Thermal and Step-Flow Instabilities of Epitaxial $SrRuO_3$ Thin Films Grown by Pulsed Laser Deposition

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The thermal stability of electrically conducting $SrRuO_3$ thin films grown by pulsed laser deposition on (001) $SrTiO_3$ substrates has been investigated by atomic force microscopy, reflection high-energy electron diffraction (RHEED), scanning tunneling microscopy (STM), and x-ray photoelectron spectroscopy (XPS), under reducing conditions (25–800 ^{o}C in 10^{-7}–10^{-2} Torr O_2). The as-grown $SrRuO_3$ epitaxial films exhibit atomically flat surfaces with single unit-cell steps, even after exposure to air at room temperature. However, the combined *ex-situ* analyses upon annealing under the reduced conditions show different features on the film surface, including islands and pits, that could destroy or deteriorate the quality of epitaxial films grown subsequently, and reveal a dramatic change of the structure and composition due mostly to high-temperature anneals under low oxygen background pressure. This study allowed us to determine a stability diagram of oxygen pressure and temperature for $SrRuO_3$ films, which indicates conditions under which they can serve as bottom electrodes and transfer the high crystallinity of single-crystal $SrTiO_3$ substrates to the subsequent oxide films. In addition, the step-flow instability of single-stepped $SrRuO_3$ films has also been investigated as functions of the film thickness and substrate off-cut. The terrace-step bunching and multiple-stepped islands are typically observed when the film thickness exceeds a critical thickness depending on the substrate off-cut. In this presentation, a systematic study on essential conditions for synthesizing *nearly-perfect* functional oxide films on $SrRuO_3$-electroded SrTiO3 will be presented.

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