Anomalous Hall effect in $Co_3Sn_2S_2$ thin films fabricated by co-sputtering

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The magnetic Weyl semimetal (MWS) is a new class of topological materials, characterized by a pair of Weyl nodes with opposite spin chirality [1]. Recent studies have shown that a shandite-type compound, $Co_3Sn_2S_2$, which was known as a half-metal previously, is a promising candidate for MWS [2,3]. As illustrated in Fig. 1, the crystal structure has Co kagome lattices in *a*-*b* plane, forming linearly dispersed spin-split bands near the Fermi level [2]. In the bulk single crystals, anomalous Hall effect arises below the Curie temperature T_C ~ 175 K with a very large tangent of Hall angle σ_{xy}/σ_{xx} of 0.2 (the ratio of Hall conductance σ_{xy} to longitudinal conductance σ_{xx}) [2,3]. To explore exotic transport phenomena and device functions in MWSs, the preparation of high-quality $Co_3Sn_2S_2$ thin films is essential. In this study, we successfully fabricated *c*-axis oriented $Co_3Sn_2S_2$ films by co-sputtering and observed the anomalous Hall effect [4].

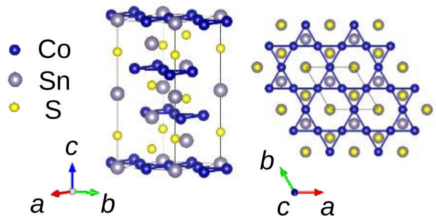

Fig. 1. Crystal structure of $Co_3Sn_2S_2$.

$Co_3Sn_2S_2$ thin films were grown on Al_2O_3 (0001) substrates using SnS_x targets with Co metal chips attached. To adjust the sulfur content in the films, SnS_x targets (SnS and SnS_2 mixed phase) with different levels of x (x = 1.0, 1.35, 1.5, and 2.0) were used. The detailed growth conditions were reported elsewhere [4]. The composition and structure of films were characterized by energy dispersive X-ray spectroscopy and X-ray diffraction, respectively.

The film-target composition relationships were $Co_3Sn_{2.00}S_{1.54}$ for SnS, $Co_3Sn_{2.02}S_{1.97}$ for $SnS_{1.35}$, $Co_3Sn_{2.03}S_{2.22}$ for $SnS_{1.5}$, and $Co_3Sn_{1.89}S_{3.25}$ for SnS_2. While all the films showed $Co_3Sn_2Sn_2$ (000*n*) diffraction peaks, the nearly stoichiometric films ($Co_3Sn_{2.02}S_{1.97}$ and $Co_3Sn_{2.03}S_{2.22}$) exhibited large diffraction intensities with suppression of impurity phases. Figure 2 (a) and (b) show temperature dependences of longitudinal resistivity ρ_{xx} at zero field and Hall resistivity ρ_{yx} under a perpendicular magnetic field μ_0H of 1 T, respectively. In the nearly stoichiometric films, a ρ_{xx} kink around 180 K corresponding to T_C and a large ρ_{yx} of about 50 μΩcm are observed. As shown in Fig. 2(c), the σ_{xy}/σ_{xx} reaches 0.24 at 125 K, which is comparable or even larger than the bulk values reported [2,3]. In this talk, the composition dependence of magnetization and the doping effect will also be presented.

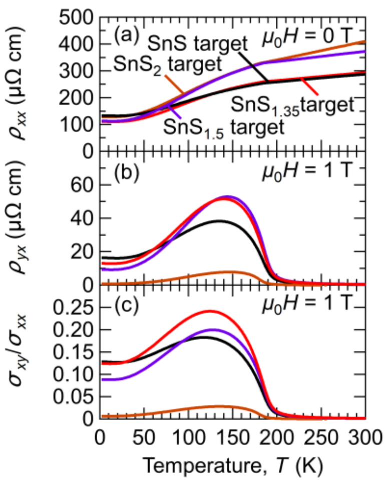

Fig. 2. (a) ρ_{xx}, (b) ρ_{yx}, and (c) tangent of Hall angle σ_{xy}/σ_{xx} of Co-Sn-S films fabricated with SnS_x targets.

References [1] B. Yan and C. Felser, *Annu. Rev. Condens. Matter Phys.* **8**, 337 (2017). [2] E. Liu *et al*., *Nat. Phys.* **14**, 1125 (2018). [3] Q. Wang *et al*., *Nat. Commun.* **9**, 3681 (2018). [4] K. Fujiwara *et al*., *Jpn. J. Appl. Phys.* **58**, 050912 (2019).