Reversible electronic and magnetic structuresin epitaxial strontium cobaltite thin films

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The redox reaction in solids and the resultant changes in the physical properties are essential ingredient in applications such as solid oxide fuel cells, gas sensors, and many other devices that exploits ionic (or oxygen) transport property as their key function. Transition metal oxide strontium cobaltite ($SrCoO_x$, SCO)is one of the promising materials for such applications, as it has a richphase diagram depending on the oxygen content (x). The valence state of the multivalent Co changeswith the modification of x, and mainly governs the material's electronic, magnetic and opticalproperties.

Thelattice structures, optical, and electromagnetic properties of SCO epitaxial thin filmshave been investigated. Real-time optical spectroscopy, x-ray diffraction, x-ray absorption spectroscopy, magnetic measurements, transport measurements, and first principles calculation have been performed. In particular, brownmillerite $SrCoO_{2.5}$ (BM-SCO) and perovskite $SrCoO_3$(PV-SCO) thin films have been studied, where they have distinct crystal structures and valence states. BM-SCO has a one-dimensional oxygen vacancy ordered structure with a common Co^{3+} valence state. On the other hand, PV-SCO has a typical perovskite structure. Both experimental and theoretical results coherently indicated that these two films have drastically different electronic and magnetic ground states as well. Despite such large discrepancy in the physical properties, however, we found thata topotactic transformation between two structurally distinct phases could be readily achieved in high quality epitaxial thin films. The temperature dependent, ambient controlled real-time ellipsometry conspicuously showed that these two topotactic phases could be reversibly obtained at relatively low temperatures. Our study suggests that the electronic structure of SCO can be switched reversibly through oxygen insertion and extraction, simultaneously with the crystal structure and Co valence state. Thus, it provides a valuable insight in studying the link between the fundamental physical properties and its technological applications oftransition metal oxide epitaxial thin films.