

Pt layer thickness dependence of voltage induced *interfacial* Dzyaloshinskii-Moriya interaction change in Fe|Pt|MgO junction

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Interfacial Dzyaloshinskii-Moriya interaction (*iDMI*) is an antisymmetric exchange interaction attributed to broken inversion symmetry in surfaces and/or interfaces together with spin-orbit interaction [1]. This *iDMI* modulates magnetism drastically and is voltage controllable [2]. Previously [3], we presented the enhancement of voltage-induced *iDMI* change by the factor of three by the insertion of Pt monolayer into the Fe|MgO interface. In present research, we studied thickness dependence of the Pt layers for voltage-induced *iDMI* change and the possible mechanisms of it.

The multilayers including Fe(20 nm)|Pt(t_{Pt} =0.1-0.8 nm)|MgO(5 nm) were prepared on a V(001) underlayer. Figure 1 shows a schematic image of the spin-wave device and measurement circuit. Spin-wave spectra were measured by using vector network analyzer (VNA) through the two micro-sized antennas. External magnetic field was applied normal to the propagation direction in order to induce magnetostatic surface spin waves in Fe. By applying DC Voltage (V_{DC}), voltage modulation of spin waves was observed. From the voltage modulation of spin-wave resonant frequency shift, we estimated the voltage controlled magnetic anisotropy (VCMA) and voltage induced *iDMI* change. Figure 2 shows Pt layer thickness dependence of (a) VCMA and (b) *iDMI* change. As you can see, largest enhancements of VCMA and voltage induced *iDMI* change were observed in 0.2-nm-thickness Pt. We discuss the possible mechanisms of these enhancement in terms of spin-orbit interaction and electric dipole.

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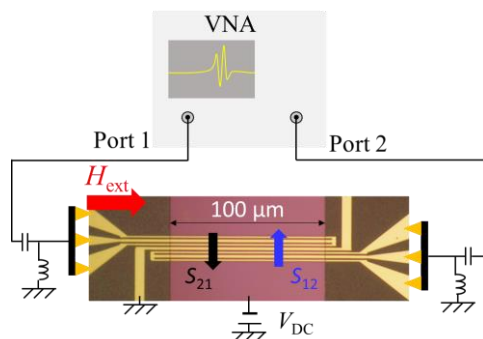


Figure 1 Measurement set up and spin-wave device

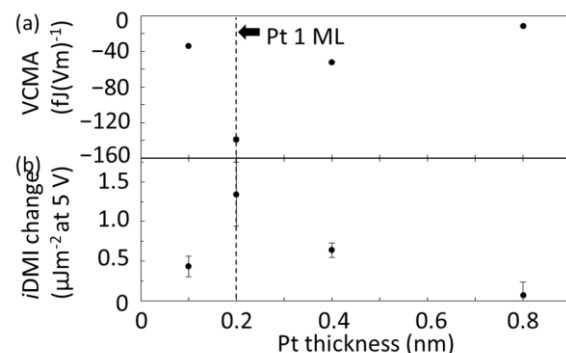


Figure 2 Pt thickness dependence of (a) VCMA and (b) voltage induced *iDMI* change at 5 V

[1] M. Bode, et al., *Nature*, **447**, 190-193 (2007).

[2] K. Nawaoka, et al., *APEX*, **8**, 063004(2015).

[3] K. Nawaoka, et al., JSAP spring meeting 22a-W241-6 (2016)