Non-off Axis Sputtering Deposition of Ferrimagnetic Insulator Film with Perpendicular Magnetic Anisotropy

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In recent years, epitaxially grown garnet thin film with perpendicular magnetic anisotropy (PMA) attracts much attention such as Thulium iron garnet (TmIG) since the creation and transport of skyrmions at room temperature have been reported using this material[1)]. Most researchers use convenient method for materials science to fabricate TmIG such as pulse laser deposition or off-axis sputtering[2,3)], while the reports of industrial-friendly magnetron sputtering are limited[4)]. To accelerate the development of research in this interesting material, fabrication by a simpler non-off-axis sputtering is required. Here, we report the successful growth of PMA-TmIG using non-off-axis magnetron sputtering.

Radio-frequency magnetron sputtering technique was applied to grow TmIG film without heating substrate. Three pieces of Gadolinium Gallium Garnet (GGG) (111) substrates were placed on different positions on the substrate holder to examine the effects of plasma damages on the film structures and magnetic anisotropy in the off-axis and non-off-axis sputtering conditions. The deposition time was 120 min. Post deposition annealing was carried out in O_2 atmosphere at 800°C for 3 hours.

The structural difference was examined using X-ray diffraction (Bruker D8-DISCOVER) in 2θ-ω scan as show in Fig. 1a. Only from the sample deposited at position 3 forms strained TmIG crystal. The structural difference is attributable to the elemental composition. The Magnetic anisotropy was examined by angle-dependence of the resonance field of the ferromagnetic resonance (FMR) using a microwave cavity system (Bruker EMX) and Kerr Microscope in an out-of-plane field. This sample was confirmed to have PMA from the FMR measurement and clear hysteresis loop was observed as shown in Fig. 1b. This study demonstrated a simple method to fabricate a PMA-TmIG film.

Reference

1. S. Vélez *et al. Nat. Nanotechnol.* **17**, 834–841 (2022). 2. C. N. Wu *et al. AIP Adv.* **8**, 055904 (2018).
3. V. D. Duong, *et al. J. Alloys Compd.* **927**, 166800 (2022).
4. Z. Ye *et al. Adv. Electron. Mater.* **8**, 2100590 (2022).

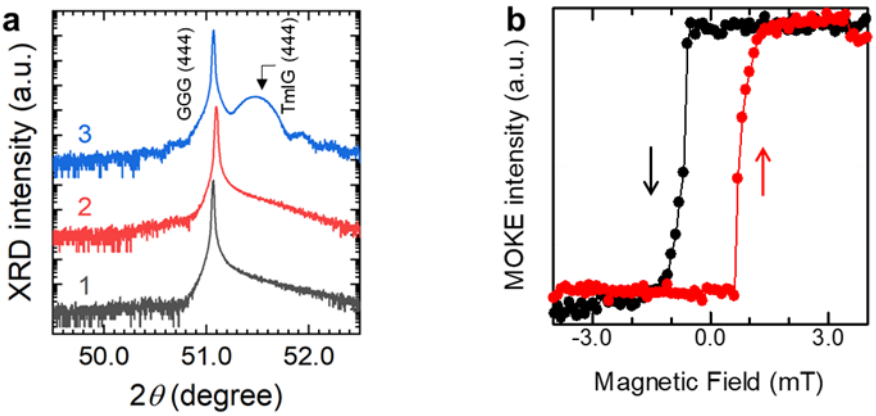

Figure 1a: X-ray diffraction patterns of the films deposited at different positions. The legends indicate the position of the substrate during deposition.

1b: Major hysteresis loop of the sample 3 in the Fig, 1a in an out of plane field measured by magneto-optical Kerr effect at 290K. The black and red plots represent down sweep and up sweep respectively.