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

Broad Section D

Title of Project： Non-collinear spintronics

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Research Project Number：19H056622　Researcher Number：60704492
Keyword：Spintronics, Non-collinear magnetic structure

【Purpose and Background of the Research】

Spintronics, where two characters of electron – charge and spin – are utilized simultaneously, allows electrical control of collective magnetic ordering of magnetic materials. This has been a central topic of the spintronics research for the past two decades and various opportunities that classical magnetic engineering cannot achieve has been unraveled. Direct electrical manipulation of magnetization through the spin-transfer torque (STT) was demonstrated in 1999 and is utilized nowadays in STT-MRAM, a nonvolatile magnetic memory utilizing the STT-induced magnetization switching. In 2011, spin-orbit torque (SOT) was found as an alternative driving force to control the magnetization of ferromagnets and high-speed magnetization switching, which is not readily achieved by the STT, has been demonstrated. In addition, in 2016, SOT was found to allow electrical control of Néel vector of collinear antiferromagnets, which has not been considered to offer technological benefits, gathering great attentions recently. As described above, new horizons have been opened by appearance of new magnetic ordering and driving force.

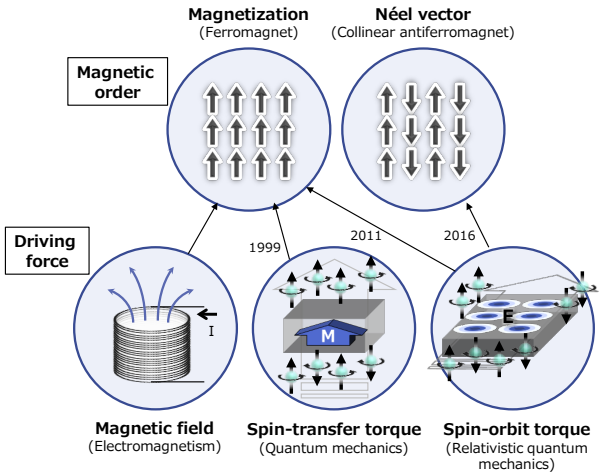

Figure 1 Electrical control of magnetic ordering

Figure 1 shows an overview of the electrical control of collective magnetic ordering described above. In this project, we aim to offer a new opportunity in the electrical control of magnetic ordering and to this end we focus on non-collinear magnetic structures which have not been explored in this field so far.

【Research Methods】

This field has mainly dealt with collinear magnetic ordering till now. Our project will explore a new paradigm "non-collinear spintronics" that should be spread beyond the conventional "collinear spintronics" paradigm. Several recent studies have revealed various interesting phenomena observed in non-collinear magnetic structures, which are realized as a consequence of frustration of several magnetic interactions. We will carry out experimental investigation where advanced stack-structure deposition, microfabrication, and measurement technique will be utilized, together with theoretical studies, and clarify the capability and functionality of the novel physical properties of the non-collinear magnetic structures.

【Expected Research Achievements and Scientific Significance】

The electrical control of magnetic ordering is not only a critical building block of nonvolatile magnetic memory, but also a promising ingredient for unconventional, e.g., neuromorphic, computing. "Non-collinear spintronics" explored in this project is expected to push out the frontier of spintronics, as well as forming a new basis for such low-power, intelligent integrated circuits and information devices.

【Publications Relevant to the Project】

· S. Fukami *et al.*, "Magnetization switching by spin–orbit torque in an antiferromagnet– ferromagnet bilayer system," *Nature Materials*, vol. 15, pp. 535-541 (2016).
· S. Fukami *et al.*, "A spin–orbit torque switching scheme with collinear magnetic easy axis and current configuration," *Nature Nanotechnology*, vol. 11, pp. 621-625 (2016).

【Term of Project】

FY2019-2023

【Budget Allocation】

155,500 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.spin.riec.tohoku.ac.jp/en/