Effect of In-plane Magnetic Field on Rashba Spin-orbit Interaction

Won Young Choi[1,3]*, Jae Hyun Kwon[2], Joonyeon Chang[1], Suk Hee Han[1] and Hyun Cheol Koo[1,3]

[1]Spin Convergence Research Center, Korea Institute of Science and Technology

[2]Department of Electrical and Computer Engineering, National University of Singapore

[3]KU-KIST Graduate School of Converging Science and Technology, Korea University

Since spin FET was proposed by Datta and Das[1,2], many researches related to spin injection, detection and modulation has been progressed. For electric device, ferromagnetic material is used for spin injector and detector due to its spin imbalance. In order to control the spin with electric field, the Rashba spin-orbit interaction (SOI) is concerned. Rashba SOI causes spin precession depending on its strength, so gate controlled strength of Rashba SOI induces shift of spin state.

Obtaining strength of Rashba SOI is important because spin state is determined by it. The Rashba SOI is induced by inversion asymmetry of quantum well structure and the slope of conduction band represents the strength of Rashba SOI. The strength of Rashba SOI is experimentally obtained from the Shubnikov de Hass (SdH) oscillation. The SdH oscillation is conductance change of channel for perpendicular magnetic field as a result of Zeeman spin splitting of Landau level which is quantization of cyclotron motion by applied magnetic field. The frequency of conductance oscillation is different for spin up and down due to the Rashba SOI. Consequently, the SdH oscillation shows the beat patterns.

However, as a tool for electrical manipulation of spin, interaction between Rashba SOI and magnetic field is not clearly investigated. In this study, the interaction is examined by tilted magnetic field. The Rashba SOI can be converted into effective magnetic field, Rashba field, and then vector sum of external magnetic field and Rashba field deserves consideration. 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 SOI 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.

References

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

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