静磁表面スピン波への電気伝導性の影響

Influence of conductivity on magnetostatic surface spin waves

福岡大理 [1], エクセター大 [2] ○眞砂卓史 [1], 笠原健司 [1], M. F. Azis[2], F. Ogrin[2], V. V. Kruglyak[2]

Fukuoka Univ., Univ. of Exeter, ○T. Manago[1], K. Kasahara[1], M. F. Azis[2], F. Ogrin[2], V. V. Kruglyak[2]

E-mail: manago@fukouka-u.ac.jp

Introduction

The emerging field of magnonics has gained significant interest, ranging from fundamental studies of spin wave properties to their application for the information transport and processing. In order to integrate spin wave devices with conventional Si devices, ferromagnetic metals are favorable for wave guide materials rather than YIG because of Si process compatibility. However, conductivity of metals could affect the spin wave propagation properties. In our previous paper, thicker wave guide of Py showed high group velocity, but the decay length did not increase very much [1]. We performed a micromagnetic simulation incorporating conductivity in order to investigate whether the conductivity affects the decay length.

Simulation

Simulations of the spin wave propagation incorporating conductivity and permeability were performed using COMSOL software. Quasi-static electromagnetics and linearized LLG equation were combined for the calculation. Gaussian pulse excitation with a pulse width of 50 ps was applied using the SG type antenna. The reaching time and amplitude of the spin waves were extracted from the Gaussian fitting of the envelope of the waveform, and then the group velocity v_g and decay length λ were analyzed.

Results and discussion

Figure.1 is the summary of the v_g obtained by the experiments and simulations. The estimated v_g from the dispersion relation is agreement with the analytical solution regardless of conductivity. Those from wave form, however, are overestimated and it is remarkable for the results incorporating conductivity. The overestimation originates from a dispersive propagation due to many k vectors containing in the excited spin waves. Additionally, damping due to conductivity plays an important role for the overestimation.

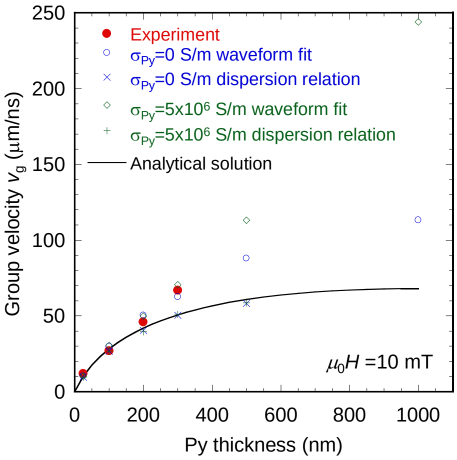

Fig.1 Summary of group velocity v_g. Red circles are experimental results and black solid line is the analytical solution. Blue and green are simulation results of 'without conductivity' and 'with conductivity', respectively.

Figure 2 is the summary of the λ. Without conductivity, the λ increases monotonously, as expected from the increase in v_g. With conductivity, on the other hand, λ increases initially for thin Py thickness but tends to decreases with thickness. This behavior is in good agreement with the experimental results. Thus, conductivity of the waveguide enhances damping of the spin wave. The origin that the decay length does not increase is the conductivity of the waveguide.

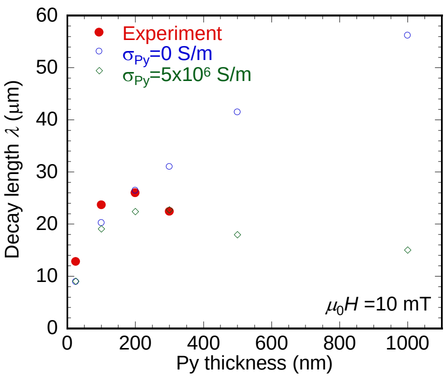

Fig.2 Summary of decay length λ. Red circles are experimental results. Blue and green are simulation results of 'without conductivity' and 'with conductivity', respectively.

Acknowledgements

This work was partly supported by funds (Nos. 167003 and 175005) from the central Research Institute of Fukuoka University.

Reference

[1] M. Ohta et al., Jpn. J. Appl. Phys, **54**, 113001 (2015).