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

Broad Section D

Title of Project : Renaissance of Metallic Superlattices

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Research Project Number : 18H05246 Researcher Number : 00187981
Keyword : Metallic superlattices, Spin-orbit interaction, Antiferromagnetic structure, Spin caloritronics

【Purpose and Background of the Research】

Metallic superlattices, where different metal layers are alternated periodically in a nanometer scale, were extensively studied for the giant magnetoresistance (GMR) effect and interlayer exchange coupling in 1980's-90's, giving the basis of spintronics. The recent progress of spintronics shows the following new developments: spin orbitronics incorporating spin-orbit interaction, antiferromagnetic spintronics utilizing the merits of antiferromagnets, and spin caloritronics based on the interplay between spin and heat. For these emerging research areas, the importance of interfaces has attracted much attention because of the possible enhancement of spin-orbit interaction at interfaces. The metallic superlattice as an assembly of interfaces will be useful for the systematic study of interface effects.

In this research project, as show in Fig. 1, we revisit metallic superlattices from the viewpoint of modern developments of spintronics. We aim to elucidate the role of interface on spin-orbit interaction by using metallic superlattices, demonstrate the spin-orbit torque switching in an antiferromagnetically-coupled superlattice, and fabricate a metallic superlattice showing a large thermo-magnetic effect and a small thermal conductivity.

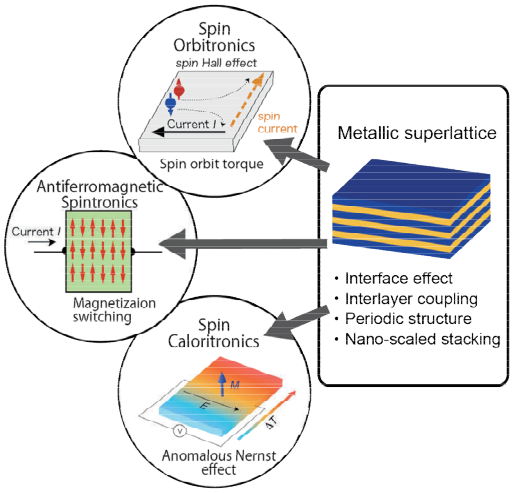

Fig. 1 Renaissance of Metallic Superlattices

【Research Methods】

For spin orbitronics, the layered structure of "Nonmagnet 1 / Ferromagnet / Nonmagnet 2" is used to evaluate interface magnetic anisotropy and spin-orbit torque simultaneously. The systematic study enables us to elucidate the mechanism of spin-orbit interaction at interfaces, leading to enhanced spin-orbit toque.

For antiferromagnetic spintronics, "Ferromagnet / Nonmagnet / Ferromagnet" is the basic layered structure. We aim to find a nonmagnetic material showing both strong antiferromagnetic interlayer coupling and large spin-orbit torque.

For spin caloritronics, we focus on the anomalous Nernst effect in metallic superlattices, and investigate a guiding principle for a high dimensionless figure of merit (ZT) by utilizing interface effect and nano-layering effect.

【Expected Research Achievements and Scientific Significance】

The observation of giant spin-orbit toque is expected due to the enhanced spin orbit interaction at interfaces in metallic superlattice, contributing significantly to the development of spin orbitronics. In addition, the study of spin caloritronics may open the application of metallic superlattice as a new thermo-electric material.

【Publications Relevant to the Project】

"Enhancement of anomalous Nernst effects in metallic multilayers free from proximity-induced magnetism", K. Uchida, T. Seki, K. Takanashi *et al.*, *Phys. Rev. B*, 92, 094414-1-6 (2015).

【Term of Project】 FY2018-2022

【Budget Allocation】 150,900 Thousand Yen

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