Domain Structure in Fatigue-Free $SrBi_2Nb_2O_9$

SCIENTIFIC ACHIEVEMENT:

We have succeeded in the first experimental observation of the domain structure in thin films of $SrBi_2Nb_2O_9$, a ferroelectric material that is fatigue-free, i.e. does not show a loss of switched polarization with increasing number of switching cycles. Observation of this domain structure furthers our understanding of the contributions of elastic strain, dipole-dipole interactions, and electrostatic field effects to the complex domain structures found in oxide ferroelectric. The orthorhombic ferroelectric phase $SrBi_2Nb_2O_9$ is structurally very similar to typical perovskite ferroelectrics having 90° domains, but is unique because its ferroelastic distortion is essentially zero, resulting in a ferroelectric domain structure that is independent of strain energy contributions. Additionally, because no spontaneous polarization exists along the *c* axis for this material, the domain morphology along this azimuth is controlled by electrostatic field effects only. However, because of the absence of ferroelastic distortion, most standard strain-based techniques for imaging ferroelectric domains are not feasible with this material. Instead we utilized Fourier processing of high-resolution transmission electron microscopy images, to form a series of orthogonal polar-domain maps generated from unique superlattice reflections associated with individual domain orientations. Domain walls in $SrBi_2Nb_2O_9$ are found to be highly curved, indicating that the highly faceted 90° domain morphology found in typical oxide ferroelectrics is dominated by strain energy. The curved walls also indicate that $SrBi_2Nb_2O_9$ is fairly tolerant of the space charge associated with divergence of the normal component of the polarization at such walls.

SIGNIFICANCE:

Little experimental or theoretical evidence exists for the relative importance of the various contributions to ferroelectric domain morphology. The domain maps obtained in this investigation allow us to formulate a better understanding of these various components of the free energy balance used to describe domain structure. Comparison with simulation gives excellent agreement. Our goal is now to correlate the observed structure with the lack of fatigue in this system. Of particular interest is the extent to which space-charge and its compensation influences domain wall mobility. Future experiments to address these issue will be accomplished using *in-situ* methods to observe polarization dynamics. These experiments will utilize electron microscopy, as well as x-ray microprobe/nanoprobe techniques under development at the Advanced Photon Source.

PERFORMERS:

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FWP:

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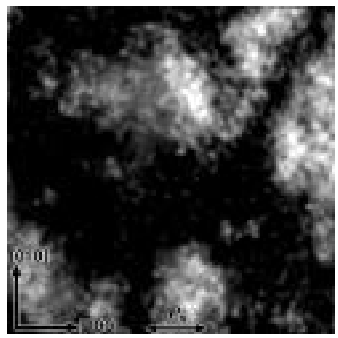
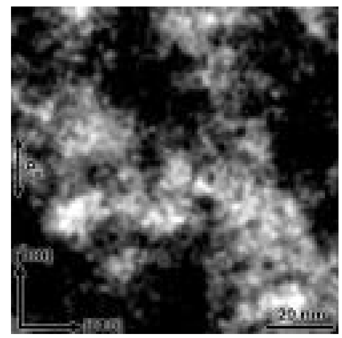
Fourier analysis of images yields ferroelectric domain maps for a zero-strain ferroelectric

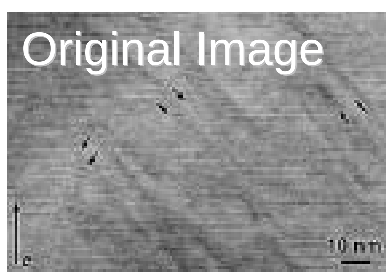


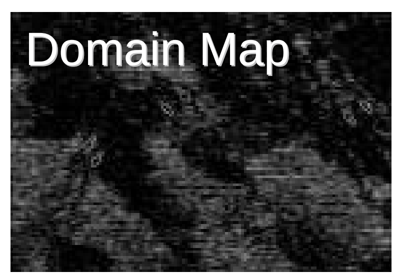


Imaging along the non-polar ***c*** axis reveals a complementary 90° domain morphology controlled by electrostatic and dipole-dipole interactions, with no strain contribution.

Imaging along the polar ***a***/***b*** axis reveals a 90° domain morphology controlled by electrostatic interactions alone (in ***c*** direction).

Results allow us to improve theoretical models of the evolution of domain structures.





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