Spin Seebeck Effect in SiO_2/[Py/Pt-strips]

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1. Introduction

It is known that the Seebeck effect is a conversion of temperature difference directly into electricity. In spintronics society, recently, spin version of Seebeck effect, the spin-Seebeck effects (SSE) was observed experimentally at room temperature[1]. This SSE is expected to useful for future spintronic and spin caloritronics applications. The SSE generates a spin current by placing ferromagnetic metal, magnetic insulator [2], and ferromagnetic semiconductor [3] in a temperature gradient. According to the main results of SSE, the sign reversal of voltage between hot and cold ends takes place at the center of the sample due to the change of the direction of spin current polarization vector. However, asymmetric behavior of magnitude voltage at hot end and cold end is inconsistent with the feature of SSE observed in Ref. [4].

In this study, we experimented SSE in SiO_2/[Py/Pt-strips] sample that the thermally induced spin voltage by using ISHE(inverse spin hall effect) of a Pt film.

2. Experimental method

The sample structure is that [Py(10, 50 nm)/Pt(15 nm)-strips] are deposited on the SiO_2 surface. The lengths of the SiO_2 layer and the [Py/Pt-strips] along the x (y) direction are 8 mm (4 mm) and 100 mm (3 mm), respectively. Then [Py/Pt-strips] were attached on the SiO_2 layer within a gap of 700mm. An in-plane magnetic field, H, is applied along the negative x direction. An uniform temperature gradient, ∇T, is appled along the x direction. The ∇T on the surface of the SiO2 layer is directly measured by measuring temperature difference(ΔT) of hot end and cold end. Additionally, we prepared the same size of SiO_2/[Py(thickness=10, 50nm) strips] (No Pt layer) due to confirm origin of asymmetric behavior of voltage signal.

3. Results and discussion

Fig 1. show the measured voltage (V) of SSE (red line) and anomalous Nernst-Ettingshausen effect (ANE, Ref. [4]) (green line) as a function of the position of [Py/Pt-strips](red line) and Py strip (green line) for Py thickness=10 nm(ΔT=35 K). Fig 2. show the measured voltage (V) of SSE and ANE as a function of the position of [Py/Pt-strips] (red line) and Py strip(green line) for Py thickness=50 nm(ΔT=35K). Originally, in SSE experiment, the ANE is eliminated due to $V_{ANE} \propto M \times \nabla T = 0$. However, in our results, the sign change in voltage of SSE between the hot and cold ends has not been observed, we obtained an offset voltage at x=0. We attribute this offset to the longitudinal SSE caused by an additional temperature gradient along the thickness direction of Py layer($M \perp \nabla T$, $V_{ANE} \neq 0$). A possible origin of the offset voltage will be discussed in detail.

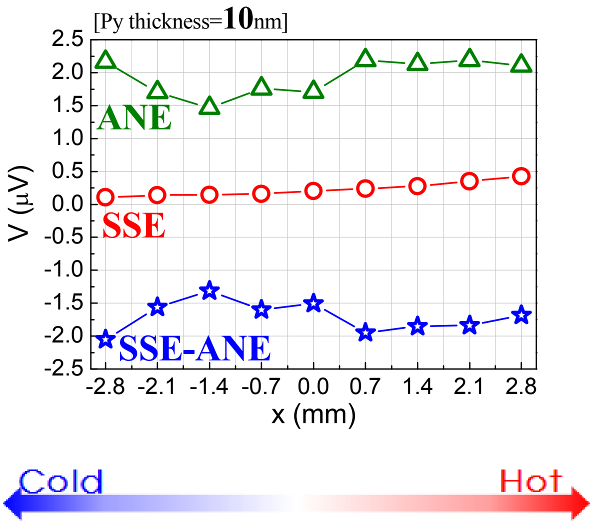

Fig 1. The voltage of SSE (red) and ANE (green) as a function of the position of [Py/Pt-strips] (red) and Py strip (green) for Py thickness=10 nm.

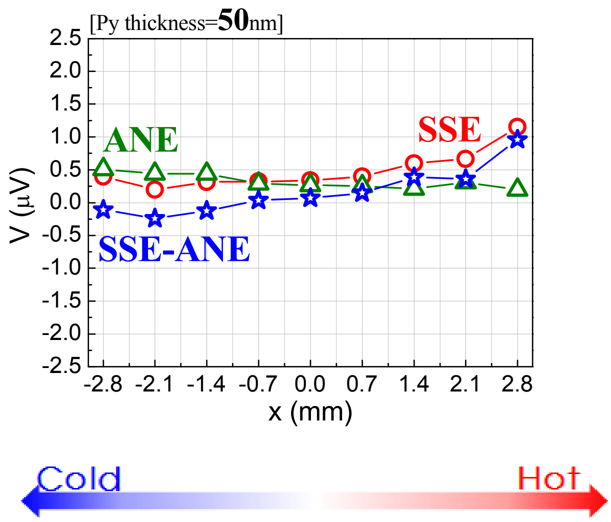

Fig 2. The voltage of SSE (red) and ANE (green) as a function of the position of [Py/Pt-strips] (red) and Py strip (green) for Py thickness=50 nm.

4. Reference

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