Magnetic Phase Transition and Electric Polarization Flop of $TmMn_2O_5$

M. Fukunaga[1], K. Nishihata[1], H. Kimura[1], Y. Noda[1], and K. Kohn[2]
[1] *IMRAM, Tohoku University,* [2] *Waseda University*

We have performed simultaneous measurements of magnetic neutron diffraction, ferroelectric *D*–*E* hysteresis loops and the permittivity along the *a*-axis of $TmMn_2O_5$ at FONDER. $TmMn_2O_5$ is a rare-earth (R) manganese oxide of the form RMn_2O_5, which is known as multiferroic materials that exhibit coupling between ferroelectricity and magnetic ordering. It is believed that ferroelectricity of RMn_2O_5 appears only along the *b*-axis, and application of the electric field along the *a*-axis has not been performed. It was observed that neither the neutron diffraction profiles nor the phase transition temperatures depend on the applied electric field along the *a*-axis as well as the *b*-axis. But interesting results were obtained by the simultaneous measurement.

Figure 1 exhibits simultaneous measurement results of the magnetic propagation wave vector q_x, q_z, integrated intensity, and the remanent polarization along *a*- and *b*-axes of $TmMn_2O_5$ below 6 K, where a low-temperature incommensurate magnetic phase (LT-ICM1) changes into another magnetic phase (LT-ICM2). The filled symbols (with the electric field along the *a*-axis), the open symbols (*b*-axis) and q_x were measured separately. Although the dielectric properties along *a*- and *b*-axes of the same sample cannot be measured simultaneously, neutron diffraction results measured simultaneously with the dielectric properties guarantee the temperature axis of the two experiments. It was clearly obserbed that the decrease in the polarization along the *b*-axis coincides the decrease in the LT-ICM1 phase, and the increase in the polarization along the *a*-axis coincides the increase in the LT-ICM2 phase. As a result, it seems that the polarization flops from the *b*-axis to the *a*-axis. The polarization along the *a*-axis of RMn_2O_5 was observed probably for the first time. The inset shows the observed *D*–*E* hysteresis loop along the *a*-axis at 4.3 K, in which the linear permittivity component is subtracted.

The two magnetic phases exhibit almost the same magnetic propagation wave vector, but different magnetic structures cause the different dielectric properties. Magnetic structure analyses of both phases are required to discuss the difference between the two phases.

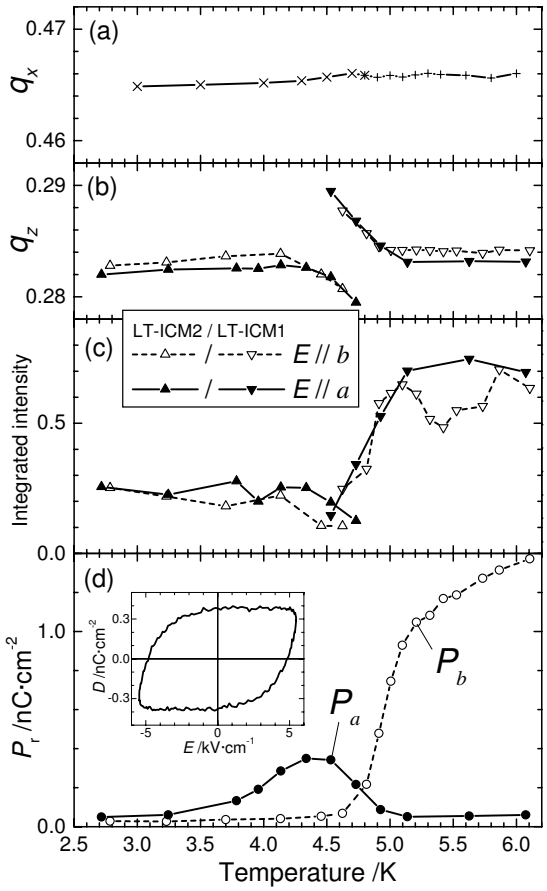

Fig. 1. Simultaneous measurement results of (a) the propagation wave vector q_x, (b) q_z,(c) integrated intensity, and (d) remanent polarization along *a*- and *b*-axes, P_a and P_b of $TmMn_2O_5$ during cooling.