Time-Resolved X-ray Topography Study on Growth of 180° Ferroelectric Domains

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Understanding the mechanism of nucleation and growth of 180° ferroelectric domains is an on-going subject of numerous theoretical and experimental investigations. The ferroelectric transition and the domain structure are intimately coupled to dielectric, ferroelectric, piezoelectric, pyroelectric, and nonlinear optical properties in a wide range of materials. In the past, the x-ray topography technique has been applied to investigate the ferroelectric domains in single crystals. However, the lack of sufficient diffraction contrast between the adjacent antiparallel ferroelectric domains made it difficult for investigation of domain dynamics.

Using the coherent x-rays from a third generation synchrotron source, we have greatly enhanced the diffraction contrast from the neighboring antiparallel ferroelectric domains. With this phase-contrast topography technique, we carried out a time-resolved diffraction imaging study of the nucleation and growth of 180° ferroelectric domains in barium titinate single crystals during the polarization switching. The diffraction images were collected with 1-micron spatial resolution and down to 10-ms acquisition time. We have observed drastically different domain growth mechanisms due to the surface treatment at the electrode-sample interfaces, suggesting the nucleation and growth is dominated by the defects at the electrode interface. We present the morphology of 180° domains and describe growth kinetics as a function of temperature and applied potentials.

Keywords: x-ray topography, ferroic domain structure, growth kinetics