The Fabrication of Spin-Thermoelectric Device using the Sol-Gel Method

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1. Introduction

In recent years, a ferrimagnet insulator-$Y_3Fe_5O_{12}$ (YIG) has been attracted much attention due to its prominent applications to spincaloritronic devices such as a spin voltage generator utilizing the spin Seebeck effect (SSE) [1, 2]. Subsequently, a variety of fabrication methods for YIG films have been developed; a pulsed laser deposition [3], an RF/DC sputtering [4], a spin coating [5], and a sol-gel [6] method have been studied. Here, we utilized the sol-gel method to fabricate homogeneous YIG film. The sol-gel method is available to synthesize fine and homogeneous ceramics with high production efficiency. In this presentation, we explore the variation of magnetic properties of YIG film according to the heat treatment procedure.

2. Experiments

We prepared raw materials of the yttrium nitrate ($Y(NO_3)_3.6H_2O$, 99.99%), iron nitrate ($Fe(NO_3)_3.9H_2O$, 99.99%), citric acid ($C_6H_8O_7.H_2O$). The solution of the citric acid was dissolved into 100 mL of distilled water at room temperature for 18 hours with stirring speed of 300-rpm. The solution of the citric acid was maintained at 1pH. 100 mL of citric acid was added to the yttrium nitrate ($Y(NO_3)_3.6H_2O$, 99.99%) and the iron nitrate ($Fe(NO_3)_3.9H_2O$, 99.99%) in regular sequence. The resulting solution was followed by stirring for 24 hours at 80 ℃ to obtain a homogenous gel. And then the powder YIG was obtained from the grinding the completely dried solution. The calcination process was carried out at 850 ℃ in air for 2 hours at a heating rate of the 7.7 ℃/min to get rid of residual impurities. Sintering has been done at 1400 ℃ for 2 hours. To measure SSE according to temperature gradient along film thickness direction (longitudinal geometry), the 15-nm-thickness Pt electrodes have been fabricated on the YIG surface through the photolithography and DC sputtering. For the sake of enhancement the SSE signal (spin voltage), we adopted parallel Pt electrodes circuit design. X-ray Diffractometer (XRD) was used for finding crystalline structure. The magnetic properties of the fillet were measured using SQUID Vibrating Sample Magnetometer at room temperature (25 ℃) as well as magneto-optical Kerr effect.

3. Results & Discussion

To examine the effect of heat treatment to properties of YIG, we compared the crystalline structure and magnetic properties before and after sintering process. For both cases, the XRD pattern showed good agreement with the Joint Committee on Powder Diffraction Standard (JCPDS-ICSD; number 014342) of the pure YIG. However, magnetic properties vary dramatically according to the sintering process. After the sintering process, we found huge enhancement of the saturation magnetization of YIG film. From the previous studies [7], it is

well known that calcination temperature can affect the crystalline structure of YIG film. In this work, however, we found that the sintering process can play a crucial role for the magnetic properties of YIG film.

4. References

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