【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project： Spin-orbitronics and device application

Teruo Ono
(Kyoto University, Institute for Chemical Research, Professor)

Research Project Number：15H05702　Researcher Number：90296749
Research Area：Science and Engineering
Keyword：Spin device

【Purpose and Background of the Research】

The aim of this project is to establish the field of Spin-orbitronics: we will exploit the spin-orbit interaction of electrons in solids to form new materials with novel functionalities and find new physics, which will enable development of high speed, energy efficient electronic devices and technological innovations.

【Research Methods】

To meet the goal of this project, we focus on the following key areas.
(1)Explore materials using spin-orbit engineering
(2)Develop means of manipulating spins via the spin-orbit effects

The spin-orbit effects we focus on here are the Dzyaloshinskii-Moriya interaction, the spin Hall effect and the Rashba effect, which all take place in systems with broken structural inversion symmetry. The spin-orbit effects can be engineered by building artificial materials with broken structural inversion symmetry at the atomic scale using state of the art film deposition techniques. As first principle calculations and related theoretical frameworks can predict the physical properties of such artificial materials, we will collaborate with experts on theory and computations to design new material systems.

【Expected Research Achievements and Scientific Significance】

This project will explore new physics and phenomena based on the spin-orbit effects. The significance of this project is, however, not only to impact academic research but also to create technological innovations that will impact the industries.

The explosion of the amount of digital data stored in personal computers, servers and data centers in the last decade is causing concern on the sustainability of the information storage technologies due to power consumption problem. To tackle this problem, it has been suggested that all volatile semiconductor memories need to be converted to non-volatile memories and such non-volatile memories need to be implemented with logic devices to reduce the power consumption. However, such approach is expected to face challenges in the future: as further scaling of the technology node reduces stability of digital data bits and the power needed to "write" information becomes too large. With regard to storage devices, such as the hard disk drives and the solid state drives (e.g. NAND-flash), there is an increasing demand in developing fast storage technology that can keep up with the data transfer rates of communication devices. Currently transferred data are temporarily stored in the semiconductor volatile memories before permanently being written in the storage devices. The use of volatile memory layers lead to complicated and costly memory architectures and to consume extra power. The goal of this project is to provide solutions to these issues by engineering non-volatile materials and developing means to write information with extremely small power based on Spin-orbitronics.

【Publications Relevant to the Project】

・D. Chiba, S. Fukami, K. Shimamura, N. Ishiwata, K. Kobayashi, T. Ono, "Electrical control of the ferromagnetic phase transition in cobalt at room temperature", Nature Materials 10, 853 (2011).
・T. Moriyama, S. Takei, M. Nagata, Y. Yoshimura, N. Matsuzaki, T. Terashima, Y. Tserkovnyak, T. Ono, "Anti-damping spin transfer torque through epitaxial nickel oxide", Appl. Phys. Lett. 106, 162406 (2015).

【Term of Project】

FY2015-2019

【Budget Allocation】

432,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.scl.kyoto-u.ac.jp/~onoweb/