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Topotactic synthesis of mixed-anion oxide epitaxial thin films

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Transition metal oxides exhibit fascinating physical and chemical properties, including superconductivity, colossal magnetoresistance, ferroelectricity, and photocatalytic abilities. Since these properties are strongly affected by bonding interactions between the d orbital of transition metal cations and the p orbital of oxide anions, moderate replacement of O^{2-} by H^- or F^- can drastically change the characters. One of the most excellent methods to obtain oxyhydrides and oxyfluorides is topotactic synthesis using reagents, where guest species can be introduced into a host crystalline structure without destroying the initial crystalline matrix, for example, insulating $BaTiO_3$ changes into oxide hydride $BaTiO_{2.4}H_{0.6}$ with metallic nature by CaH_2 treatment and bulk crystal of $SrFeO_{3-\delta}$ changes into $SrFeO_2F$ by annealing with poly-CH_2CF_2 (PVDF) at 400°C. Though this method has mainly been applied to powder bulk samples, the reaction on thin-film samples is expected to have several advantages over bulk: considerably higher reactivity owing to the larger surface area/volume ratio, stabilization of the crystal framework by epitaxial effect, and modification of physical properties by epitaxial strain. In this study, we examined four types of topotactic reactions for various transition-metal oxide epitaxial thin films, i.e., hydridation and strong reduction using CaH_2, fluorination using PVDF, and strong oxidation using NaClO solution, as schematically illustrated in Figure 1. Furthermore, we found interesting electronic properties in the obtained mixed-anion oxide thin films, such as ferromagnetic metal to antiferromagnetic insulator transition. These reactions will be useful for designing and synthesizing novel mixed-anion compounds in epitaxial thin film form.

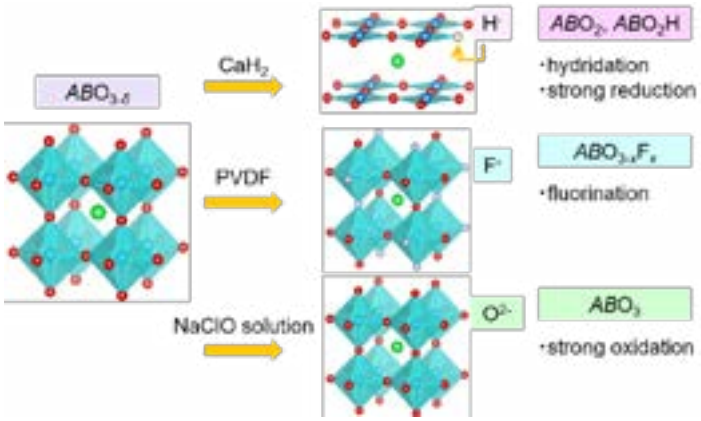

Figure 1: Schematic image of the topotactic reactions of hydridation and strong reduction using CaH_2, fluorination using PVDF, and strong oxidation using NaClO solution.

Biography

Akira Chikamatsu holds a PhD degree from University of Tokyo in 2008, and currently works at University of Tokyo as Assistant Professor. He is an expert in "Solid-state chemistry and physics, thin-film growth, and electron spectroscopy". He developed new thin-film growth techniques of mixed-anion transition metal oxides, and succeeded in creating some new materials by these methods. His current research interests include "Searching for new functionalities and new phenomena in mixed-anion transition metal oxides by using layer-by-layer thin film growth and topotactic reaction technologies".

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