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Effect of in-Plane Magnetic Field on Rashba Spin-Orbit Interaction

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The spin-orbit interaction has received great attention in the field of spintronics, because of its property and applicability. For instance, the spin-orbit interaction induces spin precession which is the key element of spin transistor proposed by Datta and Das, since frequency of precession can be controlled by electric field. The spin-orbit interaction is classified according to its origin, Dresselhaus and Rashba spin-orbit interaction. In particular, the Rashba spin-orbit interaction is induced by inversion asymmetry of quantum well structure and the slope of conduction band represents the strength of Rashba spin-orbit interaction. The strength of spin-orbit interaction is experimentally obtained from the Shubnikov de Hass (SdH) oscillation. The SdH oscillation is resistance change of channel for perpendicular magnetic field as a result of Zeeman spin splitting of Landau level, quantization of cyclotron motion by applied magnetic field. The frequency of oscillation is different for spin up and down due to the Rashba spin-orbit interaction. Consequently, the SdH oscillation shows the beat patterns. In many research studies, the spin-orbit interaction was treated as a tool for electrical manipulation of spin. On the other hands, it can be considered that the Rashba field, effective magnetic field induced by Rashba effect, may interact with external magnetic field. In order to investigate this issue, we utilized InAs quantum well layer, sandwiched by InGaAs/InAlAs as cladding layer. Then, the SdH oscillation was observed with tilted magnetic field in y-z plane. The y-component (longitudinal term) of applied magnetic field will interact with the Rashba field and the z-component (perpendicular term) will induce the Zeeman effect. As a result, the strength of spin-orbit interaction was increased (decreased), when applied magnetic field is parallel (anti-parallel) to the Rashba field. We found a possibility to control the spin precession with magnetic field.

Keywords: Rashba spin-orbit interaction, SdH oscillation, Zeeman spin splitting