In situ TEM studies on RRAM device and epitaxial thin films

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Resistive switching of oxide-based metal-insulator-metal has been widely studied due to the fundamental research interest and the great potential applications. The fundamental understanding of the microscopic physical properties of resistive switching is necessary but still insufficient. Transmission electron microscopy has been widely applied to study nano-materials and nano-devices[1-3]. Here, the resistive switching processes are studied by electron holography and *in situ* energy filtered imaging in HfO_2-based resistive random access memory, which directly demonstrate the microscopic evolution behaviors of the nano-filaments in the formation and rupture processes[4]. Electron holography reveals that the electrons migrate from the bottom (cathode) to the top (anode) interface of the HfO_x film in forming process and move back from the top (cathode) interface at reset operation, which indicates definitely that the switch behavior occurs in the top interface of the hafnia layer. Meanwhile, *in situ* plasmon energy filtered images demonstrate that the oxygen vacancies are gradually generated in the insulator layer to form the channels connecting two electrodes under the positive bias.

Tuning magnetic properties of perovskite thin films is a central topic of recent studies because of its fundamental significance. In this work, we demonstrated the modification of the magnetism of $La_{0.9}Ca_{0.1}CoO_3$ (LCCO) thin films by introducing stripe-like superstructure in a controllable manner using the electron beam irradiation (EBI) in a transmission electron microscope. The microstructure, electronic structure, strain change and origin of magnetism of the LCCO thin films were studied in details using aberration-corrected scanning transmission electron microscopy, electron energy loss spectroscopy and *ab initio* calculations based on density functional theory[5]. The results indicate that the EBI induced unit cell volume expansion accompanies the formation of oxygen vacancies and leads to the spin state transition of Co ions. The low spin state of Co^{4+} ions depress the stripe-like superstructure, while higher spin states of Co ions with lower valences are conductive to the formation of "dark stripes"[6].

References

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