Magnetic phase transition induced modulation of ferroelectric properties in hexagonal $RFeO_3$ (R = Tb, Ho) system

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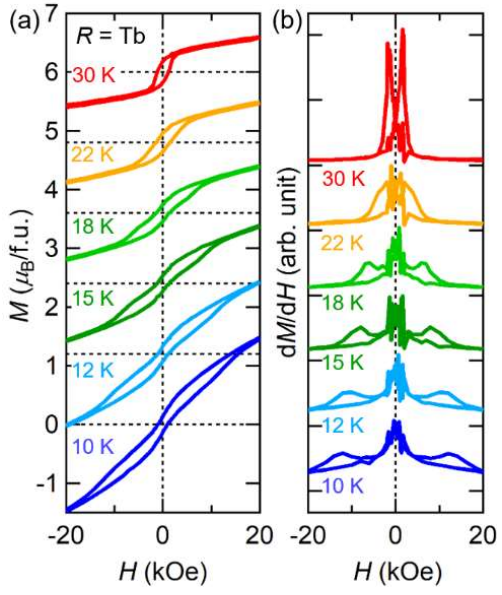
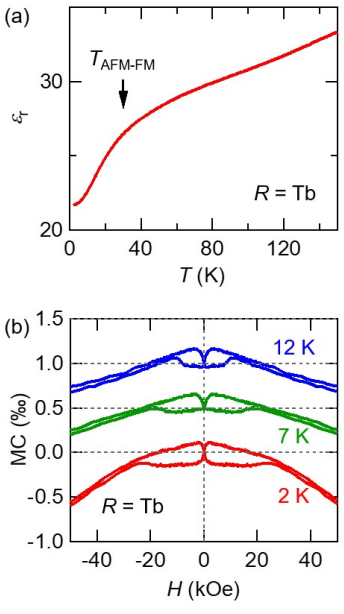
[Introduction] Hexagonal rare-earth iron oxides (h-RFeO$_3$) are promising multiferroic materials owing to the high ferroelectric transition temperature and spontaneous magnetization. Since both the ferroelectric and magnetic properties of h-RFeO$_3$ depend on the tilting of the FeO$_5$ bipyramids, fascinating features provided by magnetoelectric coupling are expected. In this study, we prepared h-TbFeO$_3$ and h-HoFeO$_3$ films which undergo transition between antiferromagnetic (AFM) and ferromagnetic (FM) phases by applying temperature and/or magnetic field. Interestingly, when magnetic phase transition occurs, their ferroelectric properties are modulated, indicating the strong magnetoelectric coupling of the films.

[Experiment] The h-TbFeO$_3$ and h-HoFeO$_3$ films were fabricated on epitaxial ITO-buffered (111) YSZ single crystal substrates. Out-of-plane magnetization was measured by SQUID magnetometer. Ferroelectric and dielectric properties were evaluated using ferroelectric tester and LCR meter, respectively.

[Results and discussion] Figures 1(a) and 1(b) show magnetization versus magnetic field (M–H) curves and their differential (dM/dH–H) curves for the h-TbFeO$_3$ film as a function of temperature (T), respectively. FM–AFM phase transition were observed by inducing T and/or H. The required H values for the FM–AFM phase transition increased with decreasing T. Figure 2(a) illustrates T dependence of permittivity (ε_r) for the h-TbFeO$_3$ film. There is a kink in the curve at 30K, which corresponds to the FM–AFM phase transition temperature. Figure 2(b) displays H dependence of the magneto-capacitance (MC: $\varepsilon_r(H)/\varepsilon_r(0\ \mathrm{kOe}) - 1$) values as a function of T. The MC–H curves show the hysteresis behavior. The H values at which the hysteresis changes in the MC–H curves are equal to the H value at which the FM–AFM phase transition occurs, indicating the magnetoelectric coupling in the film. In addition, the h-TbFeO$_3$ and h-HoFeO$_3$ films exhibit ferroelectric behavior. The ferroelectric properties are also affected by the FM–AFM phase transition. The detailed results will be discussed in the meeting.



← **Figure 1.** (a) M–H curves and (b) dM/dH–H curves for the h-TbFeO$_3$ film as a function of T.



→ **Figure 2.** (a) ε_r–T and (b) MC–H curves for the h-TbFeO$_3$ film.