# Experimental report

11/09/2019

**Proposal:** 5-41-908 **Council:** 10/2016

**Title:** Resolving the magnetic structure in the high temperature incommensurate phase of a coherently strained (010) oriented o-TbMnO3 thin films

**Research area:** Materials

**This proposal is a continuation of 5-41-856**


**Main proposer:** **Saumya MUKHERJEE**

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**Local contacts:** Bachir OULADDIAF


**Samples:** TbMnO3

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| D10 | 10 | 8 | 23/02/2017 | 03/03/2017 |


## Abstract:

We plan to determine the magnetic structure of the orthorhombic (o-) TbMnO3 thin film deposited on (010) oriented o-YAlO3 substrates in the high temperature incommensurate (HTI) phase by measuring 20-30 magnetic reflections at D10. Neutron diffraction on triple-axis spectrometer RITA-II at SINQ show an onset of HTI phase below TN ~ 41K (0, qk ~ 0.496, 1), which locks into a LTC phase below Tlock ~ 33 K (0, qk = 0.5, 1). In contrast to the bulk o-TbMnO3 [1], these films demonstrate a large polarisation (~0.4 μC cm-2) along the a-axis below TFE ~ 41 K, in the HTI phase. Concomitant onset of the ferroelectric phase and the HTI magnetic phase of the TbMnO3 makes this system highly interesting to study the magnetic structure in the HTI phase. This experiment will be a continuation to the previous experiment to study the low temperature commensurate (LTC) phase at D10. Resolving the magnetic structure in the HTI phase in these strained films unambiguously will provide unique understanding of the mechanism behind the enhancement of multiferroicity in TbMnO3. The sample to be measured is a 44 nm thin (010) oriented o-TbMnO3 film.

**Proposal: 5-41-908**

**Resolving the magnetic structure in the high temperature incommensurate phase of a coherently strained (010) oriented o-$TbMnO_3$ thin films using neutron diffraction.**

**Abstract**: We plan to determine the magnetic structure of the orthorhombic (o-) $TbMnO_3$ thin film deposited on (010) oriented o-$YAlO_3$ substrates in the high temperature incommensurate (HTI) phase by measuring 20-30 magnetic reflections at D10. Neutron diffraction on triple-axis spectrometer RITA-II at SINQ show an onset of HTI phase below $T_N$ ~ 41K (0, qk ~ 0.496, 1), which locks into a LTC phase below $T_{lock}$ ~ 33 K (0, qk = 0.5, 1). In contrast to the bulk o-$TbMnO_3$ [1], these films demonstrate a large polarisation (~0.4 μC $cm^{-2}$) along the a-axis below $T_{FE}$ ~ 41 K, in the HTI phase. Concomitant onset of the ferroelectric phase and the HTI magnetic phase of the TbMnO3 makes this system highly interesting to study the magnetic structure in the HTI phase. This experiment will be a continuation to the previous experiment to study the low temperature commensurate (LTC) phase at D10. Resolving the magnetic structure in the HTI phase in these strained films unambiguously will provide unique understanding of the mechanism behind the enhancement of multiferroicity in $TbMnO_3$. The sample to be measured is a 44 nm thin (010) oriented o-$TbMnO_3$ film.

**Results:** In this experiment we measured a set of magnetic reflections in the HTI phase. For this experiment we used the D10 diffractometer in four-circle mode with the analyser option in order to maintain a low background. We measured the magnetic Bragg peaks at T = 35 K < $T_N$. The diffraction results allowed us to determine the magnetic structure as *ab* spiral phase in this film in the HTI phase. One of the representative scan is shown in Figure 1. Few of magnetic reflections which we measured are (0 ±*q* 1), (0 ±*q* 3), (1 1±*q* 1), (1 -1±*q* 1), (0 ±*q* 3), (2 ±*q* 1). Clear understanding of the strain induced change of the magnetic properties in o-TbMnO3 helped in developing strain dependent control over the multiferroic properties. Our sample showed first-order phase transition at TN and therefore was sensitive to the cooling or warming process. At D10, we spend 0.5 days for cooling the sample to T = 10 K. Measurement of nuclear reflections of the substrate and the film to refine the low temperature lattice parameters took 1.5 days. The magnetic reflections for the 5 mm x 10 mm x 44 nm film were measured with monitor count rate of 16 minutes per point at D10, ILL and took approximately 2+2 =4 hours for each *q* and omega scan to complete.

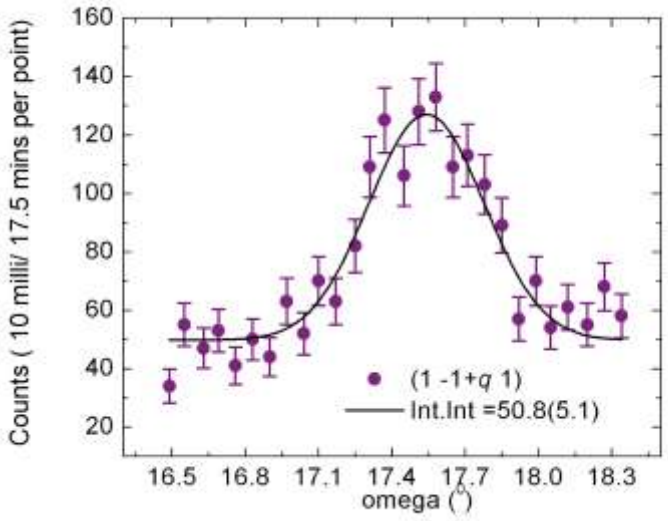


Fig. 1: Showing magnetic reflection (1 -1±*q* 1) measured at *T* ~ 35 K.