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Magnetic and Transport Properties of Thin Films of MnTe Altermagnet Candidate

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In recent years, magnetic materials called alternating magnetic materials have been attracting attention. Alternating magnets are antiferromagnets that break time-reversal symmetry by multiple sublattices consisting of magnetic atoms and surrounding nonmagnetic atoms[1].

This magnetic material has spin splitting of the bands originating from time-reversal symmetry breaking, and various physical phenomena related to it are expected to occur [2]. In particular, the anomalous Hall effect in this magnetic material occurs despite the fact that the overall magnetization is zero, and the characteristic electronic state is considered to be the origin [3].

MnTe, the subject of this study, consists of two types of Mn sublattices, one consisting of magnetic Mn atoms and the other of nonmagnetic Te atoms, and its two spins are alternately aligned along the c-axis, thus satisfying the conditions for alternating magnetism (Fig.1).

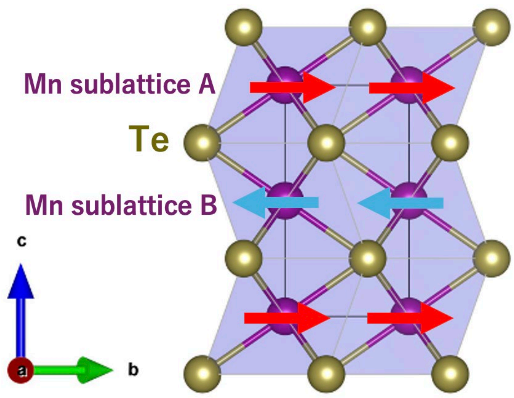

Fig.1 Crystal and magnetic structure of MnTe

The electronic state can be observed by SARPES, and it has been reported that when alternating magnets are grown as thin films on single-crystal substrates by molecular beam epitaxy (MBE), their physical properties differ depending on the substrate used, including magnetization, Hall resistance behavior, and strain [4].

MnTe thin film on SrF_2 substrate has an antiferromagnetic magnetization curve and hysteresis of Hall resistance due to anomalous Hall effect, while MnTe thin film on GaAs substrate has a weak ferromagnetic magnetization curve with small hysteresis and no hysteresis Hall resistance observed (Fig. 2).

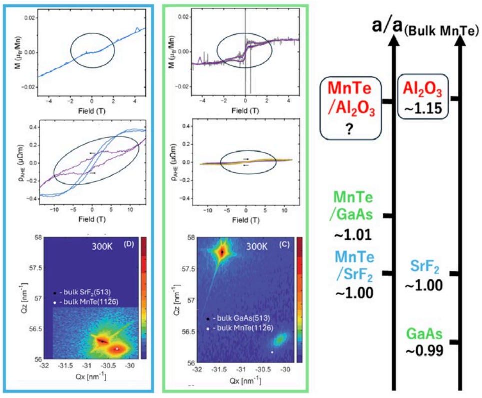

Fig2. Magnetic field dependence of magnetization and Hall resistance of MnTe thin films grown on different substrates using MBE: SrF_2 substrate (blue box), GaAs substrate (green box)[6], Ratio of the in-plane lattice constant (a) of the MnTe film and substrate on each substrate to the lattice constant (a_0) of bulk MnTe

This difference is expected to be due to the strain that the MnTe films are subjected to from the substrate, and the magnitude of the difference in lattice constant of these MnTe films from bulk MnTe, MnTe/GaAs>MnTe/SrF_2. However, the magnitude of the difference in lattice constant between the epitaxial surface of the substrate and bulk MnTe is GaAs<SrF_2, and the magnitude of strain is not simply determined by the difference in lattice constant between the substrate and MnTe (Fig.2).

Therefore, in this study, we newly set up an MBE apparatus to measure the strain applied to the thin film and its physical properties using an Al_2O_3 substrate, which has a larger difference in lattice constant from bulk MnTe than SrF_2 and GaAs, and to verify the relationship between the strain applied to the thin film and the physical properties.

As a result, the following physical property behaviors were observed in the MnTe/Al_2O_3 prepared in this study.

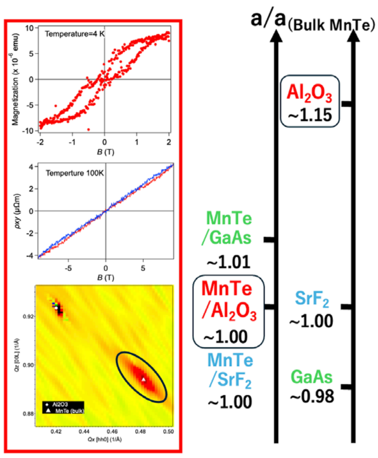

Fig.3Results of this study

There is hysteresis in the magnetization and no hysteresis in the Hall resistance (Fig. 3). This behavior is similar to that of MnTe/GaAs, but the distortion is closer to that of MnTe/SrF_2 (Fig. 3).

This suggests that the difference in physical properties is not due solely to substrate distortion.

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