Thickness Dependence of Current-Induced Effective Magnetic Field in $La_{0.67}Sr_{0.33}MnO_3/SrTiO_3$ heterostructure

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Last year, we have reported that effective magnetic field H_{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_{eff} to clarify the origin of the H_{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 resisitance R_{yx} was measured under application of rotating external magnetic field H_{ext} in the plane. The in-plane angle φ-dependence of R_{yx} in the presense of a static H_{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 $\mu_0 H_{ext}$ = 0.5 T along $[\bar{1}10]$ at device temperture T_d = 130 K, we measured R_{yx} under various currents while rotating H_{ext} around one of hard axes $[\bar{1}00]$ in the counterclockwise direction. The magnitude of H_{ext} was seted larger than the magnetic anisotorpy field to prevent domain nucleation. T_d was determined by using longitudinal resitance to correct Joule heating. Switching of magnetization direction under positive current occurs at largerφ compared with that under negative current, where positive (negative) current is directed along [100] ($[\bar{1}00]$). This behaviour is consistent with previous results: H_{eff} along [010] ($[0\bar{1}0]$) is induced by positive (negative) current [1]. We evalutaed H_{eff} from the difference of switching angle [2]. Although thinner LSMO film exhibited large H_{eff} at lower current (Figure) , it was scaled with the effective current density, I/wt_{eff}, where t_{eff} = total LSMO thickness – dead layer thickness (6 u.c.) [3], suggesting that the H_{eff} can be induced in LSMO bulk reagion.

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References

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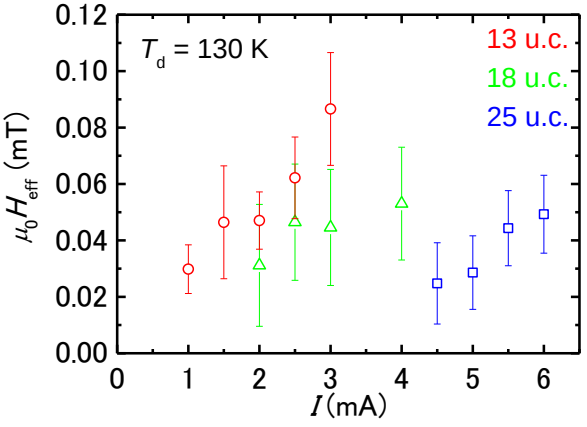

Figure: I-depnedence of H_{eff}