Investigation of the inverse Rashba-Edelstein effect in Bi/Ag and Ag/Bi on ferromagnetic insulator

^OM. Matsushima¹, S. Dushenko^{1,2}, R. Ohshima^{1,2}, Y. Ando¹, T. Shinjo¹, and M. Shiraishi¹ Kyoto Univ.¹, Osaka Univ.² E-mail: matsushima.masayuki.43r@st.kyoto-u.ac.jp

Bi/Ag interface is now one of the most promising platforms in spintronics, since it has a sizable Rashba effect [1]. This effect induces a spin-charge conversion called as the inverse Rashba-Edelstein effect (IREE) reported in a Bi/Ag/NiFe system [2]. However, an introduction of the NiFe prevents quantitative discussion on the IREE length and the Rashba parameter α , because of the self-induced electrometive.

parameter, α_R , because of the self-induced electromotive forces (EMFs) from the NiFe due to such as the inverse spin Hall effect (ISHE) [3]. In this study, we demonstrate spin-charge conversion in Bi/Ag and Ag/Bi systems on Y₃Fe₅O₁₂ (YIG), a ferromagnetic insulator, because they can exhibit reversed sign of α_R and allow eliminating spurious signals from the NiFe.

Bi (7 nm) and Ag (5 nm) were evaporated on a YIG $(10 \ \mu m)/Gd_3Ga_5O_{12}$ (GGG) substrate by thermal deposition (see Figs .1(a) and (b)). The spin current was injected in the Bi/Ag bilayers from the YIG by spin pumping under the ferromagnetic resonance induced by ESR (JEOL, TE₀₁₁ cavity). Charge current in the Bi/Ag and the Ag/Bi converted from pure spin current by the IREE or the ISHE was measured as the EMF. Figures 1(c) and (d) show the EMFs from the Bi/Ag/YIG and the Ag/Bi/YIG systems, respectively. Both signals are normalized by the resistance measured by an electrical four terminal method. In order to eliminate spurious effects possessing different symmetry, their subtraction was implemented by using an equation, $\{I(\theta) - I(\theta + 180^\circ)\}/2$ ($I(\theta)$): the charge current, θ : the angle of the external magnetic field). Interestingly, (1) there is no remarkable difference between the subtracted signals obtained from the Bi/Ag and the Ag/Bi samples despite of the expected sign reversal of the $\alpha_{\rm R}$, and (2) the magnitude of the EMF is greater than that from Bi (7 nm)/YIG, i.e., enhancement of the EMF takes place. A model calculation teaches us that the sign of the EMF in the Ag/Bi and in the Bi/Ag can be reversed even when the EMF of the ISHE in the Bi is. These results provide materials for further discussion on the IREE and the ISHE in Bi-based system.

- 1. C. R. Ast et al. Phys. Rev. Lett. 98, 186807 (2007).
- 2. J.C. Rojas-Sánchez *et. al.*, Nature Comm. **4**, 2944 (2013).
- 3. A. Tsukahara, M. Shiraishi *et. al.*, Phys .Rev. B **89**, 235317 (2014).



Fig.1 Schematic illustrations of (a) the Bi/Ag/YIG and (b) the Ag/Bi/YIG systems, and electromotive forces under the resonance field in (c) the Bi/Ag/YIG and (d) the Ag/Bi/YIG systems.