

Magnetic Structures in Nano-Fabricated Pt/Co/Ta Multilayer Film

Hamanaka, K.¹, Suzuki, H.¹, Ishida, T.^{2,3}, Kuwahara, M.^{1,4} and Saitoh, K.⁵

¹ Graduate School of Engineering, Nagoya University, Japan, ² Institute of Materials and Systems for Sustainability, Nagoya University, Japan, ³ Global Research Center for Environment and Energy base on Nanomaterials Science, Japan, ⁴ IMASS, Nagoya University, Japan, ⁵ Nagoya University, Japan

Multilayer films are expected to be applied to memory devices since physical interactions occur at interfaces of different kind of metals. In Pt/Co/Ta multilayer film, it was reported that the skyrmion originating from the interface Dzyaloshinskii-Moriya (DM) interaction between the ferromagnetic layer and the nonmagnetic layer was observed at room temperature [1]. However, this multilayered film system has few observation examples by a transmission electron microscope (TEM) due to the Neel type magnetic structure. Therefore, the observation of this sample is performed by a method capable of detecting vertical magnetization such as magnetic force microscopy (MFM) and magnetic soft transmission X-ray microscopy (MTXM). However, the spatial resolutions of the methods are not enough to analyze the tiny magnetic structure. Therefore we try to analyze the magnetic structures by electron holography and Lorentz microscopy with sample tilting in a TEM.

Here, we report a preparation of the Pt/Co/Ta multilayers in shape and size which is suitable for TEM observations and detailed analysis. We prepared the multilayered sample on a 10-nm thick SiN membrane in order to perform the TEM observation. Electron beam lithography and pulsed laser deposition were used for fabrication of magnetic thin film samples. Consequently, we could perform the fine patterning and control the size, shape, and thickness of the magnetic thin film with an accuracy of a few nanometers. The magnetic multilayer film has a disk shape with a several diameters of 0.5 to 2.5 μm , and the film thickness of Pt, Co and Ta are 3 nm, 0.9 nm and 4 nm, respectively. This three-layered structure is deposited five times repeatedly so as to strengthen the DM interaction.

Magnetic structures in the multilayered film was observed by electron beam holography. We succeeded in confirming a leakage magnetic field similar to Neel type skyrmion. Fig. 1 shows a reconstructed phase image of a disk with 15° tilting the specimen holder.

[1] S. Woo, et al., Nature Mater. **15**, 501-506 (2016)

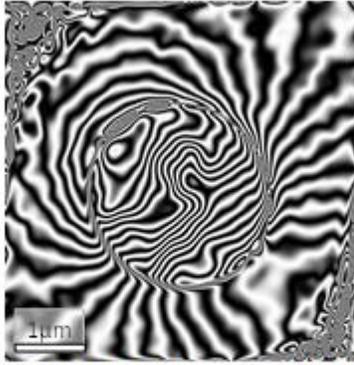


Fig 1. Reconstructed phase image of Pt/Co/Ta disk tilted by 15° showing the leakage magnetic field. The diameter of the disk is $2.5\mu\text{m}$.