組成勾配を導入した磁性層による表面弾性波の非対称な減衰

Asymmetric attenuation of surface acoustic waves by magnetic layers with compositional gradients

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Surface acoustic wave (SAW) is mechanical vibrations that propagate locally on a solid surface and is used in devices such as high-performance filters. In the context of spintronics, SAWs interact with magnetization in large magneto-strictive materials like Ni and Co via the magnetoelastic coupling to excite spin waves. The attenuation of SAW, induced by spin wave excitation is known to be asymmetric in both the direction of propagation and a direction of an external magnetic field [1]. Several studies attribute this asymmetry to the shear strain components in SAWs, which are asymmetric in the propagation direction. In particular, Tateno et al. observed that the asymmetry in attenuation becomes more pronounced by increasing the ratio of shear components to symmetric longitudinal components [2]. However, to add a Si layer with several hundred nm in thick is required for achieving it, and the detailed mechanism for the asymmetry remains elusive. In this study, a composition gradient was introduced in a 20 nm thick magnetic layer, expecting that static strain from the gradient can enhance the asymmetry.

The measurement setup is shown in Fig. 1. We fabricated inter digital transducers (IDTs) on a piezoelectric $LiNbO_3$(LN) substrate for SAW excitation and detection, and a magnetic film of LN/$[Co/Ni]_4$((4/1)(3/2)(2/3)(1/4) nm)/MgO(2 nm) between the IDTs. When an AC voltage is applied to the IDTs using a vector network analyzer, SAWs are excited due to the inverse piezoelectric effect. The SAWs excite spin waves in the magnetic layer and lose energy in it. The SAWs that pass through the magnetic layer are then detected electrically in the pair of IDTs via the piezoelectric effect. The so-called non-reciprocal characteristics were investigated by normalizing the amplitudes of S_{21} and S_{12}, which have different propagation directions. The results are shown in Fig.2, where the enhanced asymmetry compared to a Ni monolayer is successfully realized. Further details will be presented during the discussion.

[1] R. Sasaki et al. Phys Rev. B **95**, 020407(R) (2017). [2] S. Tateno et al. Phys Rev. Appl.**13**, 034074 (2020).

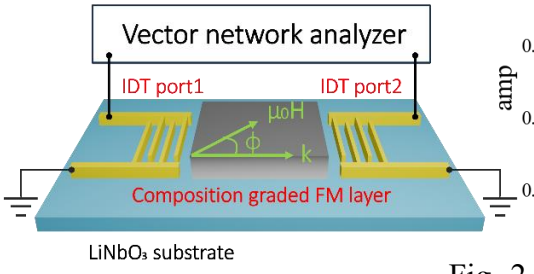

Fig. 1 Experiment setup

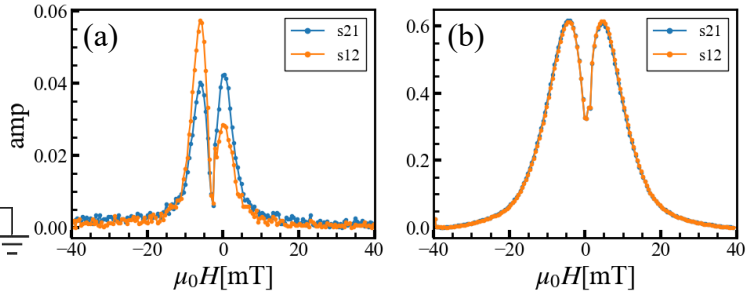

Fig. 2 Comparison of the Magnetic Field Dependence of SAW Attenuation in (a) a FM Layer with a Composition Gradient (left, ϕ =-10 °) and (b) a Ni Single Layer (right, ϕ =45 °)