Spin Seebeck Effect in $Gd_3Ga_5O_{12}$/YIG($Y_3Fe_5O_{12}$)/Pt

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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 and magnetic insulator[2] in a temperature gradient. In ferromagnetic metal and insulator, the thermally generated a pure spin current induces spin voltage. The spin voltage can be measured electrically by means of the inverse spin-Hall effect (ISHE) in a paramagnetic metal[3]. In this study, we reproduced the experiment of SSE in YIG($Y_3Fe_5O_{12}$)/Pt sample that the thermally induced spin voltage by using ISHE of a Pt film.

2. Experimental method

The experiment of the SSE in YIG($Y_3Fe_5O_{12}$) film, Fig.1 (a) show a schematic illustration of the measurement system. The sample structure is substrate ($Gd_3Ga_5O_{12}$)/ YIG($Y_3Fe_5O_{12}$, 2800nm) and Pt wires (15nm) are deposited on the YIG surface. The lengths of the YIG layer and the Pt wire along the x (y) direction are 8 mm (4 mm) and 100 mm (3 mm), respectively. Then Pt wires were attached on the YIG layer within a gap of 700mm. An in-plane magnetic field, H, is applied along the negative x direction. An uniform temperature gradient, $\bigtriangledown T$, is appled along the x direction. The $\bigtriangledown T$ on the surface of the YIG layer is indirectly measured by measuring temperature difference of dummy sample (Si/SiO_2(300nm)/Pt(15nm)).

3. Results and discussion

Fig.1 (b) show the measured voltage (V) as a function of the external field (H) for the temperature difference from 0 K to 50 K. $\triangle T$ indicates a temperature difference of the each ends of the YIG surface along the x axis. Absolute value of the measured voltage shows minimum at 0 Oe and abruptly increased then saturated when the field is over 10 Oe. When the $\triangle T$ is 0 K, observed spin voltage is 0 V and spin voltage is increased as the $\triangle T$ is larger.

Fig.1 (c) show the spin voltage(V) from Fig.1(b) as a function of the temperature difference by using ISHE for H=100 Oe. In this specimen, the magnitude of spin voltage is proportional to $\triangle T$. This result of spin voltage is consistent with the feature of the typical ISHE induced by SSE. We obtained that spin voltage for YIG/Pt is approximately 3.86 times larger than the reported results[2] in $LaY_2Fe_5O_{12}$/Pt at entire temperature range.

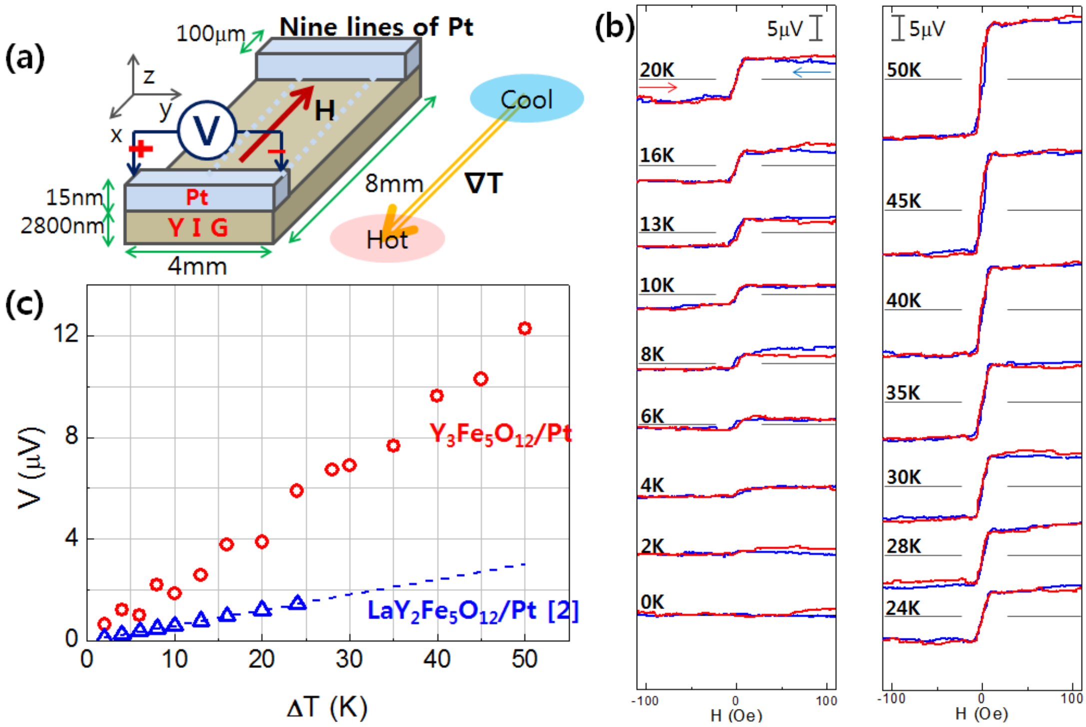

Fig. 1. (a) Schematic illustration of the YIG/Pt. (b) The field dependence of spin voltage in hot zone. (c) Spin voltage as a function of the temperature difference for H=100Oe. Red points in YIG/Pt represented our experiment results and blue points show reported results[2] in $LaY_2Fe_5O_{12}$/Pt.

4. Conclusion

We have measured the thermally induced spin voltage in YIG/Pt by using the inverse spin-Hall effect in a Pt wire, and we confirmed that spin voltage is proportional to temperature difference. As a further study, we have plan to measure the spin voltage behavior from the other location of the Pt wires and different structure.

5. Reference

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