Epitaxial growth of highly strained RuO_2 thin film by self-buffering method

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Rutile RuO_2 draws considerable attention for its applications in the field of electronics and chemical industry because of its rare combination of low resistivity (35 μΩ cm) at room temperature and high thermal and chemical stability [1]. In applications for electrodes and catalysts, RuO_2 is often deposited as thin films onto surfaces of active materials, and is subjected to external stress caused by growth mode of crystal and/or lattice mismatch [2]. Despite the possibly great impact on electrical and electrochemical properties, strain effect in RuO_2 has been scarcely explored partly because of the lack of method to control strain in rutile RuO_2, whose lattice constants hardly match to those of available single crystal substrates. Although surface-growth-mode-induced strain is a good candidate to apply external strain to a film, the strain amplitude is limited to about 1% at highest. In this study, we report successful growth of highly strained RuO_2 epitaxial thin films with self-buffering method and its physical properties.

Rutile RuO_2 epitaxial thin films were deposited on yttria-stabilized zirconia (YSZ) (111) and sapphire (0001) substrates by pulsed laser deposition. In the self-buffering method, buffer layer was deposited at 450°C followed by the deposition of main layer at various temperatures in order to control strain state. X-ray diffraction showed epitaxial growth of (100)-oriented RuO_2 with three-fold multi domain structure. Reciprocal space mapping clearly evidenced the highest strain of 3.4% and 4.0% in RuO_2 thin films on YSZ (111) and sapphire (0001) substrates, respectively, at the optimum growth temperature (Fig. 1). Island growth mode observed by atomic force microscope suggests that surface-growth-mode-induced strain was enhanced by the buffer layer (Fig. 2.).

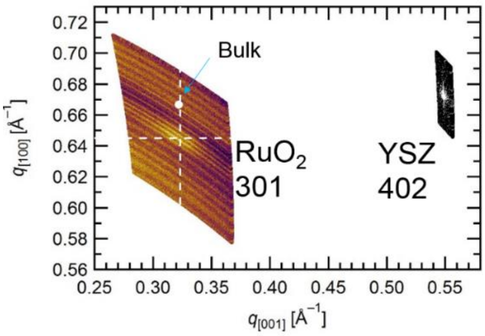

Fig. 1. Reciprocal space mapping around 301 diffraction of RuO_2 thin film epitaxially grown on YSZ (111) surface with self-buffering method.

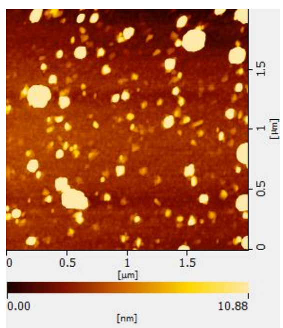

Fig. 2. Surface morphology of rutile RuO_2 epitaxial thin film on YSZ substrate.

[1] G.V. Samsonov, The Oxide Handbook, (IFI/Plenum, New York, 1982). [2] W. D. Nix *et al.*, *J. Mater. Res.*, **14**, 3467 (1999).