

重元素ドーブ Fe 薄膜における異常ネルンスト効果

Anomalous Nernst effect in heavy elements-doped Fe films

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○ (1. 物材機構、2. トヨタ自動車)

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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 beneficial, power generation based on the SE has rarely been used as practical applications so far because of several serial issues in Seebeck modules such as an unavoidable complex thermopile structure and low energy conversion efficiency. On the other hand, anomalous Nernst effect is also thermoelectric phenomenon that generates an electric voltage to the cross product direction between the magnetization and the temperature gradient in a ferromagnetic material. Previously, Sakuraba et al. proposed that there is important advantage to apply ANE for thermoelectric applications; electric voltage can be easily increased by making simple laterally connected structure, which can lead to various kinds of new applications that can not be realized by general SE [1,2]. However, to improve thermopower originating from ANE is necessary to realize practical applications. In this study, we have investigated the effect of heavy elements (Ta, Ir, Bi) doping to Fe film for an enhancement of ANE effect.

The heavy elements doped Fe films were deposited by a co-sputtering method using pure Fe and Ta/Ir/Bi targets on thermally-oxidized Si and MgO substrates. ANE effect was measured by applying temperature gradient and external magnetic field to the in-plane and out-of-plane directions of the films, respectively.

We found that ANE in Fe films can be drastically enhanced by doping Ir atoms. The Fe film with 16-18 at.% Ir shows about 4 times larger thermopower of ANE (S_{ANE}) and one order of magnitude larger ANE angle θ_{ANE} ($= S_{ANE}/S_{SE}$) than those in pure Fe film (Fig.1). Observed θ_{ANE} of 38% is the highest ever reported in any ferromagnetic materials such as FePt ($\theta_{ANE} \sim 15\%$). Although S_{ANE} is still rather small due to small S_{SE} of Fe, the enhancement of θ_{ANE} by heavy element doping is important for a further improvement of thermopower of ANE.

[1]Sakuraba et al., APEX 6, 033003 (2013),

[2]桜庭裕弥、高梨弘毅 パリテイ vol.29, No.6 (2014).46-50

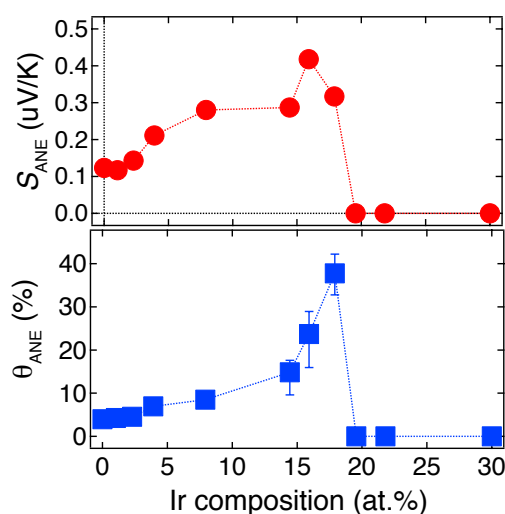


Fig.1 Ir composition dependence of S_{ANE} and θ_{ANE} in Fe(Ir) films