# Voltage modulation of interfacial Dzyaloshinskii-Moriya interaction on Fe|MgO

○縄岡 孝平[1]、三輪 真嗣[1]、塩田 陽一[1,2]、野崎 隆行[2]、湯浅 新治[2]、水落 憲和[1]、鈴木 義茂[1]
（1 阪大院基礎工、2 産総研ナノスピン）

**Kohei Nawaoka[1], Shinji Miwa[1], Yoichi Shiota[1,2], Takayuki Nozaki[2], Shinji Yuasa[2],**
**Norikazu Mizuochi[1], Yoshishige Suzuki[1] (1 Osaka Univ., 2 AIST)**
**E-mail: nawaoka@spin.mp.es.osaka-u.ac.jp**

Dzyaloshinskii-Moriya interaction (DMI) is an antisymmetric exchange interaction. The DMI changes magnetism drastically and is voltage controllable [1]. Up to now, this voltage modulation of DMI has been studied in multiferroic materials. Recently, interfacial DMI was reported in spin-wave research on W/Fe[2], but its voltage modulation has never been reported yet. In this research, we demonstrated the voltage modulation of interfacial DMI in spin wave devices.

Fe|MgO-based single crystalline multilayer was prepared by molecular beam epitaxy on MgO substrate. Figure 1 is the schematic image of a spin-wave device and measurement circuit. Two micro-antennae with vector network analyzer (VNA) were employed to generate and detect the spin-waves. By applying external magnetic field normal to the spin-wave propagation direction, magnetostatic surface spin-wave has been employed to characterize the voltage controlled magnetic anisotropy and interfacial DMI. Spin-wave signal was modulated by external voltage. We found that the voltage modulation was explained by the resonant frequency shift [3]. Figure 2 shows relation between their frequency shift of $S_{21}$ ($S_{12}$) and external voltage as black (blue) circles. Their slopes were estimated to be $\delta f_{21}$=0.032±0.01 and $\delta f_{12}$=0.028±0.01 (MHz/V), respectively. The frequency shift can be mainly explained by voltage controlled magnetic anisotropy, in addition, the distinct difference between the $\delta f_{21}$ and the $\delta f_{12}$ shows the voltage controlled interfacial DMI at Fe|MgO. [3] In the presentation, the effect of the Pt-atomic-layer insertion at the Fe|MgO interface will be also discussed.

This work was funded by ImPACT Program and the Grant-in-Aid for Scientific Research (S).

a

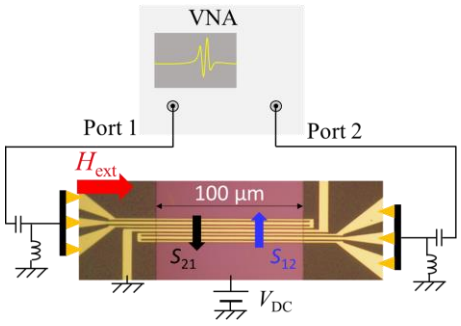


Figure 1 Measurement set up and spin-wave device

b

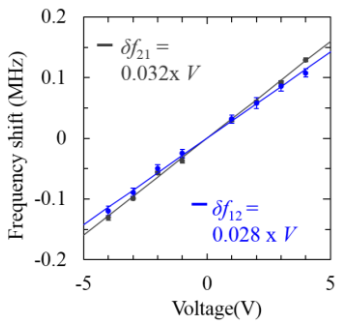


Figure 2 Voltage dependence of freq. shift

[1] H. Katsura, *et al.*, PRL. **95**, 057205 (2005).
[2] K. Zakeri, *et al.*, PRL. **104**, 137203 (2010).
[3] K. Nawaoka, et al., APEX, **8**, 063004(2015) .