Detection of Rashba spin splitting via a side injection

Youn Ho Park[1,2*], Hyun-jun Kim[1], Joonyeon Chang[1], Heon-Jin Choi[2], and Hyun Cheol Koo[1,3†]

[1]Spin Convergence Research Center, Korea Institute of Science and Technology (KIST), Seoul 136-791, Republic of Korea

[2]Department of Materials Science and Engineering, Yonsei University, Seoul 120-749, Republic of Korea

[3]KU-KIST Graduate School of Converging Science and Technology, Korea University, Seoul 136-701, Republic of Korea

[†]Correspondence to: hckoo@kist.re.kr

The demonstration of Datta-Das spin field effect transistor (spin-FET) [1], is one of the major concern in the field of spin transport devices because it can be utilized for switching and logic devices. For developing Spin-FET, spin transport efficiency in a quantum well structure is crucial factors. Some reports [2, 3] have researched spin injection into semiconductor quantum well, however, the spin injection efficiency is still low to operate spin-FET at room temperature. In this research, we experimentally observed spin dependent electrochemical potentials in the non-local geometry at room temperature.

The inverted High Electron Mobility Transistor (HEMT) with a 2 nm InAs active layer is utilized as a channel. The channel size of 8 μm was defined by conventional Ar-dry etching. Previous works [2, 3] used etching process for top contact between spin injector and the semiconductor channel. In this research, we deposited $Ni_{81}Fe_{19}$ magnetic electrodes (FM) at the side of the InAs quantum well channel. The junction area between FM1 (FM2) and the InAs channel is only 0.5 μm × 2 nm (1μm × 2 nm) which is much smaller than that of previous works. Using the current injection into the side of the quantum well, the potentiometric signal and the rotation of spin torque induced magnetization are simultaneously detected. In this geometry, the spin is injected from the injection ferromagnet into the channel directly and the chemical potential is monitored by the detection ferromagnet. For the side injection, the milling of cladding layer is not necessary, so the efficient spin transport and the undamaged Rashba spin splitting are produced. The ferromagnetic detector sense the Rashba effect induced chemical potential change of the channel and this potentiometric signal is also modulated by the magnetization direction of detector. The large chemical potential changes of 1.03 Ω and 0.96 Ω are observed at 1.8 K and 300 K, respectively.

References

[1] S. Datta *et al*., Appl. Phys. Lett. 56, 665 (1990).
[2] H. C. Koo *et al*., Science, 325, 1515 (2009).
[3] J. Wunderlich *et al*., Science. 78, 1335, (2010).