. A pulsed driving current was sent alternatively to each electrode. The entire side-wall became bright no matter which electrode was selected. EL at RT from the side-wall was detected by photo-multiplier through a quarter wave plate (QWP) and a linear polarizer (LP). With the optical axis of LP fixed at 45 °, the intensity of \( \sigma^+ \) - and \( \sigma^- \)-components of EL (\( I_{\sigma^+} \) and \( I_{\sigma^-} \)) was detected, respectively, with QWP at 0 ° and 90 °. Fig.2 (a) and (b) show the experimental data of helicity switching with frequency of 100 kHz at RT. Fig.2 (c) shows circular polarization \( P = (I_{\sigma^+} - I_{\sigma^-})/(I_{\sigma^+} + I_{\sigma^-}) \) extracted from the data shown in Figs.2 (a) and (b), which indicates that helicity of circularly polarized light can be switched according to the selection of electrodes.

Fig. 1
(a) Measurement setup.
(b) Schematic illustration of device cross-section

Fig. 2
Experimental data showing 100-kHz helicity switching detected with QWP at (a) 0° and (b) 90°.
(c) Circular polarization extracted from the data shown in (a) and (b).