Spin wave transport in different metallic and ferromagnetic YIG bilayer system

Sarker Md Shamim (M2)[1]*, Hiroyasu Yamahara[1], Hitoshi Tabta[1]
[1]*Department of Electrical Engineering and Information System, The University of Tokyo, Japan*
**E-mail: sarker@bioxide.t.u-tokyo.ac.jp*

We present the experimental observation of the effect of different metal stripe on the spin wave (SW) propagation path in one dimensional magnonic crystal of yttrium iron garnet (YIG). Propagating magnetostatic surface spin wave (MSSW) was excited and detected by metallic co-planner wave guide (CPW) and vector network analyzer (VNA). Detected SW signal shows that insertion of metallic stipe can suppress the spin wave propagation, which is different for different metal interfaces. Our experimental observation is quite different than the previous mathematical prediction [1]. Because, in their prediction they have considered the spin pumping dependent enhancement of damping constant in the magnonic layer only. However, another crucial phenomenon named as spin backflow and two magnon scattering plays significant role in the material with weaker spin orbit interactions (SOI).

90 nm-thick YIG film was grown on a (111)-oriented single crystalline $Gd_3Ga_5O_{12}$ (GGG) substrate by pulsed laser deposition (PLD) technique. From the AFM image, the surface roughness was measured as 0.6 nm RMS. Subsequently, a system of two co-planner waveguide (CPW) made of 90 nm thick Au was integrated into the YIG film using EB Lithography. The widths *W* of the signal and the ground lines and their separation were selected as 10 μm. The separation between the central lines of the exciting and detecting antenna was designed 145 μm. We investigated 2 types of device here: one is single layered, and another is CPW device with different metal stripe (Au, Pt, Cr etc) shown in Figure 1(a) and 1(b), respectively.

We recorded FMR spectra for in plane external bias magnetic fields by measuring S_{11} for single layer and metallic layered devices. For references we presented the results for Au and Pt layered devices here. Plotted S11 spectra shown in Figure 1(c) shows a shift in resonance frequency, which can be attributed to the susceptibility of the corresponding metallic layer. Figure 1(d) represents the transmission spectra of the single layered, Pt layered and Au layered devices. Here, our observation shows a significant difference in the transmission spectra both in terms of the signal amplitudes and the transmission modes. According to the previous prediction, Pt layered device should have higher suppression of the transmitted signal than Au layered device due to stronger spin pumping. Here the suppression summery shown in Figure 1(e) shows the opposite scenario. In terms of spin pumping indicated by the ESR response shown in Figure 1(f), this scenario cannot be explained. To explain this scenario, we have introduced the spin backflow and two magnon scattering. The metallic layers are often used as the control electrodes in SW devices. These electrodes are often placed in the SW propagation path. Therefore, it is crucial to select the layer elements that do not impact the SW propagation significantly. Based on our study, Pt is a better candidate for an electrode than Au.

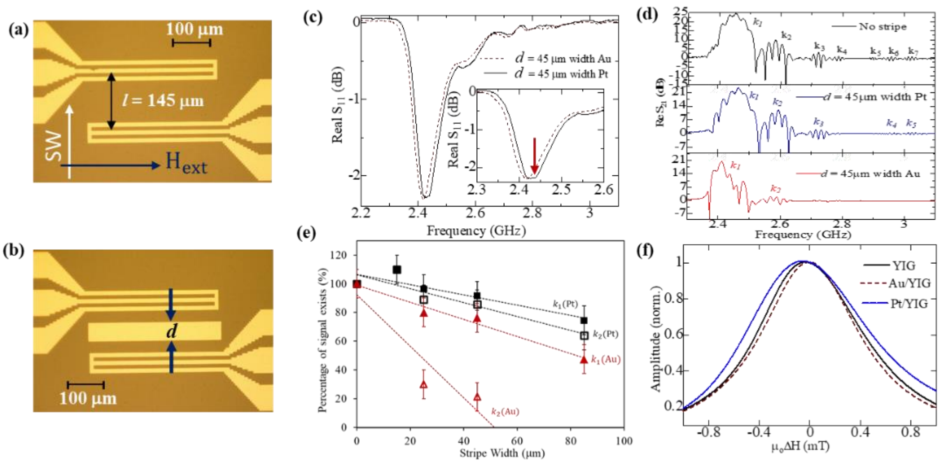

Figure.1 SW device (a) single layered and (b) metallic layered (c) Shift of S_{11} peak for different bilayers (d) S_{21} spectra of single, Pt and Au layered devices (e) Summery of the signal suppression (f) ESR measurement

1. Y. Tserkovnyk et al., Phys. Rev. Lett., Vol. 88, No. 11 (2002)