Gate-controlled Spin-orbit Interaction Parameter in a GaSb Two-dimensional Hole Gas Structure

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The Rashba spin-orbit interaction parameter (a) in a quantum well system is a critical factor to implement spin-based transistor because the spin precession angle is decided by gate-controlled spin-orbit interaction parameter [1]. Usually *n*-type channel is selected for the spin transport in the spin transistor. However, in order to apply for the complementary logic, *p*-type channel should be also necessary.

In this research, using a two-dimensional hole gas (2DHG) structure, Shubnikov-de Haas (SdH) oscillation measurement is performed for extracting the spin-orbit interaction parameter of the *p*-type channel. We grew a *p*-type GaSb channel which is sandwiched by double cladding layers of $In_{0.53}Ga_{0.47}As$ and $In_{0.52}Al_{0.48}As$. A Be-doped InP layer is used as a carrier supply layer in the 2DHG structure. In this structure, the Rashba spin-orbit interaction, which can arise from an asymmetry in the confined potential of the quantum well, induces imbalance of spin-up and -down holes. For the SdH measurement, 64μm wide Hall bar is defined by photo-lithography with dry etching process and a 100 nm thick SiO_2 layer is deposited as a gate insulating layer.

We have calculated the spin-orbit interaction parameter and the effective mass using the Shubnikov-de Haas (SdH) oscillation measurement in a GaSb two-dimensional hole gas (2DHG) structure as shown in fig 1. The inset illustrates the device geometry. The spin-orbit interaction parameter of 1.71×10^{-11}eVm and effective mass of $0.98m_0$are obtained at T = 1.8 K, respectively. Figure 2 shows the gate dependence of the spin-orbit interaction parameter and the hole concentration at 1.8 K, which indicates the spin-orbit interaction parameter increases with the carrier concentration in *p*-type channel. On the order hand, opposite gate dependence was found in *n*-type channel [1, 2]. Therefore, the combined device of *p*- and *n*-type channel spin transistor would be a good candidate for the complimentary logic device.

참고문헌

[1] H. C. Koo, J. H. Kwon, J. Eom, J. Chang, S. H. Han, and M. Johnson, Science, **325**, 1515 (2009).

[2] J. Nitta, T. Akazaki, and H. Takayanagi, Phys. Rev. Lett. **78**, 1335 (1997).

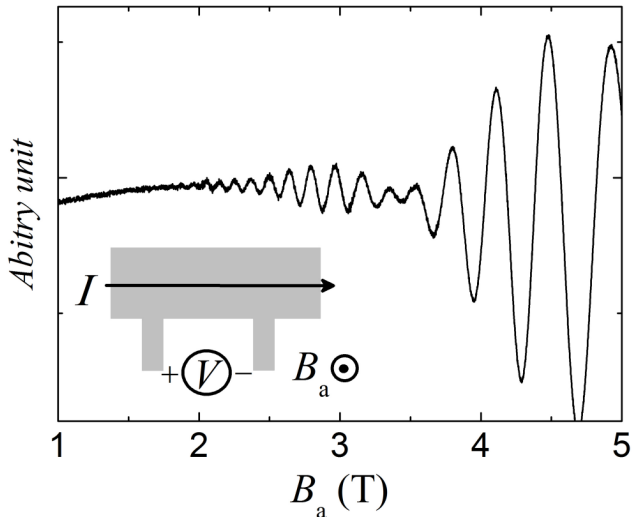

Fig. 1. Shubnikov-de Haas (SdH) oscillation at T = 1.8 K. The inset shows the measurement geometry and the fast Fourier transform of the SdH curve.

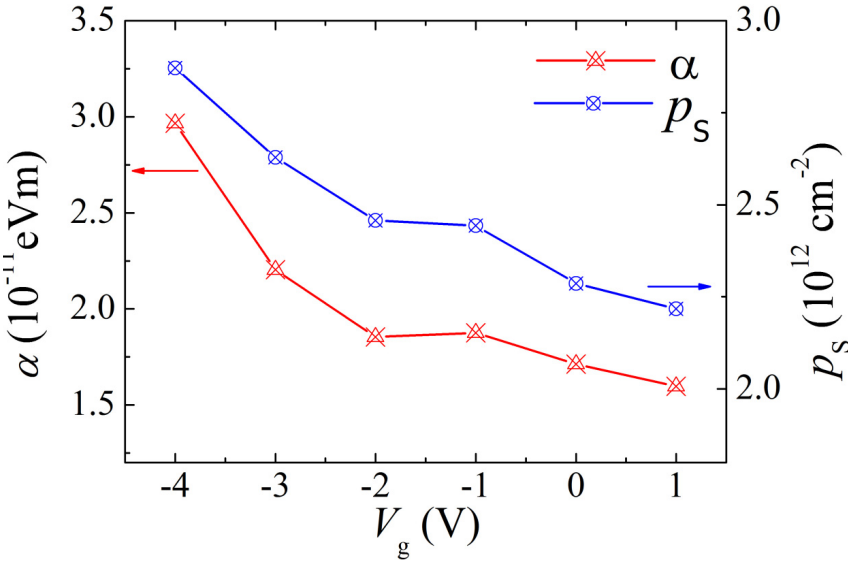

Fig. 2. Gate voltage dependences of the Rashba spin-orbit interaction parameter and carrier density.