

【Grant-in-Aid for Scientific Research(S)】

Integrated Science and Innovative Science (New multidisciplinary fields)



Title of Project : Development of Novel Spin Dynamics Devices

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Research Area : New multidisciplinary fields

Keyword : Spin devices

【Purpose and Background of the Research】

The purpose of this project is to develop novel spin devices that utilize the current-induced spin dynamics in non-uniform spin structure, such as a magnetic domain wall and a magnetic vortex. Specifically, we aim to confirm the basic operations of three types of spin dynamics devices: vortex core memory, race-track memory, and domain wall oscillator. The vortex core memory is a non-volatile memory in which bit data is stored as the direction of the vortex core magnetization. In this memory, the direction of the core magnetization is controlled by the current-induced core switching phenomena which was found by our group, and the direction of the core magnetization is read out by using the tunnel magnetoresistance effect. The race-track memory is a non-volatile multi-bits memory which was proposed by IBM. In this multi-bits memory, domain walls are used to store bit data, and the current-induced domain wall motion is used for data shifting. The race-track memory is expected to overwhelm the Hard Disk Drive and Flash memory by its low power consumption and low bit cost. The domain wall oscillator is a device that converts the current-induced domain wall rotation into microwave, and the microwave frequency can be tuned by the current flowing through a domain wall.

【Research Methods】

To develop novel spin dynamics devices described above (vortex core memory, race-track memory, and domain wall oscillator), we plan to perform the following items.

- (1) Elucidation of physics of the current-induced spin dynamics
- (2) Confirmation of the basic operations of three types of spin dynamics devices: vortex core memory, race-track memory, and domain wall oscillator.

【Expected Research Achievements and Scientific Significance】

In general, the magnetic devices like Hard Disk Drive have high energy saving performance due to its non-volatility, i.e., data can be retained even if the electrical power is turned off. In this project, the vortex core memory and the race-track memory are developed as new novel non-volatile memories. The vortex core memory is expected as a fast non-volatile memory and it could be used in non-volatile logic devices in the future. The race-track memory is a novel device that satisfies high recording density, low bit cost, and reliability. The domain wall oscillator is a microwave generator based on the completely different operating principle from the conventional ones. These new spin dynamics devices proposed in this project can be integrated into the conventional silicon technology, leading to the seamless development of present electronics.

【Publications Relevant to the Project】

T. Koyama, D. Chiba, K. Ueda, K. Kondou, H. Tanigawa, S. Fukami, T. Suzuki, N. Ohshima, N. Ishiwata, Y. Nakatani, K. Kobayashi and T. Ono, "Observation of the intrinsic pinning of a magnetic domain wall in a ferromagnetic nanowire", *Nature Materials* 10 (2011) 194.

K. Yamada, S. Kasai, Y. Nakatani, K. Kobayashi, H. Kohno, A. Thiaville, T. Ono, "Electrical switching of the vortex core in a magnetic disk", *Nature Materials*, 6 (2007) 269.

【Term of Project】 FY2011-2015

【Budget Allocation】 165, 700 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.scl.kyoto-u.ac.jp/~ono/onolab/public_html/indexj.html