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

Broad Section D

Title of Project : Transformation of thermal and spin functions by nanosuperstructures

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Research Project Number : 21H05016 Researcher Number : 50397759
Term of Project : FY2021-2025 Budget Allocation : 148,900 Thousand Yen
Keyword : spintronics, thermomagnetic effects

【Purpose and Background of the Research】

A new research field called "spin caloritronics", which deals with the correlation between heat and spin, has been attracting much attention. This research deals with the interaction between heat and "spin current", which is defined as the flow of spin angular momentum, and is expected to be applied to new thermoelectric conversion devices and cooling devices by incorporating the concept of spin, in addition to interesting physics. However, the guiding principle for the fundamental question of how to control and maximize the effects of various thermomagnetic phenomena, which are the basis of the correlated functions of heat and spin, has not been established.

We have focused on the relationship between magnetization, magnetic anisotropy, spin current and thermomagnetic phenomena, mainly in ordered alloy materials, and have conducted research to explore their microscopic physical phenomena. As a result, we found that one of the thermomagnetic effects, the anomalous Nernst effect (schematic diagram in Fig. 1), is highly superior to existing thermoelectric conversion phenomena such as the Seebeck effect, and thus has potential applications in thermoelectric conversion devices. In this study, we aim to fabricate nanometer-sized magnetic superstructures, elucidate the innovative physics related to the heat-spin correlation phenomena, and exploit their functions to the limit.

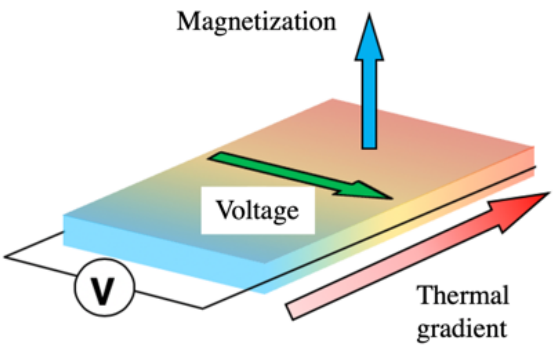

Fig. 1 Schematic diagram of the anomalous Nernst effect

【Research Methods】

In this study, we aim to answer the core question: "What magnetic structures and physical parameters determine the properties of thermomagnetic effects such as the anomalous Nernst effect, and what are the essential factors that control and maximize them?". We will create nanosuperstructures such as ultrathin layers, multilayers, porous structures, nanodots, and granular structures, and explore the relationship between their thermomagnetic effects and various physical parameters. Through these studies, we will establish the guiding principles for controlling and maximizing the thermomagnetic effect.

For this purpose, the following research terms will be established and carried out.

(1) Design and fabrication of magnetic nanosuperstructures
(2) Characterization of the crystal/magnetic structures and elucidation of thermal/spin functions of magnetic nanostructures
(3) Realizing high-performance/multi-functional thermal and spin functions in magnetic nanosuperstructures

【Expected Research Achievements and Scientific Significance】

We will deepen our understanding of the physics related to the thermomagnetic effects and demonstrate its applicability to novel thermoelectric power generation devices utilizing optimized magnetic nanosuperstructures. This will lead to highly efficient thermoelectric devices using thermomagnetic effects such as the anomalous Nernst effect.

【Publications Relevant to the Project】

· M. Mizuguchi and S. Nakatsuji, "Energy harvesting materials based on the anomalous Nernst effect", Science and Technology of Advanced Materials **20**, 262-275 (2019).
· P. Sheng, T. Fujita, and M. Mizuguchi, "Anomalous Nernst effect in $Co_x(MgO)_{1-x}$ granular thin films", Applied Physics Letters **116**, 142403-1-5 (2020).

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