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$L1_0$-FePt/MnGa 熱電対列の異常ネルンスト効果と熱電発電応用

Thermoelectric applications using anomalous Nernst effect in $L1_0$-FePt/MnGa thermopiles

東北大金研 [1], 東北大 WPI[2]　○桜庭裕弥 [1], 長谷川浩太 [1], 窪田崇秀 [2], 水上茂美 [2], 水口将輝 [1], 宮崎照宣 [2], 高梨弘毅 [1]

Tohoku Univ. IMR [1], Tohoku Univ. WPI-AIMR[2], ○Y. Sakuraba[1], K. Hasegwa[1], T. Kubota[2], S. Mizukami[2], M. Mizuguchi[1], T. Miyazaki[2], K. Takanashi[1]

E-mail: y.sakuraba@imr.tohoku.ac.jp

Thermoelectric power generation technology based on the Seebeck effect (SE) has attracted much interest for long years. Although generating electric power from waste heat is economical and ecologically friendly, power generation based on the SE has rarely been used in practical applications so far because of high cost of making Seebeck modules. Here, we propose a new thermoelectric power generation technique based on the anomalous Nernst effect (ANE) in ferromagnetic materials. ANE is the phenomenon that generates an electric voltage to the cross product direction between the magnetization and the temperature gradient in a ferromagnetic material(FM). There are many advantages to use ANE for thermoelectric applications especially in a viewpoint of cost; (i)electric voltage can be simply increased by making simple laterally connected structure, (ii)an internal resistance, which determined the extractable maximum power, can be decreased just by increasing the thickness of FM, (iii)Ubiquitous elements such as Fe and Mn can be used, etc.

In this study we investigated anomalous Nernst properties in various kinds of ferromagnetic materials especially $L1_0$-FePt, FePd and MnGa. As shown in Fig.1, we clearly observed the opposite sign of V_{ANE} against magnetization direction between FePt and MnGa. The anomalous Nernst coefficient Q_S, which is expressed as $Q_S = E_{ANE}/\mu_0 M_S \nabla T$, is 0.58 μV/TK and -0.76 μV/TK for FePt and MnGa, respectively. It should be noted that, MnGa consisting of only ubiquitous elements shows large Q_S compared with FePt, which is a promising characteristics for practical applications. In the presentation, we will report an enhancement of anomalous Nernst voltage by making the thermopile structures using $L1_0$-FePt/MnGa(as shown in Fig.2). We will also show you the results of ANE in in-plane magnetized FM with applying temperature gradient to out-of-plane direction, which is more practical configuration for applications.

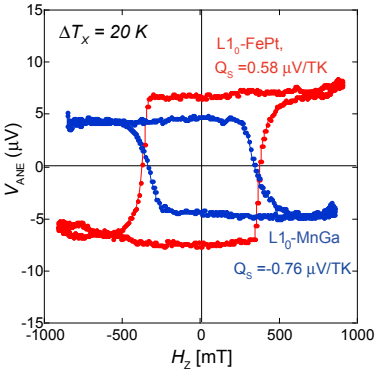

Fig.1 Magnetic field dependence of anomalous Nernst voltage in perpendicular-magnetized FePt and MnGa.

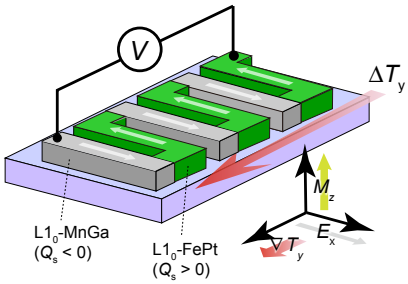

Fig.2 Thermopile structures consisting of perpendicular magnetized $L1_0$-FePt and $L1_0$-MnGa.