

Thickness dependence of current-induced effective magnetic field acting on domain wall in SrRuO₃

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Spintronics devices using current-induced domain wall (DW) motion have been attracting much attention for next-generation memory and logic. Topological Hall torque (THT) is a candidate of the driving mechanism because it can reduce the current density required to drive DW [1]. The THT originates from the Weyl points, and current-induced effective magnetic field H_{eff} acting on a DW is explained well by the THT in ferromagnetic oxide SrRuO₃ (SRO) [2]. However, the relationship between the Weyl points and THT remains to be experimentally elucidated. A previous study shows thick SRO films exhibit positive magnetoresistance (MR) reflecting existence of the Weyl points, whereas MR turns to negative with decreasing SRO thickness [3]. In this work, we investigated H_{eff} and MR in SRO with various thicknesses to clarify it.

15, 22, and 30-nm thick SRO films were grown on miscut ($\sim 2^\circ$) SrTiO₃ (001) substrates by using pulsed laser deposition. The films were patterned into Hall bar devices with 200-nm wide channels and a pair of Hall probes. A 200-nm wide Au/Cr line (Oersted line), which is orthogonal to the SRO channel direction, was defined on the channel. After preparing a DW in the channel by applying a current pulse to the Oersted line, we measured modulation of the propagation field H_p of the DW by H_{eff} under various current densities J_s (-3.2×10^9 A/m² - 3.2×10^9 A/m²) and at various temperatures (115 K - 135 K). The H_p decreased almost linearly with increasing J_s at each temperature, from which we determined generation efficiency η_J of H_{eff} per J . The device having the thicker SRO film shows the larger η_J at a given temperature, and η_J had the maximum at 125 K with respect to temperature for all the devices. Similar temperature dependence of η_J is observed in SRO, and it is described well by a model based on the THT [2]. We also measured MR under a perpendicular magnetic field of up to 7 T at 1.8 K for the Hall bar devices in the same wafers. Although all the devices show negative MR, magnitude of MR decreases with increasing thickness of SRO, which is consistent with the previously reported thickness dependence of MR reflecting contribution of the Weyl points in SRO [4]. These results suggest the thickness dependence of H_{eff} is related to blurring of the contribution from Weyl point in the thinner SRO film.

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References

- [1] Y. Araki, *et al.*, Phys. Rev. Lett. **127**, 277205 (2021).
- [2] M. Yamanouchi, *et al.*, Sci. Adv. **8**, eabl6192 (2022).
- [3] S Kaneta-Takada, *et al.*, Appl. Phys. Lett. **118**, 092408 (2021).
- [4] K. Takiguchi, *et al.*, Nat. Commun., **11**,4969 (2020).