Preparation of $TmFe_2O_4$ Thin Films and Their Magnetic Properties

__(D2) YouJin Kim__[1], Shinya Konishi[1], Yuichiro Hayasaka[2], Katsuhisa Tanaka[1]

Department of Material Chemistry, Graduate School of Engineering, Kyoto University[1]

The Electron Microscopy Center, Tohoku University[2]

Multiferroic materials, which combine more than two ferroic order parameters in a single phase, have attracted great attentions recently. In particular, materials with ferro-, ferri-, or antiferromagnetic and ferroelectric properties have been actively studied. These materials are anticipated to be applied for data storage systems. RFe_2O_4 (R = Sc, Y, In, and Dy to Lu) is regarded as one kind of multiferroic materials[1]. However, studies about RFe_2O_4 except for bulk $LuFe_2O_4$ are not so many, and particularly, there exist much less reports on RFe_2O_4 thin films. It is imperative to synthesize high-quality thin films and to carry out structure and properties characterization of thin films for device applications.

In this report, we present successful preparation of epitaxially grown $TmFe_2O_4$ thin films and their magnetic properties. This is the first report on the $TmFe_2O_4$ thin film to the best of our knowledge. $TmFe_2O_4$ thin films were epitaxially grown on yttria-stabilized zirconia (111) substrates by using a pulsed laser deposition method. Figure 1 shows the out-of-plane X-ray diffraction pattern of the resultant thin film, suggesting that the thin film wa epitaxially grown with c-axis orientation. The temperature dependence of magnetization (Fig. 2(a)) is similar to that reported for bulk polycrystalline $TmFe_2O_4$, but the observed Néel temperature is somewhat lowered. The magnetization almost linearly increases with an increase in magnetic field at 300 K as illustrated in Fig.2(b), suggesting that the thin film is likely paramagnetic at room temperature. Why the non-zero magnetization is observed at 300 K (Fig.2(a)) and the magnetic field dependence of magnetization (Fig.2(b)) manifests a deviation from the linear relation even at 300 K is not clear at this moment, but may be ascribable to magnetic impurity such as iron oxide and metallic iron with higher Curie temperatures. Another possible origin is the locally enhanced magnetic interactions at the interface between different layers contained in the present thin film, the structure of which was detected by our HAADF-STEM observations

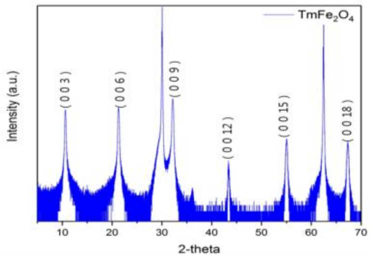

Fig 1. Out-of-plane X-ray diffraction patterns of the $TmFe_2O_4$ thin film.

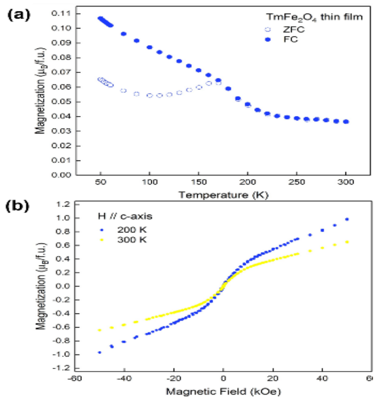

Fig.2 (a) Temperature dependence of magnetization curves for the $TmFe_2O_4$ thin film. (b) Magnetic field dependence of magnetization at 200 and 300 K

---

1 N. Ikeda *et al.*, *Nature* **436**, 1136 (2005).