D-5

Gate controlled spin-orbit interaction in a two-dimensional electron gas layer

Jae Hyun Kwon[1]*, Hyun Cheol Koo[1†], Jonghwa Eom[1,2], Hyung Jun Kim[1], Joonyeon Chang[1], and Suk-Hee Han[1]
[1]Center for Spintronics Research, Korea Institute of Science and Technology, Seoul 136-791, Korea
[2]Department of Physics and Institute of Fundamental Physics, Sejong University, Seoul 143-747, Korea
(† Correspondence : hckoo@kist.re.kr, Phone: +82-2-958-5423, Fax: +82-2-958-6851)

1. Introduction

The main mechanism underlying the functions of spin-FETs is that the amount of spin precession of the traveling electron depends on a spin-orbit interaction in a semiconductor quantum well [1]. In a spin-FET, an electric field applied by a gate electrode modulates the spin-orbit interaction, and hence controls the amount of spin precession. Therefore the gate controlled spin-orbit interaction is key mechanism to operate spin-FET. The external electric field generate the spin-orbit interaction in the high mobility system, while structural asymmetry of a quantum well shows the same phenomenon. If the quantum well asymmetry is linearly changed by electric field, the modulation of spin-orbit interaction is very simple. However, the electric field dependence of spin-orbit interaction shows non-linear relationship and it is determined by the structure of high mobility semiconductor system. Therefore, we have to decide the proper range of the gate voltage for an efficient modulation of spin-orbit interaction.

2. Experiment details

In this paper, we utilize an inverted high electron mobility transistor (HEMT) structure with InAs channel. In this system, the InAs channel is sandwiched by $In_{0.52}Al_{0.48}As/In_{0.53}Ga_{0.47}As$ double cladding layers. The thickness of the InAs active layer was chosen to be only 2 nm to reduce the structural stresses induced between the active layer and the InP substrate. In order to obtain spin-orbit interaction parameter Shubnikov-de Haas oscillation (SdH) was measured at T = 1.8 K. The channel width was defined using ion milling after conventional lithography and the channel resistance was measured in the magnetic field (B) perpendicular to the plane.

3. Results and discussion

Observing the node positions of the SdH oscillation signals for various gate voltage we determined the gate voltage dependence of the spin splitting energy. Using the spin splitting energy and the frequency of SdH oscillation data, the carrier concentration and spin-orbit interaction parameter were decided. As shown in Fig. 1, the spin-orbit interaction parameter decreases with increasing gate voltage. However, the spin orbit interaction parameter is not changed with varying gate electric field. The reason is that the band structure of quantum well dose not linearly band with electric field.

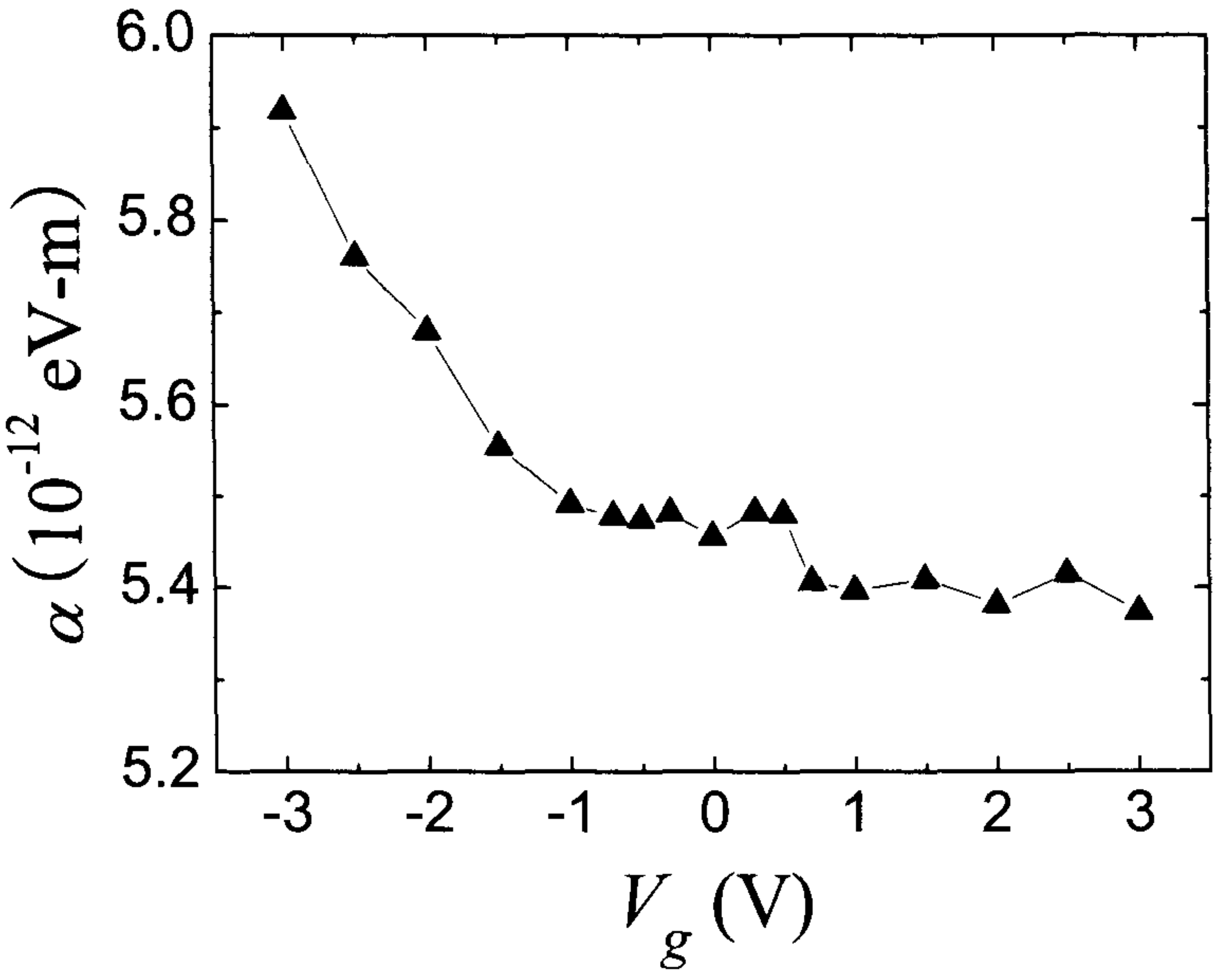

Fig. 1. Gate voltage dependence of spin-orbit interaction parameter and carrier concentration.

4. References

[1] S Datta, B Das, Appl. Phys. Lett. 56. 665. (1990).