# Domain Growth Behavior of Orthorhombic Strontium Manganese Oxide Films


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A number of perovskite-type oxides, represented by the chemical formula $ABO_3$, have a distorted crystal structure with variation of A and B site ions. The crystal distortions lead to a formation of domain structures. Recently, heteroepitaxial films have been provided as a route to create unique domain structures. The domain growth behavior is closely related to the film thickness and lattice mismatch between the films and substrates [1, 2]. However, the intrinsic behavior of the domain structures is not clearly understood. Therefore, we investigated the detail domain structure of orthorhombic $SrMnO_{2.5}$ films grown on the different substrates. [3].

Orthorhombic $SrMnO_{2.5}$ films were grown on the (001) LSAT (a = 0.3868 nm) and (001) $SrTiO_3$ (a = 0.3905 nm) substrates by pulsed laser deposition. The domain structures of the obtained films were investigated by transmission electron microscopy (TEM) and scanning TEM (STEM).

Figure 1 (a) shows the annular bright-field (ABF) STEM image of obtained $SrMnO_{2.5}$ film grown on a LSAT substrate viewed along the [001] zone axis. The ABF image clearly shows the position of O columns and O vacancy columns. Figure 2 (b) shows the crystal structure model of the $SrMnO_{2.5}$ viewed along the [001] zone axis [4]. The O vacancy ordering of the ABF image is coincident with that of a $SrMnO_{2.5}$ crystal structure, indicating that the prepared film is surely $SrMnO_{2.5}$. Figure 3 (a) shows the bright-field TEM image and the electron diffraction pattern of a $SrMnO_{2.5}$ film. The bright-field TEM image shows that the strain contrast originates from the existence of domains having two orientations. $SrMnO_{2.5}$ film has two types of orthorhombic orientations on a substrate as shown in Fig. 2 (c). Different domain configurations of the A and B lattice orientations lead to the observed electron diffraction pattern. The dark-field TEM images of $SrMnO_{2.5}$ film taken from a 010 reflection are shown in Fig. 2 (b). The dark-field TEM images clearly visualize a unique pattern like a maze, *i.e.*, a labyrinth-type domain structure. A schematic of the domain configurations of the $SrMnO_{2.5}$ film are shown in Fig. 2 (d). The domain boundaries lie parallel to the (100) or (010) faces of a cubic substrate. And, the domain widths became smaller when $SrMnO_{2.5}$ film is grown on a larger lattice mismatch substrate of $SrTiO_3$ [3]. Thus, a labyrinth-type domain structure arises from relaxation of strain induced by lattice mismatches. In addition, the width of domains in the films is estimated using a geometrical relationship for explaining of the average distance of misfit dislocations [3]. These results indicate the very useful information for controlling the domain structure of orthorhombic perovskite oxide films.


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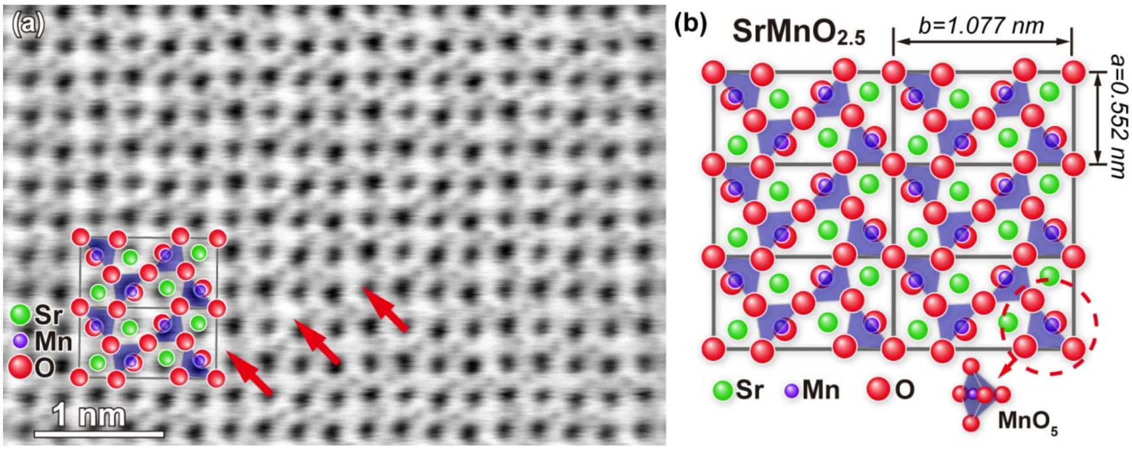


FIG. 1. (a) ABF image of $SrMnO_{2.5}$ film grown on LSAT substrate viewed along [001] zone axis. The red arrows in the image indicate the position of O vacancies. (b) The crystal structure model of $SrMnO_{2.5}$ viewed along the [001] zone axis. The squares show the unit cell of $SrMnO_{2.5}$.

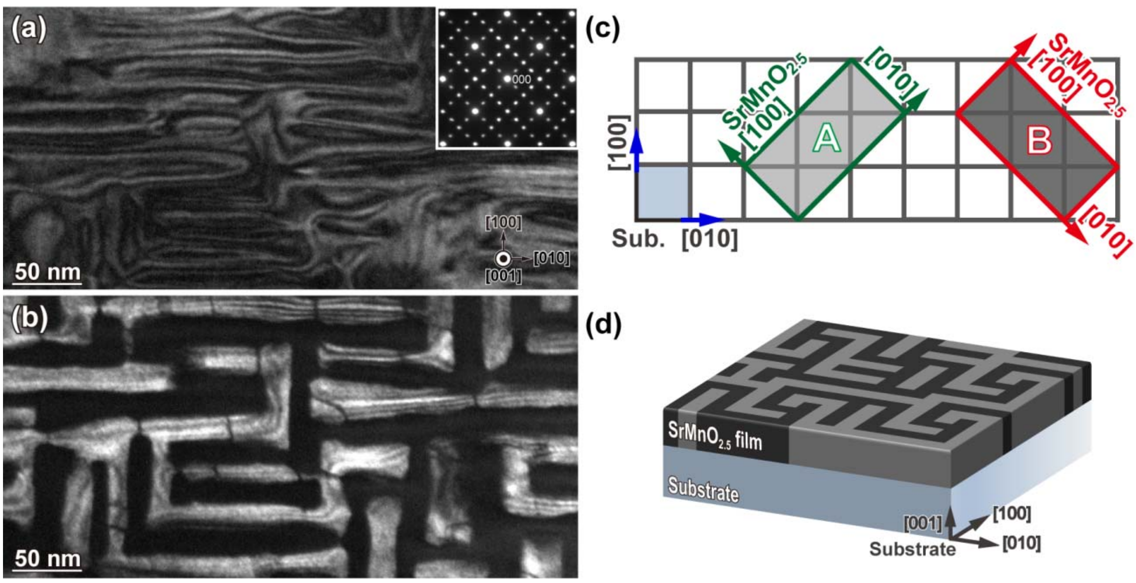


FIG. 2. (a) Bright-field TEM image of $SrMnO_{2.5}$ film viewed along the [001] zone axis. The insets show an electron diffraction pattern. The Millar indices are based on a cubic substrate. (b) Dark-field TEM image of a $SrMnO_{2.5}$ film taken from a 010 reflection. (c) The orientation relationship between a $SrMnO_{2.5}$ film and a cubic perovskite (substrate) viewed along [001] zone axis. (d) Schematic of the orthorhombic domain structure of the $SrMnO_{2.5}$ film.