Magnetic properties of V/Fe/Bi/MgO multilayer characterized by spin-wave spectroscopy

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Voltage control of interfacial magnetism such as magnetic anisotropy as well as Dzyaloshinskii-Moriya interaction[1] can be employed for operational technology of magnetic random access memory. Since Bi has large spin-orbit interaction, we would like to employ Bi to enhance the voltage controlled magnetic anisotropy in Fe/MgO-based devices. We have previously reported that ultrathin Bi can be epitaxially grown on bcc-Fe (001) [2]. In this study, we report magnetic properties of the epitaxial V/Fe/Bi/MgO multilayer by spin-wave spectroscopy.

A MgO (001) substrate/MgO(5 nm)/V(20 nm)/Fe(20 nm)/Bi(t_{Bi}=0, 0.15, 0.30 nm)/MgO (5 nm) single-crystal multilayer was fabricated by molecular beam epitaxy (MBE). The MgO(5 nm) and V(20 nm) layers were deposited at 150 °C, and other layers were deposited at room temperature. The V layer was post-annealed at 500 °C for 30 minutes. After that, SiO_2 (50 nm) was deposited by sputtering. The multilayer was patterned into a rectangle shape (100 μm×400 μm), and micro-sized antennas were prepared on it. We measured *S* parameter by using vector network analyzer to characterize propagating spin-wave. External magnetic field direction is normal to the spin-wave propagating direction to excite the magneto-static surface spin waves (MSSW). Figure 1(a) is a typical $|S_{11}|$ spectra with t_{Bi} = 0.3 nm. Each spectrum was subtracted by the background spectra with the magnetic field of 270 mT. Resonant frequencies of the MSSW are defined as frequencies of $|S_{11}|$ peaks. From the conventional analytic formula to characterize the MSSW, interfacial magnetic anisotropy field can be estimated. We found that perpendicular magnetic anisotropy field increased when we increase Bi thickness at Fe/MgO interface as shown in Fig.1(b). In the presentation, post-annealing temperature dependence of Fe, characteristics of propagating spin-waves (S_{21} and S_{12}) and its voltage control will be discussed.

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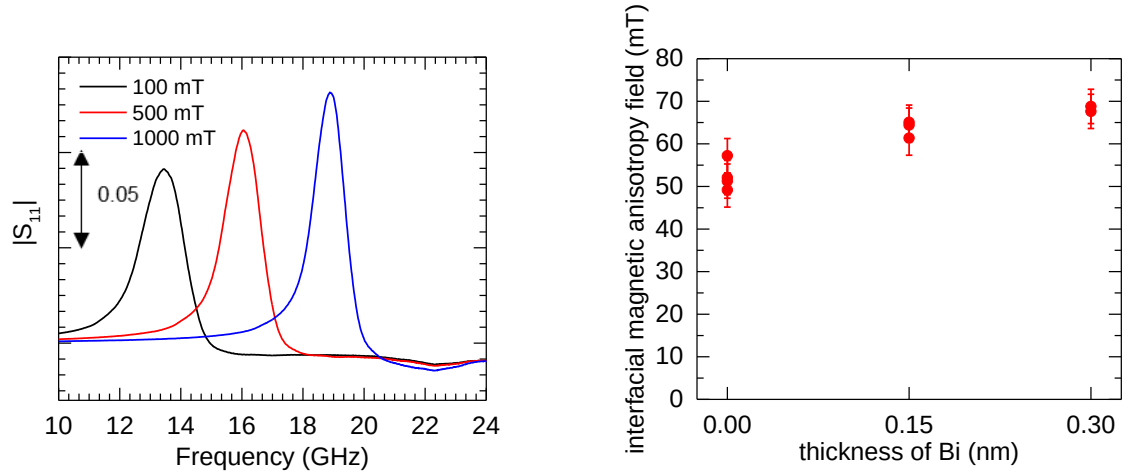

Fig. 1. (a) Typical spin-wave spectra and (b) Bi thickness dependence of interfacial magnetic anisotropy field

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