Spin wave propagation characteristics of defect spinel epitaxial γ-$Fe_{2-x}Al_xO_3$ thin films for magnetics applications

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To realize low-energy-consumption magnonic devices, a generation and/or propagation of the spin wave (SW), it is necessary to minimize dissipation from electron scattering. The magnetic insulator has been regarded as an ideal SW source and media. From this viewpoint, ferrite provides natural superiority because of its high insulating properties unlike the metallic Permalloy, CoFeB, and Heusler compounds.[1] The garnet-type ferrite has been regarded as a candidate material for the magnonic application because of its high Néel temperature (~600 K) and low damping constant (~10^{-5}). However, their epitaxial growth is possible only on the garnet-type substrates. This point becomes a barrier for its application in the fabrication of magnonic devices. Therefore, the other ferromagnetic ferrite with low damping property and good lattice matching with conventional crystalline substrates have been strongly desired.

Here we chose the spinel-type γ-Fe_2O_3 and as the candidate materials, substituted parts of the Fe^{3+} with Al^{3+}. Through tailoring the chemistry cation of spinel ferrite, the samples are concluded with higher crystallinity, low damping constant and better SW transmission properties. Thin films of the spinel-type γ-$Fe_{2-x}Al_xO_3$ (FAO; $x = 0 - 0.5$) were deposited on (100)-oriented single crystal MgO substrates by pulsed laser deposition. Pulsed laser deposition was performed at O_2 pressure of 0.1 Pa, and the substrate temperature of 400°C. The films' thickness was confirmed as about 50 nm, showing ferromagnetism property at room temperature and high insulating.

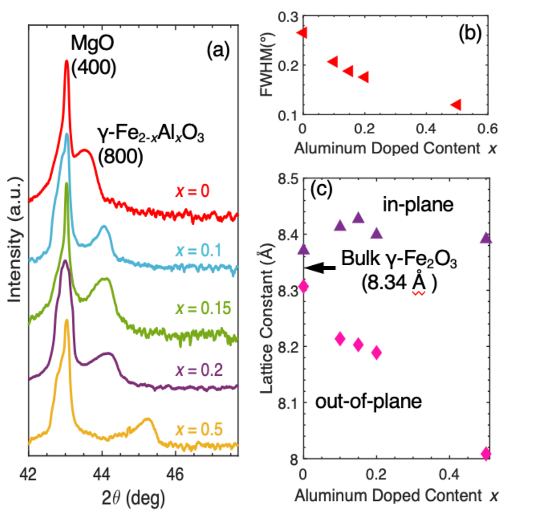

Figure 1 Structural properties of epitaxial FAO films

In order to structurally characterize films, we performed out-of-plane and in-plane XRD measurements as shown in Fig. 1. The results indicate that films are epitaxial with the underlying MgO substrates and are of high crystalline quality. The lattice constant calculation results suggest that the film undergoes a larger tetragonal distortion to remain coherently strained to the MgO substrate.[2]

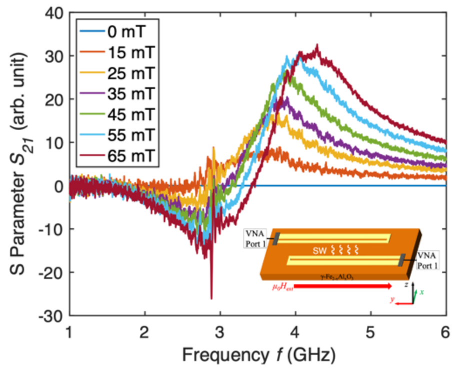

Figure 2 SW transmission characteristic (S21) of γ-$Fe_{1.85}Al_{0.15}O_3$ sample

The SW property is measured by a vector network analyzer. On applying RF current to the two-arm co-plane waveguides, an Oersted field is created around the signal wire and will raise SW and propagate on the surface of the ferrite film. As shown in Fig. 2, the SW frequency shifts depending upon the external magnetic field. The amplitude grows with the increasing magnetic field, and reaches about 0.3 with an external magnetic field of 65 mT.

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Reference:

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