【Grant-in-Aid for Scientific Research (S)】
Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project : Spin Hall Nanoelectronics

Kazuya Ando
(Keio University, Faculty of Science and Technology, Assistant Professor)

Research Project Number : 26220604 Researcher Number : 30579610
Research Area : Applied Physics
Keyword : Spintronics

【Purpose and Background of the Research】

The electron spin degrees of freedom emerges in the physics of electrons in nanoscale materials; a wide variety of physical phenomena, arising from interaction between spin, change, and elementary excitations, appears in nanostructures. Controlling these phenomena played by electron spins in solids leads to next-generation electronic technology. This study aims to develop the foundation of the spin-based technology utilizing the spin Hall effect, induced by the relativistic effect in a solid.

The physics of spin currents in metals and inorganic semiconductors has been established through the systematic study since the beginning of spintronics. In contrast, it has been difficult to study the spin physics in hopping conduction materials because of the absence of the versatile way for generating spin currents in these materials. Recently, we have discovered a method for spin injection into a wide range of materials through dynamical spin exchange coupling at ferromagnetic/nonmagnetic interface: dynamical spin injection. This discovery has opened a new route for exploring the physics of spin currents. In this study, we extend the work on the dynamical spin injection. We explore comprehensive physics of spin transport and spin conversion, which covers the spin current physics not only in band conduction systems but also in hopping conduction systems, in combination with the spin Hall effect.

【Research Methods】

The spin Hall effect arising from the spin-orbit interaction enables electric generation and detection of spin currents. By combining the spin Hall effect and dynamical spin injection at spin hetero interfaces, we explore the physics of spin transport and spin-charge conversion in band and hopping transport systems. This combination further allows to study spin exchange at hetero junction in the presence of symmetry breaking and spatially nonuniform spin dynamics. The interface spin exchange at insulator/metal interfaces also gives rise to spin-carrier conversion from magnons to electrons. Using this spin-carrier conversion, we reveal nonlinear spintronic effects arising from angular momentum transfer from the lattice to the spin system.

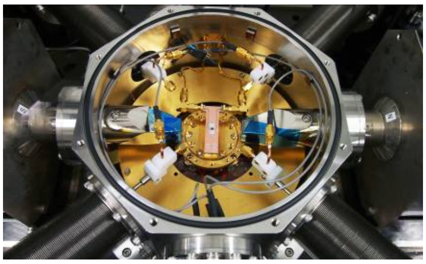

Figure 1 Spin current measurement system

【Expected Research Achievements and Scientific Significance】

The spin Hall effect enables to develop the physics of spin currents, which has been difficult to address using the conventional spintronic techniques. This study promises to open a route for next-generation electronic technology based on the spin Hall effect: spin Hall nanoelectronics.

【Publications Relevant to the Project】

・K. Ando, S. Takahash, J. Ieda, H. Kurebayashi, T. Trypiniotis, C. H. W. Barnes, S. Maekawa, and E. Saitoh, "Electrically tunable spin injector free from the impedance mismatch problem," Nature Materials 10, 655 (2011).
・ K. Ando, S. Watanabe, S. Mooser, E. Saitoh, and H. Sirringhaus, "Solution-processed organic spin-charge converter," Nature Materials 12, 622 (2013).

【Term of Project】 FY2014-2018

【Budget Allocation】 150,000 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ando.appi.keio.ac.jp
ando@appi.keio.ac.jp