Efficient spin current injection in Co_2MnSi/Pt films

◦(P)**Y. Sasaki[1], S. Sugimoto[1], Y. K. Takahashi[1], and S. Kasai[1,2]**

(1. NIMS, 2. JST PRESTO)

E-mail: SASAKI.Yuta@nims.go.jp

Spin pumping is one of the promising ways to generate the spin current in ferromagnetic (FM)/nonmagnetic (NM) heterostructures[1,2]. A magnetization precessional motion under the ferromagnetic resonance (FMR) condition induces the spin current flow to the NM layer and it is converted into a transverse charge current via the inverse spin Hall effect(ISHE) in the NM layer. The key factor determining the spin transport property is the spin mixing conductance[3, 4, 5] at the FM/NM surface. The spin injection efficiency depends on the choice of the materials, however, there are few reports on its FM material dependence. In this study, the spin injection efficiency in Co_2MnSi(CMS), which shows a large spin polarization and large magnetoresistance, was systematically investigated using the spin pumping method.

Films with a structure of MgO(001) substrate//MgO(20)/CMS or Fe(5)/Pt(2) were fabricated using an ultrahigh vacuum magnetron sputtering system. The MgO substrate was thermally flushed at 700°C for 1 hour in the chamber before the deposition process. All layers were deposited at room temperature and the MgO buffer layer was *in situ* annealed at 700°C for 1 hour to obtain a smooth surface. CMS layer was *in situ* annealed at T_a of 400, 500 and 600°C for 1 hour to improve the chemical ordering. The blanket films were patterned into 8-μm-wide, 100-μm-long bars by electron-beam lithography and ion milling. A waveguide to apply a rf magnetic field for FMR was placed 2 μm away from the bars.

The voltage spectra with the applied rf magnetic field frequency of 12 GHz in microfabricated Fe reference sample and CMS samples with various T_a are shown in Fig. 1. The peak voltage in the spectrum decreased with increasing T_a. The peak voltage in the CMS T_a=400°C sample was 1 order larger than that in the Fe sample. The result infers that large spin mixing conductance is expected in the CMS films annealed at low T_a.

This work was partially supported by JSPS KAKENHI Grant Number H1803787, and JST, PRESTO Grant No. JPMJPR18L3, Japan.

[1] K. Ando, et al., j. Appl. Phys. **109**, 103913 (2011)

[2] R. Iguchi *et al.*, J. Phys. Soc. Japan. **86**, 011003 (2017).

[3] L. Zhu, *et al*., Phys. Rev. Lett. **123**, 057203 (2019).

[4] H. Chudo, *et al*., J. Appl. Phys. **109**, 073915 (2011).

[5] B. Bhusan, *et al*., arXiv:1911.02230

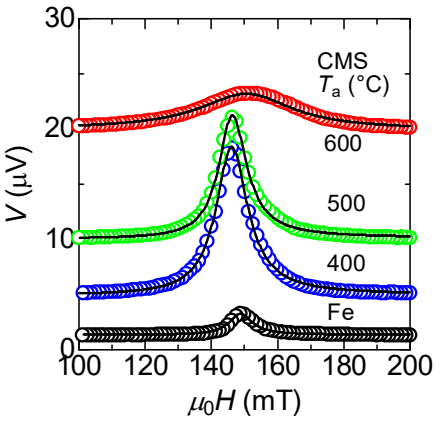

Fig. 1 Voltage spectra in CMS(5) /Pt(2) samples with various annealing temperature T_a, and Fe reference sample. Solid lines are fitting results.