Thickness Dependence of Current-Induced Effective Magnetic Field
in La$_{0.67}$Sr$_{0.33}$MnO$_3$/SrTiO$_3$ heterostructure

1School of Eng.-, and 2RIES-Hokkaido Univ.

Tatsuro Oyamada$^{1,2}$, Takayoshi Katase$^2$, Hiromichi Ohta$^2$, and Michihiko Yamanouchi$^2$

*E-mail: t-oyamada@eis.hokudai.ac.jp

Last year, we have reported that effective magnetic field $H_{\text{eff}}$ can be induced by the application of in-plane current in an oxide half-metal heterostructure, La$_{0.67}$Sr$_{0.33}$MnO$_3$/SrTiO$_3$ [1]. In this study, we measured La$_{0.67}$Sr$_{0.33}$MnO$_3$ (LSMO) thickness dependence of $H_{\text{eff}}$ to clarify the origin of the $H_{\text{eff}}$ on LSMO.

PLD-grown LSMO films (13, 18 and 25 u.c.) on TiO$_2$-terminated SrTiO$_3$ (001) substrates were processed into devices with Hall bar electrode geometry having a $w = 10$-µm wide channel along [100]. Transverse resistance $R_{xy}$ was measured under application of rotating external magnetic field $H_{\text{ext}}$ in the plane. The in-plane angle $\phi$-dependence of $R_{xy}$ in the presence of a static $H_{\text{ext}}$ indicates that all the LSMO films have an in-plane biaxial magnetic anisotropy with the easy axes almost along $<110>$ (the hard axes almost along $<100>$). After aligning magnetization direction by $\mu_0H_{\text{ext}} = 0.5$ T along $[110]$ at device temperature $T_d = 130$ K, we measured $R_{xy}$ under various currents while rotating $H_{\text{ext}}$ around one of hard axes $[100]$ in the counterclockwise direction. The magnitude of $H_{\text{ext}}$ was seted larger than the magnetic anisotropy field to prevent domain nucleation. $T_d$ was determined by using longitudinal resistance to correct Joule heating. Switching of magnetization direction under positive current occurs at larger $\phi$ compared with that under negative current, where positive (negative) current is directed along $[100]$ ($[100]$). This behaviour is consistent with previous results: $H_{\text{eff}}$ along $[010]$ ($[010]$) is induced by positive (negative) current [1]. We evaluated $H_{\text{eff}}$ from the difference of switching angle [2]. Although thinner LSMO film exhibited large $H_{\text{eff}}$ at lower current (Figure), it was scaled with the effective current density, $I/wt_{\text{dead}}$, where $t_{\text{eff}} =$ total LSMO thickness – dead layer thickness (6 u.c.) [3], suggesting that the $H_{\text{eff}}$ can be induced in LSMO bulk reaction.

This work was supported by JSPS KAKENHI for Young Scientists A (15H05517) and Grant-in-Aid for Scientific Research on Innovative Areas (25106007) from the Japan Society for the Promotion of Science.

References

![Figure: $I$-dependence of $H_{\text{eff}}$](image)

- $T_d = 130$ K
- 13 u.c.
- 18 u.c.
- 25 u.c.

© 2017 応用物理学会