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Gate-controlled spin precession of drifting electrons in GaAs QW

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We demonstrated gate-controlled spin dynamics during drift transport induced by photocurrent. We observed that the spatial frequency of spin precession depends strongly on the externally applied gate voltages and the transport directions. The experimental results enabled us to determine the tunable range of the Rashba spin-orbit interaction (SOI), which will provide important information as regards extending the spin transport length using the persistent spin helix mode [1].

The sample was a GaAs/AlGaAs-based high-electron-mobility transistor (HEMT), which contained two-dimensional electrons in a 25-nm-wide GaAs quantum well. We deposited a semi-transparent Au Schottky gate on the surface of a chip without touching the InSn ohmic contact formed in one corner of the chip (Fig. 1). A bias voltage applied between these two electrodes enabled us to tune both the electron density and the in-plane electric field simultaneously. The spin dynamics during transport was measured using spatially- and time-resolved Kerr rotation microscopy with a mode-locked Ti:sapphire laser. A circularly polarized pump light generated spin-polarized electrons at a fixed position on the sample; and a linearly polarized probe light, which can be scanned in the QW plane, was used to detect the magneto-optic Kerr effect. Since the Kerr rotation angle is proportional to the spin density at the probe position, we can obtain two-dimensional images of the spin distribution.

Figure 2 shows the gate-voltage dependence of the spatial spin propagation measured in the absence of external magnetic fields. The circularly polarized pump pulses injected electron spins at a certain position under the Schottky gate film, and the resultant photocurrent transported the electrons from the pump position toward the ohmic contact. The oscillations of the Kerr rotation, which lasted over a distance of 100 μm, are attributed to the spin precession induced by a spin-orbit effective magnetic field. When we increased the negative gate voltage from -2.6 to -4.0 V, the spatial frequency of the spin precession decreased. This change is explained by the gate modulation of the Rashba SOI. The demonstrated gate control of drifting spins realized by using a spin-obit effective magnetic field will provide a core technique for manipulating spins in semiconductor spintronics devices.

[1] J. Schliemann and D. Loss, Phys. Rev. B **68**, 165311 (2003).
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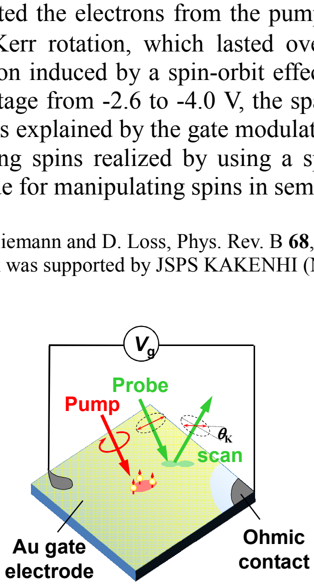

Fig. 1 Schematic image of sample structure and pump-probe measurement.

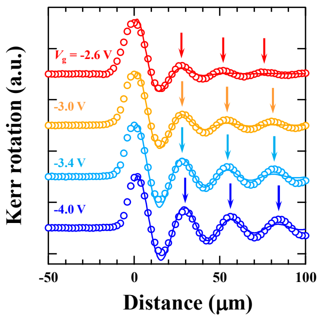

Fig. 2 Gate voltage dependence of space-resolved Kerr rotation (open circles). Solid lines indicate fitting result of empirical functions.