Comparative study of gate-modulated quantum interference effects in (001) and (113) GaAs/AlGaAs quantum wells

Sch. of Eng., Tohoku University[1], Grad. Sch. of Eng., Tohoku Univ.[2],
Dept of Phys., Univ. Regensburg.[3], Dept of Phys., Univ. Wellington.[4],
CSIS, Tohoku Univ.[4], DEFS, Tohoku Univ.[5], QUARC, QST[6]
○ T. Usubuchi[1], T. Kawano[2], M. Prager[3], D. Iizasa[2], M. Kammermeier[4],
J. Ishihara[2], S. Yamamoto[2], D. Schuh[3], D. Bougeard[3], and M. Kohda[2, 5-7]
E-mail: Usubuchi.Taisei.r3@dc.tohoku.ac.jp

Persistent spin helix (PSH) state [1] induced by Dresselhaus [2] and Rashba [3] spin-orbit interactions (SOIs) in III-V compound semiconductor quantum wells (QWs) is one of the most important states, because the PSH state provides spin manipulation and long spin lifetime simultaneously. Recently, it has been predicted that such PSH states also emerge in QW planes where at least two of the Miller indices agree in the modulus [3]. In particular, the PSH state in a (113)-oriented QW is attractive because it is expected to be a more stable spin state than that in a conventional (001)-oriented QW [4]. However, the observation of the PSH state has been mainly focused on (001)- and (110)-oriented QWs [5,6]. Here we compare the gate-modulated quantum interference effects in (001) and (113) oriented GaAs/AlGaAs QWs.

Two GaAs/AlGaAs QW structures have been grown by molecular beam epitaxy onto the GaAs substrate with two different crystal orientations; (113) and (001) planes. These GaAs QWs have identical structures except for the crystal orientation and were designed to be the PSH state in the case of a (113)-oriented QW.

We have measured quantum interference effects in (001) and (113) oriented GaAs QWs at 200 mK. Weak anti-localization effects in (001) and (113) oriented GaAs QWs at different carrier densities (gate voltages) are shown in Fig. 1. Despite having the same carrier density, WAL was consistently observed in a (001)-oriented QW, whereas transition from WAL to WL was observed in a (113)-oriented QW. This indicates that the PSH state is realized in a (113)-oriented QW. Then we will discuss the analysis results in (001) and (113) oriented QWs.

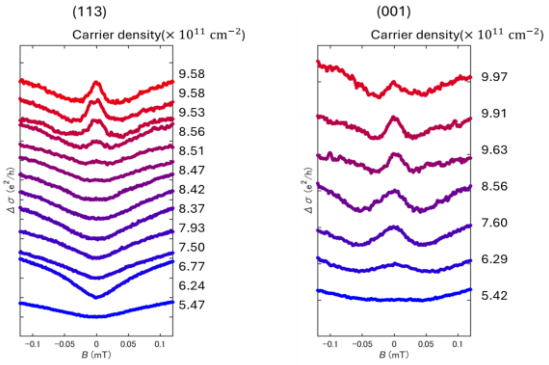

Fig.1: Magneto-conductance with different carrier densities in the (001) and (113)-oriented GaAs/AlGaAs quantum well.

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