Off-stoichiometry effects on the structural and transport properties of epitaxial $SrRu_xO_3$ (x = 0.7 and 1) thin films

Yuki K. Wakabayashi,[1,*] Shingo Kaneta-Takada,[1,2], Yoshiharu Krockenberger,[1]
Shinobu Ohya,[2,3] Masaaki Tanaka,[2,4] Yoshitaka Taniyasu,[1] and Hideki Yamamoto[1]
[1]NTT Basic Research Laboratories, [2]Department of Electrical Engineering and Information System, University of Tokyo, [3]Institute of Engineering Innovation, The University of Tokyo, [4]Center for Spintronics Research Network (CSRN), The University of Tokyo
[*]E-mail: yuuki.wakabayashi.we@hco.ntt.co.jp

The itinerant 4*d* ferromagnetic perovskite $SrRuO_3$ has been widely used in oxide electronics and spintronics as an epitaxial conducting layer [1]. Recently, renewed interest on $SrRuO_3$ emerged after the discovery of Weyl fermions in $SrRuO_3$ [2-4]. The quantum transport of the Weyl fermions can be detected only for samples having a high residual resistivity ratio (RRR) [3.4]. In general, it is possible that the Ru stoichiometry may play a role in realizing the magnetic Weyl states [1]. However, there is no unified understanding on the difference in magnetic and transport properties between $SrRuO_3$ films grown under stoichiometric and off-stoichiometric conditions.

In this presentation, we report the thickness (t)-dependent magnetotransport properties of epitaxial $SrRu_xO_3$ (x = 0.7 and 1) films grown on $SrTiO_3$ substrates by molecular beam epitaxy [5]. For the films with x = 0.7, the Ru deficiency was intentionally introduced by varying the supplied Ru/Sr flux ratio. Notably, the crystalline quality for such off-stoichiometry films is comparable for x = 0.7 and 1, and structural characterizations using diffraction or microscopy techniques can hardly distinguish any differences [5]. The residual resistivity ρ_{Res} of the $SrRu_{0.7}O_3$ film is much higher than that of $SrRuO_3$ at each t [Fig. 1(a)], indicating that the Ru vacancies serve as carrier scattering centers. For $t \leq 20$ nm, ρ_{Res} increases with decreasing t irrespective of x, implying that another scattering mechanism due to interface-driven disorders exists. Despite the large off-stoichiometry, $SrRu_{0.7}O_3$ ($t \geq 10$ nm) shows a Curie temperature (T_C) of ~ 140 K, which is only ~10 K lower than that in $SrRuO_3$ [Fig. 1(b)]. For $t < 10$ nm, T_C abruptly decreases with decreasing t. We conclude that the interface-driven disorder has a detrimental influence on the magnetic exchange interaction. In addition, the Weyl transport is not observed in the off-stoichiometric $SrRu_{0.7}O_3$ films. Therefore, proper stoichiometry control is vitally important to utilize the full potential of $SrRuO_3$ as a magnetic Weyl semimetal [5].

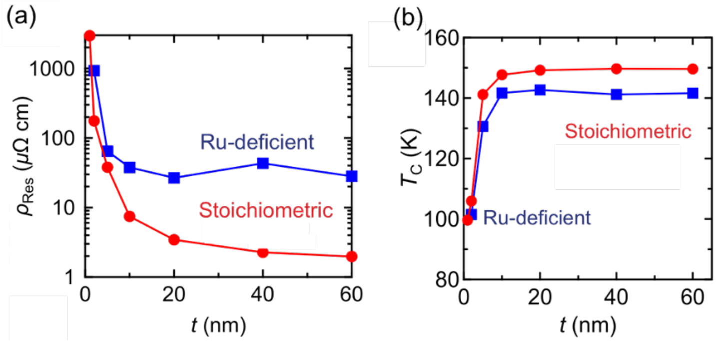

Figure 1 (a) Thickness t dependence of the residual resistivity ρ_{Res} of the stoichiometric ($SrRuO_3$) and Ru-deficient $SrRu_{0.7}O_3$ films. (b) Thickness t dependence of the T_C.

References [1] G. Koster *et al.,* Rev. Mod. Phys. **84**, 253 (2012). [2] Y. K. Wakabayashi, *et al*., APL Mater. **7**, 101114 (2019). [3] K. Takiguchi, Y. K. Wakabayashi, *et al*., Nat. Commun. **11**, 4969 (2020). [4] S. Kaneta-Takada, Y. K. Wakabayashi, *et al*., Appl. Phys. Lett. **118**, 092408 (2021). [5] Y. K. Wakabayashi, *et al*., AIP Advances **11**, 035226 (2021).