

## 【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.

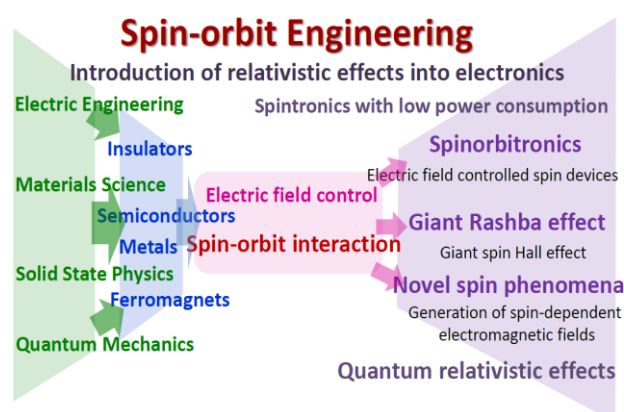


Fig. 1 Concept of spin-orbit engineering

#### 【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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