Spin wave propagation in sputter-deposited YIG nanometer films

ICR, Kyoto Univ. [1], CSRN, Osaka Univ.[2], ○Yoichi Shiota[1], Shuhei Kasukawa[1], Takahiro Moriyama[1], and Teruo Ono[1,2]

E-mail: Shiota-y@scl.kyoto-u.ac.jp

Yttrium iron garnet ($Y_3Fe_5O_{12}$, YIG) is well-known material with an extremely small magnetic damping, α = ~10^{-5} in bulk, which is two orders of magnitude smaller than that in ferromagnetic metals. The growing demands for YIG-based spintronics have led to the development of YIG thin films with a nanometer thickness range [1, 2]. Recently, magnonics has been attracted considerable interests for the transmission, storage and processing of the information using propagating spin waves [3]. To miniaturize the magnonic devices, it is necessary to reduce the thickness of YIG films for a shorter wavelength. In this study we investigate the spin wave propagation in sputter-deposited YIG nanometer films, and characterize the YIG thickness dependence of the several parameters, such as magnetic damping constant, spin wave group velocity and nonreciprocity.

The YIG thin films were grown on 0.5-mm-thick single crystal gallium gadolinium garget (GGG) substrates with (111) orientation by RF magnetron sputtering. The films were annealed at 900 °C for 8 h in the air. We varied YIG film thickness from 20 nm to 50 nm. Using electron-beam lithography and Ar ion-milling technique, the films were patterned into a circular shape with 10-μm-diameter for ferromagnetic resonance (FMR) measurement and a rectangular shape with 50-μm-width for the spin wave measurement. After patterning the YIG films, an insulating layer of 30 nm SiO_2 was deposited on the entire surface. Finally, microwave antennas were deposited for the FMR and spin wave measurement.

The propagating spin wave spectroscopy using vector network analyzer was performed under the in-plane magnetic field to excite the magnetostatic surface spin wave (MSSW) mode. The group velocity of spin wave was estimated from the oscillation period in transmission spectra. It was about 1.1 km/s in 50-nm-thick YIG waveguide under 14 mT. We found that the spin wave group velocity decreases with increasing the magnetic field and decreasing the film thickness. Then, by comparing the signal intensity, the nonreciprocity defined as A_{12}/A_{21} was also estimated, where A_{12} and A_{21} denote the signal intensity of S_{12} and S_{21}, respectively. In the presentation, we will also present thickness dependence of the magnetic damping constant estimated from FMR measurement.

[1] O. d'Allivy Kelly *et al.*, *Appl. Phys. Lett.* **103,** 082408 (2013), [2] H. Chang *et al.*, *IEEE Magn. Lett.* **5,** 670104 (2014), [3] A. V. Chumak *et al.*, *Nat. Phys.* **11,** 453-461 (2015)