DIRECT OBSERVATION OF OXYGEN VACANCY-DRIVEN STRUCTURAL AND RESISTIVE PHASE TRANSITIONS IN $La_{2/3}Sr_{1/3}MnO_3$

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Oxygen defects can have a profound effect on the physical properties of transition metal oxides. Electric-field driven migration of oxygen vacancies provides a viable mechanism for the formation, rupture and reconstruction of conducting filaments in insulating oxides, an effect that is used in nanoscale resistive switching devices [1,2]. In complex oxides where magnetic, ferroelectric and superconducting phases emerge from strong correlations between localized transition metal valence electrons, oxygen vacancies can radically alter a plurality of intrinsic properties via valance changes and structural phase transitions [3]. The ability to reversibly control the concentration and profile of oxygen vacancies in oxide nanostructures would thus open up comprehensive prospects for new functional ionic devices. Advancements in this direction require experimental techniques that allow for simultaneous measurements of oxygen vacancy dynamics, atomic-scale structural effects and macroscopic physical properties.

Here, we use in situ transmission electron microscopy (TEM) to demonstrate reversible switching between three resistance states in epitaxial $La_{2/3}Sr_{1/3}MnO_3$ films. Simultaneous high-resolution imaging and resistance probing indicate that the switching events are caused by the formation of uniform structural phases. Reversible horizontal migration of oxygen vacancies within the manganite film, driven by combined effects of Joule heating and bias voltage, predominantly triggers the structural and resistive transitions. Our findings open prospects based on dynamic control of physical properties in complex oxide nanostructures [4].

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