## Determination of spin-orbit interaction coefficients under persistent and inverse persistent spin helix states in an InGaAs/InAlAs quantum well

Tohoku Univ.

## <sup>O</sup>Kohei Yoshizumi, Atsuya Sasaki, Makoto Kohda, and Junsaku Nitta

## Email: b4tm5343@s.tohoku.ac.jp

**Introduction:** In semiconductor spintronics, effective magnetic fields induced by spin-orbit interactions (SOIs) can be utilized for spin manipulation. In III-V semiconductor quantum wells (QWs), there are two types of SOIs, *i.e.* the Rashba SOI (coefficient is  $\alpha$ ) and the Dresselhaus SOI ( $\beta$ ). However, these SOIs also induce spin relaxation due to the D'yakonov-Perel' (DP) spin relaxation mechanism [1]. When the magnitude of  $\alpha$  and  $\beta$  is equal to each other, the resultant effective magnetic fields are aligned along unidirection, leading to a long spin relaxation time due to the suppression of the DP spin relaxation mechanism. This is the so-called persistent spin helix state (PSH  $\alpha = \beta$ ) [2]. Therefore, determination of SOI coefficient becomes prerequisite for simultaneous realization of long spin relaxation as well as spin manipulation. Here, we discuss how to determine the SOI coefficients from the analysis of spin relaxation length under the PSH and inverse PSH (- $\alpha = \beta$ ) states.

**Result and Discussion:** A gate-fitted Hall bar was fabricated by using an InGaAs/InAlAs heterostructure with almost symmetric QW grown on InP (001) substrate. Magneto-conductance was measured by varying gate voltage at  $T \sim 0.3$ K and we observed the transition from weak anti-localization (WAL) to weak localization (WL) and back to WAL again by the gate voltage as shown in Fig.1. The observation of WLs in different carrier densities demonstrates the realization of PSH and *i*-PSH states. Figure 2 shows the spin relaxation length ( $\lambda_{so}$ ) evaluated from the analysis based on the WAL theory. The Dresselhaus SOI coefficients ( $\beta_1 = \gamma < k_Z^2 >$ ,  $\beta_3 = \frac{\gamma k_F^2}{4}$ ) are obtained from spin relaxation length at the completely symmetric QW ( $\alpha$ = 0) state. From the PSH and *i*-PSH states, the strength of  $\alpha$  can be related to the Dresselhaus coefficients. Here, we propose the method to determine the two SOI coefficients under PSH and *i*-PSH states on the basis of above relations.



Fig. 1: Magneto-conductance profiles as a function of carrier density.

Fig. 2: Spin relaxation length obtained by the WAL theory.

M. I. D' yakonov and V. I. Perel, Sov. Phys. Solid State 13, 3023 (1971).
J. Schlieman and D. Loss, Phys. Rev. B 68, 165311 (2003).