

【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)



Title of Project : Spin-orbit Engineering

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Research Project Number : 15H05699 Researcher Number : 00393778

Research Area : Science and Engineering

Keyword : Spintronics

【Purpose and Background of the Research】

Spin-orbit interaction gives rise to an effective magnetic field on moving electrons in an electric field. So, it is possible to generate, manipulate, and detect electron spins without using a magnetic field. Recently, novel spin related phenomena based on spin-orbit interaction are discovered in various materials such as ferromagnets, metals and topological insulators. It is expected that spin-orbit interaction is enhanced at the hetero-interface because of strong electric fields. The purpose of this project is to explore new spin functionalities and new research fields of spintronics based on spin-orbit interaction.

【Research Methods】

(1) Spin-orbitronics

Electrical spin generation, manipulation, and detection will be integrated into new spin functional devices with suppression of spin relaxation.

(2) Exploration of giant Rashba effect

Strong spin-orbit interaction strengths are reported in heavy metal/ferromagnets hetero-interface structures. We will clarify the mechanism of spin-orbit interaction by transport properties and will explore all metal spin transistor with the utilization of gate controlled giant Rashba spin-orbit interaction.

(3) Novel spin dependent electromagnetic fields

Spatial/temporal variation of spin-orbit interaction generates spin-dependent magnetic/electric fields since spin-orbit interaction works as if spin-dependent vector potential. We will pursue novel spin functionalities based on this relativistic quantum effects.

【Expected Research Achievements and Scientific Significance】

Since electron spins are mainly controlled by magnetic field, local spin manipulations at high speed are impossible. The relativistic spin-orbit interaction enables an electrical local spin manipulation with high speed and low power consumption. The concept of spin-orbit engineering is ubiquitous among various materials systems and

leads to spintronics innovation.

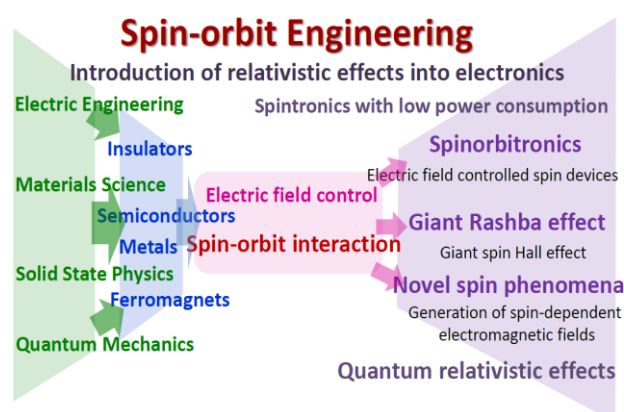


Fig. 1 Concept of spin-orbit engineering

【Publications Relevant to the Project】

- “Direct determination of spin-orbit interaction coefficients and realization of the persistent spin helix symmetry”, A. Sasaki, S. Nonaka, Y. Kunihashi, M. Kohda, T. Bauernfeind, T. Dollinger, K. Richter, and J. Nitta, *Nature Nanotechnology* **9**, 703-709 (2014)
- “Manipulation of mobile spin coherence using magnetic-field-free electron spin resonance”, H. Sanada, Y. Kunihashi, H. Gotoh, M. Kohda, J. Nitta, P. V. Santos, and T. Sogawa, *Nature Physics* **9**, 280-283 (2013)
- “Control of the spin geometric phase in semiconductor rings”, F. Nagasawa, D. Frustaglia, H. Saarikoski, K. Richter, and J. Nitta, *Nature Communications* **4**, 2526-1-7, (2013)

【Term of Project】 FY2015-2019

【Budget Allocation】 445,800 Thousand Yen

【Homepage Address and Other Contact Information】

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