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Preparation of a single-phase TaO_2 thin film

Okayama Univ.[1], ○Yuji Muraoka[1], Yuki Fujimoto[1], Takanori Wakita[1], Takayoshi Yokoya[1]

E-mail: ymuraoka@cc.okayama-u.ac.jp

Rutile-type transition metal dioxides with a d^1 configuration such as VO_2 and NbO_2 attract much attention because of their metal-insulator transition at relatively high temperature (340 and 1080 K, respectively). TaO_2 is also a rutile-type metal oxide. Since it has a d^1 configuration ($5d^1$, Ta^{4+}), one may expect it to show a meta-insulator transition as seen in VO_2 and NbO_2. So far few are reported on the physical property of TaO_2. This is mostly because TaO_2 is a metastable compound in a Ta-O binary system, and is difficult to be obtained as a single phase.

Oxidation and reduction approaches have been presented for preparation of TaO_2. In the approaches, TaO_2 can be yielded but the product usually contains other Ta oxides such as Ta_6O, Ta_2O and Ta_2O_5. Multiphase product makes it difficult for us to study the intrinsic transport property of TaO_2. A main issue for research of this compound is therefore to find a way to stabilize only TaO_2 among Ta-O metastable and stable compounds.

One of the effective ways to obtain a metastable compound is to stabilize the crystal structure of the compound in a form of film by using a template substrate. For instance, a metastable α-Ga_2O_3 with a corundum structure is obtained as a thin film grown on a corundum Al_2O_3 substrate.[1] For TaO_2, it is expected that this metastable compound is stabilized in a thin film grown on a rutile-type substrate.

A rutile-type NbO_2 is a promising substrate from viewpoint of a lattice matching with TaO_2. In addition, NbO_2 thin films are grown epitaxially on Al_2O_3(0001) substrates using a pulsed laser deposition (PLD) technique. NbO_2 thin films can be used as a template layer for the TaO_2 film growth.

We prepared TaO_2 thin films using NbO_2 template layers on Al_2O_3(0001) substrates by a PLD method. Film thickness is 8 nm for NbO_2 template layer and 43 nm for TaO_2. XRD measurements found that the film is a single-phase tetragonal TaO_2 with an (100)-orientation (Fig. 1). Importance of structural stabilization for a single-phase TaO_2, and the structural and electrical properties of the film are presented.

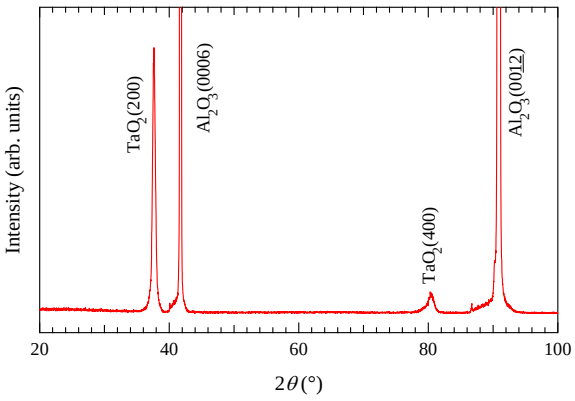

Fig. 1　XRD pattern of a TaO_2 thin film prepared using a NbO_2 template layer on Al_2O_3(0001).

[1] K. Kaneko, H. Kawanowa, H. Ito, and S. Fujita, Jpn. J. Appl. Phys. **51,** 020201 (2012).