六方晶 $TbFeO_3$ 薄膜のスピン・電荷における反フェロ―フェロ相転移

Antiferroic-to-ferroic phase transitions in spin and charge of hexagonal $TbFeO_3$ film

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[Introduction] Rare-earth iron oxides (RFeO$_3$) are known as multiferroic materials. In contrast to the most stable orthorhombic (o-) perovskite structure, showing the ferroelectricity only below a few K, metastable hexagonal (h-) RFeO$_3$ shows spontaneous ferroelectric polarization even at room temperature [1]. The ferroelectric and magnetic properties of h-RFeO$_3$ highly depend on the ionic radius of R^{3+}. Ferroelectric properties of h-RFeO$_3$ with R^{3+} = Dy^{3+}–Lu^{3+} have been studied thus far. In this study, we studied multiferroic properties of h-TbFeO$_3$ film, in order to clarify the effect of smaller R^{3+} than that of Dy^{3+}–Lu^{3+}.

[Experiment] h-TbFeO$_3$ films were fabricated on epitaxial ITO-buffered (111) YSZ single crystal substrates by PLD method. Out-of-plane magnetization was measured by superconducting quantum interference device (SQUID) magnetometer. Permittivity was measured by LCR meter. Ferroelectric properties were analyzed by the ferroelectric tester.

[Results and discussion] Figure (a) shows polarization versus electric field (P−E) curves of the h-TbFeO$_3$ film. It exhibited antiferroelectricity at 200 K and ferroelectricity at 175 K. Such antiferroelectric behavior was also observed in h-DyFeO$_3$ film. Thus, a use of small R^{3+} ions is effective to obtain antiferroelectric phase in h-RFeO$_3$ system. Figure (b) shows the magnetization versus temperature (M−T) curve. It has positive and negative peaks at 30 and 10 K, respectively, indicating that temperature-induced phase transition occurs associated with the spin reorientation [1]. The inset of Fig. (b) shows M of the film as a function of magnetic field (H). At 10 K, double hysteresis loop was observed, indicating that antiferromagnetic to ferromagnetic transition is also realized by applying different H.

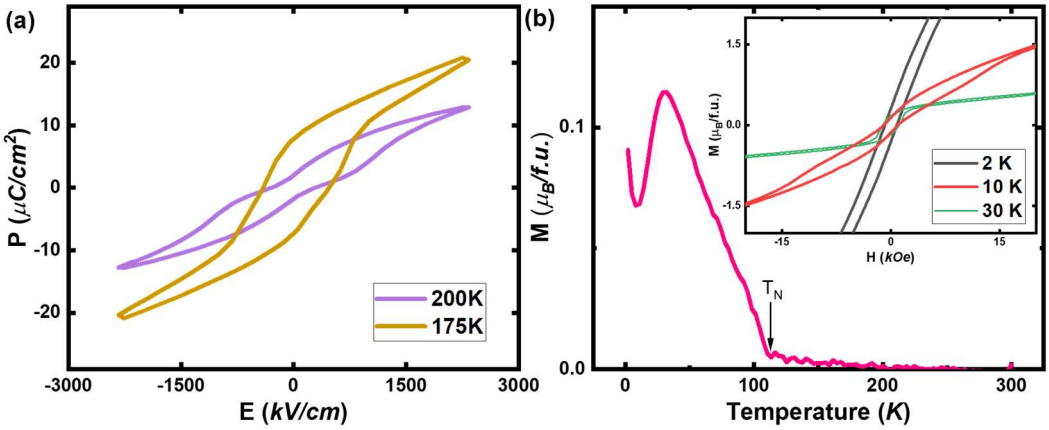

Figure (a) Polarization versus electric field curves of the h-TbFeO$_3$ film at 175 and 200 K. (b) The magnetization versus temperature curve. The inset shows magnetization versus magnetic field curves.

<Reference> [1] M. Li *et al., Phys. Chem. Chem. Phys.*, 22, 14415 (2020).