# Annealing effect on magnetic anisotropy and its voltage modulation of FeIr/MgO

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To establishing an efficient electrical control of magnetization for magnetic memory devices, it is important to obtain both a perpendicular magnetic anisotropy (PMA) and voltage-controlled magnetic anisotropy (VCMA). It has recently been reported that employing Ir, which has a large spin-orbit interaction, in Fe/MgO system enhances the PMA and VCMA [1]. In this study, we evaluated the PMA and the VCMA of Fe/Ir/MgO multilayers after annealing at various temperatures to reveal the influence of Ir insertion on the magnetic properties.

An epitaxial single crystalline multilayer of MgO (001)substrate|MgO (5 nm)|V (30 nm)|Fe (20 nm)|Ir (0-0.8 nm)|MgO (5 nm) was fabricated by molecular beam epitaxy method (Fig. 1). $SiO_2$ (50 nm) was then deposited by sputtering and 2 micro-size antennas, selectively excite wavenumber of 1.2 $\mu m^{-1}$, were prepared by microfabrication. The PMA and VCMA of this multilayer were evaluated by measuring the propagating spin-wave frequency and the frequency shift caused by voltage application. Magnetostatic surface spin-wave was employed, and was evaluated by analyzing the *S*-parameter. Figure 2 is the Ir thickness dependence of the frequency shift of the spin-wave when DC voltage of -4V (= $-3.1\times10^{-2}$ V/nm in MgO) is applied. $\Delta f_{21}$ is the voltage-induced frequency shift in $S_{21}$ (antenna1→2) and $\delta f_{12}$ is that of $S_{12}$ (antenna2→1). As the Ir thickness increases, the frequency shift monotonically decreases and vanishes at about 1 monatomic layer (~0.2 nm). In the presentation, the PMA and VCMA after annealing at various temperatures will be discussed. This work was supported by JSPS KAKENHI (No. 26103002) and ImPACT program.

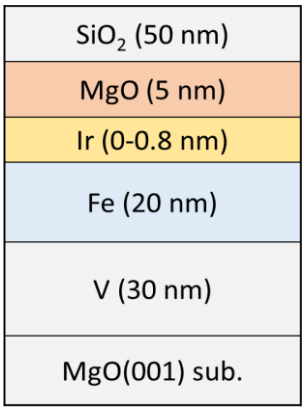


Fig. 1 Multilayer structure

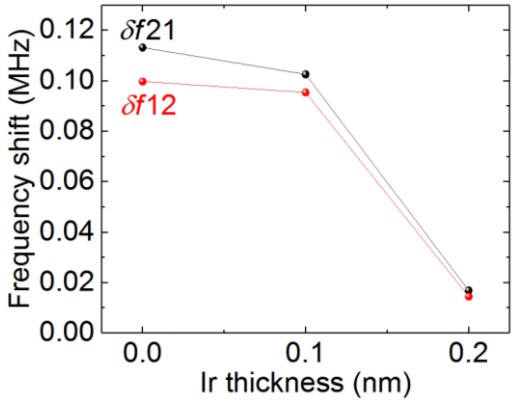


Fig. 2 Ir thickness dependence of frequency shift

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