Detection of Morin transition in Pt/Ru-doped-hematite bilayers using spin Hall magnetoresistance

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Recently, antiferromagnetic (AFM) films are of interest because of their potential for alternative materials to the ferromagnet films which have been used for conventional magnetic memories. Hematite (α-Fe_2O_3), which is one of these AFM materials, has high Néel temperature (950 K). Besides, the amount of resource is abundant. In pure α-Fe_2O_3, the Morin transition, which is AFM-WFM (weak ferromagnetic) transition, occurs below 300 K. The control of the Morin transition temperature T_M is required for practical applications. A previous report shows that T_M of the heavy-metal-doped α-Fe_2O_3 films increases above 400 K [1]. In this study, T_M of Ru doped α-Fe_2O_3 films is investigated by spin Hall magnetoresistance (SMR) [2] using angle-dependent magnetoresistance (ADMR) measurements [3].

(0001)-oriented epitaxial 5%-Ru-doped α-Fe_2O_3 films were prepared on (0001)-Al_2O_3 substrates using a pulsed laser deposition method. T_M was raised to about 300 K in order to estimate the T_M simply by SMR signal and magnetization. The magnetic properties of the film were measured also by Mössbauer spectroscopy and magnetization measurements. ADMR measurements, whose setting is shown as the insertion of Fig.1, were performed for the Pt (2.5 ~ 3.0 nm) /Ru-doped α-Fe_2O_3 (50 nm) bilayers.

As shown in Fig. 1, the SMR signals by ADMR measurements in 10 kOe at 200 K and 320 K were 0% and 0.2%, respectively, which means that the Morin transition occurred between 200 K and 320 K. Figure 2 shows the SMR signals and the magnetization as a function of temperature. The difference in SMR signals caused by the Morin transition occurred at about 260 K, but the change in magnetization was observed at about 300 K. This result implies that T_M of the α-Fe_2O_3 surface is lower than that of the center of α-Fe_2O_3 films.

[1] N. Shimomura *et al*., J. Appl. Phys. **117**, 17C736 (2015). [2] H. Nakayama *et al*., Phys. Rev. Lett. **110**, 206601 (2013).
[3] J. Fischer *et al*., Phys. Rev. Appl., **13**, 014019 (2020).

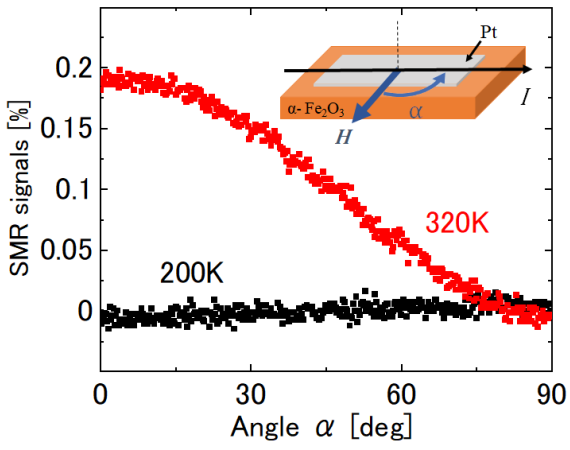

Fig.1 SMR signals at 200 K and 320 K under the magnetic field of 10 kOe. Insertion is the ADMR measurement setting for in-plane angle α.

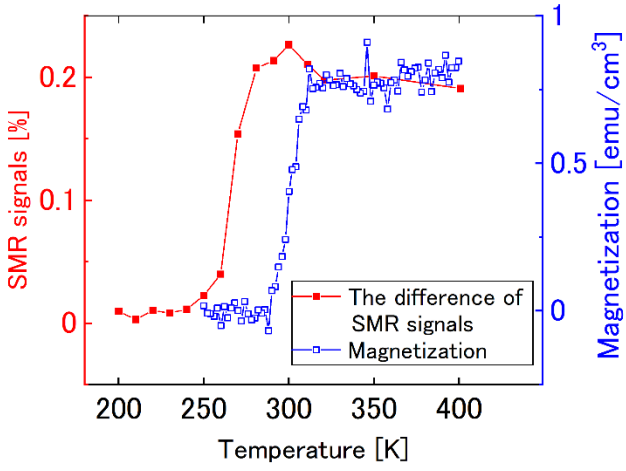

Fig.2 SMR signals of 10 kOe and the magnetization as a function of temperature.