Atomic mappings of novel domain configurations in ferroelectric thin films

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Ferroelectric domains show great potentials in electronic devices[1]. Exploring their novel configurations and understanding their structural evolution are crucial to better control the domain configurations for future applications. By means of Cs-corrected transmission electron microscopy, the domain structures were characterized in $PbTiO_3$ and $BiFeO_3$ thin films grown on scandate substrates by PLD deposition. It was found that large scale arrays of four-state vortex domains can be obtained in rhombohedral $BiFeO_3$ thin films grown on $PrScO_3$ substrates. Each vortex domain is comprised of four ferroelectric variants with two 180 domain walls and two 109 domain walls. Atomic mappings of the lattice distortions unit cell by unit cell reveal that the cores of the vortex might be charged. The strains are mainly concentrated on domain walls.

$PbTiO_3$ films grown on $GdScO_3$ substrates are domain oriented consisting of a_1/a_2 and a/c domain structure. The a_1/a_2 domains are found to distribute periodically and its width increases with increasing film thickness following square root rule. Cs-corrected STEM imaging demonstrates that the domain walls of a_1/a_2 domain structure have the rotation characteristic of 90° ferroelastic domain wall. The interchange of a_1/a_2 domains induces the formation of vertex domains composed of two 90° and one 180° domain walls. Full flux closure domains can be stabilized in PbTiO3 films with symmetric oxide electrodes. When bottom and up electrodes are $SrRuO_3$ or $La_{0.3}Sr_{0.7}MnO_3$, respectively, a/c domains appear in $PbTiO_3$ layers.

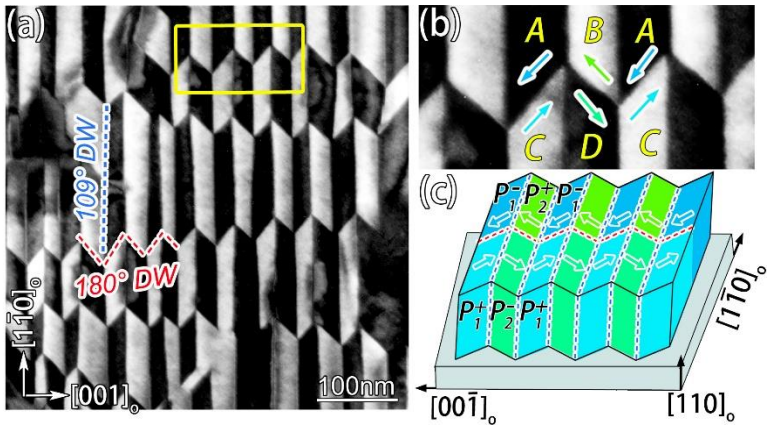

Figure 1 Four state vertex arrays in $BiFeO_3$ films on $PrScO_3$ substrates.

[1] Y.L. Tang, Y.L. Zhu, X.L. Ma, A.Y. Borisevich, A.N. Morozovska, E.A. Eliseev, W.Y. Wang, Y.J. Wang, Y.B. Xu, Z.D. Zhang, S.J. Pennycook, Observation of a periodic array of flux-closure quadrants in strained ferroelectric $PbTiO_3$ films, Science 348 (2015) 547-551.
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