【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Spintronics-Based Hardware Paradigm for Artificial Intelligence

Hideo Ohno
(Tohoku University, Research Institute of Electrical Communication, Professor)

Research Project Number : 17H06093 Researcher Number : 00152215
Research Area : Engineering
Keyword : Spintronics, Electron device/Integrated circuits

【Purpose and Background of the Research】

Owing to tremendous progresses of CMOS integrated-circuit hardware and artificial intelligence (AI) software, it has become possible for computers to execute complex tasks that had been difficult before. However, the current software based AIs require huge computer resources, power supply, and accessibility to big data, posing an obstacle for spreading of AIs to various fields. To apply the AI schemes to broad applications in society, it is indispensable to develop compact-size, low-power, and autonomous AI hardware, or *edge* AI, which can be realized by employing nonvolatile digital as well as analog devices in CMOS architecture. Spintronics devices are a promising candidate for this purpose due to their nonvolatility, capability of high-speed operation, and infinite read/write endurance. Based on these backgrounds, this project aims to establish the spintronics-based *edge* AI hardware paradigm by integrating nonvolatile spintronics devices and CMOS (Fig. 1).

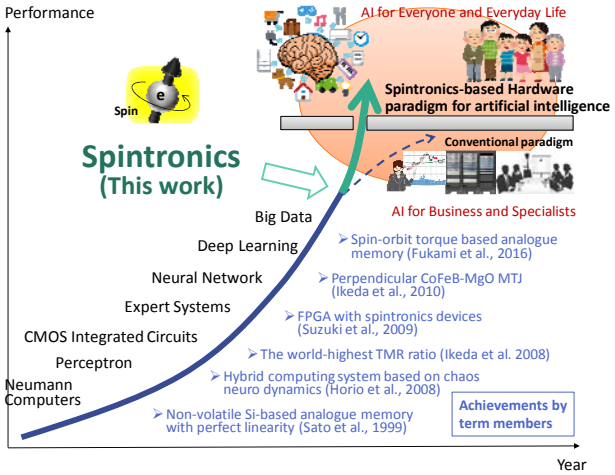

Figure 1 Background and aim of this research

【Research Methods】

To establish the AI hardware paradigm using spintronics, this project will demonstrate integrated circuits with nonvolatile spintronics devices as AI hardware. In addition, physics and material science behind the analog nature and stochastic behavior of spin systems will be deepened to aim at realizing spintronics devices used for AIs. Design methodologies of spintronics based integrated circuits that maximize the new aspect of spintronics devices will be also established. This project will be conducted with the following three teams: (1) R&D on spintronics devices for AI computing hardware, (2) realization of Neumann type AI computing hardware, and (3) realization of non-Neumann type AI computing hardware.

【Expected Research Achievements and Scientific Significance】

Construction of new paradigm based on a fusion of spintronics and CMOS for AI should lead to an establishment of a new platform for whole AI as well as other related areas. Also, the AI chips developed here should provide a concept of *edge* computing hardware, which is highly demanded in recent IoT societies.

【Publications Relevant to the Project】

- S. Fukami, C. Zhang, S. DuttaGupta, A. Kurenkov, and H. Ohno, "Magnetization switching by spin-orbit torque in an antiferromagnet-ferromagnet bilayer system," Nature Materials, vol. 15, pp. 535-541 (2016).
- W. A. Borders, H. Akima, S. Fukami, S. Moriya, S. Kurihara, Y. Horio, S. Sato, and H. Ohno, "Analogue spin-orbit torque device for artificial-neural-network-based associative memory operation," Applied Physics Express, vol. 10, 013007 (2017).

【Term of Project】 FY2017-2021

【Budget Allocation】 447,300 Thousand Yen

【Homepage Address and Other Contact Information】

http:// www.ohno.riec.tohoku.ac.jp/
ohno@riec.tohoku.ac.jp