Anomalous Hall effect in thin films of altermagnet α-MnTe grown by MBE

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α-MnTe (NiAs structure) has been known as an antiferromagnetic material with zero net magnetization. However, it has recently been suggested that the magnetism of α-MnTe should be classified as altermagnetism due to the breaking of the inversion symmetry with respect to the positions non-magnetic Te atoms in the NiAs structure[1]. The peculiar properties of α-MnTe as an altermagnet have been experimentally demonstrated by the emergence of a finite spin splitting[2] and the anomalous Hall effect[3], even with zero net magnetization. In this study, we performed Hall measurement on α-MnTe thin films in order to clarify the origin of anomalous Hall effect. We successfully grew α-MnTe thin films by MBE by optimizing the growth conditions such as the Mn and Te fluxes ratio and substrate temperature.

MnTe films were grown using MBE by supplying Mn and Te flux onto InP substrates. The substrate temperature T_S was varied in the range of 260 ~ 400°C, and the Mn and Te flux ratio was varied in the range of Te/Mn = 2 ~ 10. The crystal structure was examined by X-ray diffraction (XRD). The electric transport properties were characterized using Physical Property Measurement System (PPMS).

Figure 1 shows the XRD θ-2θ scan of the α-MnTe films grown with different Te/Mn flux ratios at a fixed substrate temperature T_S = 400°C. As shown in the figure, the mixed phases of γ-MnTe, α-MnTe and $MnTe_2$ were formed at a low flux ratio of Te/Mn = 2 while only α-MnTe was formed at higher flux ratios of Te/Mn = 8-10. We performed the Hall measurement on the film of pure α-MnTe phase grown with the flux ratio Te/Mn = 10. Figure 2 shows the results of Hall measurements at 2K and 300K with the application of magnetic field perpendicular to the film plane. As shown in the figure, the Hall resistivity was almost linear with the applied magnetic field, but hysteretic behavior, which is considered to originate from the spontaneous anomalous Hall effect, was observed only at 2K. The emergence of the anomalous Hall effect is similar to the previous report[3], but the shape of the hysteretic curve looks different. The origin of the observed hysteretic curve will be discussed at the presentation.

[1] L. Šmejkal *et al.*, Phys. Rev. X **12**, 031042 (2022). [2] J. Krempaský *et al.*, Nature **626**, 517 (2024).
[3] R. D. Gonzalez Betancourt, *et al*. Phys. Rev. Lett. **130**,036702 (2023).

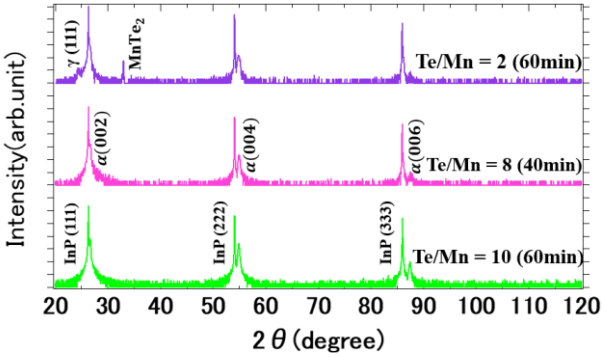

Fig. 1 XRD patterns of the MnTe films grown with flux ratios Te/Mn = 2-10 at T_S = 400°C

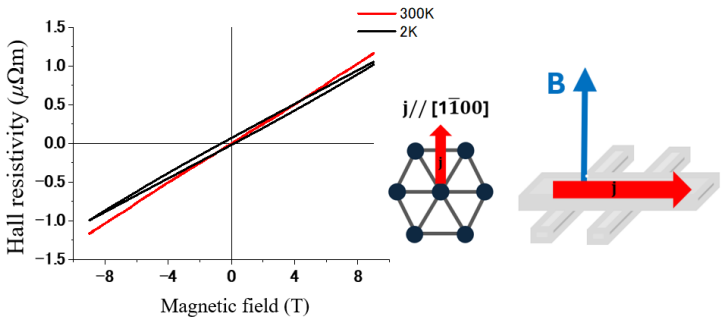

Fig. 2 Hall measurement of α-MnTe on InP(111) at 2K and 300K