Atomic-scale studies of structural and electronic properties in functional transition metal oxide thin films using scanning tunneling microscopy/spectroscopy

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Discovery of high-T_c superconductivity in cuprate has triggered enormous attention on strongly-correlated electron systems in transition metal oxides for decades. To elucidate the mechanism of exotic physical properties, many progressive efforts have been made to dramatically improve the resolution in measurements such as angle-resolved photoemission spectroscopy and scanning tunneling microscopy/spectroscopy (STM/STS). Nowadays, these techniques are widely used to understand structural and electronic properties in a variety of bulk cleavable materials as well as layered perovskite oxides. However, due to the poor cleavability, there are few reports on atomic-scale studies of three-dimensional perovskite oxides.

To overcome this problem, we focused on high-quality epitaxial thin films as a specimen, and *in-situ* studied the structures and electronic states on the thin film surfaces of transition metal oxides at the atomic level. For this purpose, we constructed ultrastable low-temperature STM combined with pulsed laser deposition (PLD) system[1] to eliminate the influence of surface contamination. In this talk, I show our atomic-scale investigations of $SrTiO_3$(100) substrates[2] (Fig. 1(a)) and thin film surfaces of perovskite-type $La_{0.75}Ca_{0.25}MnO_3$ (ferromagnet, Fig. 1(b))[3] and spinel-type $LiTi_2O_4$ (superconductor, Fig. 1(c))[4] using low-temperature STM/STS.

On a $La_{0.75}Ca_{0.25}MnO_3/SrTiO_3$(100) thin film surface, we observed uniaxial zigzag ($\sqrt{2}\times\sqrt{2}$) stripes with two orthogonal domains, accompanying an energy gap at the Fermi level. Combined with theoretical calculations, we found that the electrical dead layer (gap opening) at the surface is induced by the relaxation of the topmost truncated octahedra (MnO_5) correlated with the Mn 3*d* orbital reconstruction[3]. Furthermore, on a $LiTi_2O_4/SrTiO_3$(111) thin film surface, we succeeded in the observation of clear triangular lattices and superconducting properties (gap and vortex state) in tunneling spectra[4]. Thus, our PLD-STM studies open a path for atomic-scale visualization of functional transition metal oxides with three-dimensional structures.

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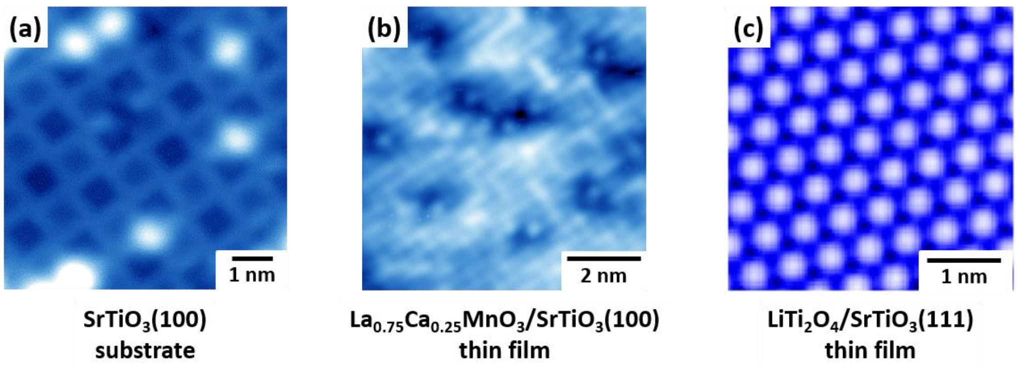

Figures: STM images on (a) $SrTiO_3$(100) substrate and (b) $La_{0.75}Ca_{0.25}MnO_3$(100) and (c) $LiTi_2O_4$(111) thin films.

References

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