Polarization domain nucleation and growth in thin PZT films.

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The dynamics of polarization domains controls polarization switching in thin film ferroelectrics. Both theories and experiments have been challenged in last 10 years by a growing need in understanding and controlling ferroelectricity at the nanoscale. Recent developments of new experimental approaches as time-resolved x-ray microdiffraction have provided experimental access to structural dynamics at the time and length scales relevant to domain dynamics. We have used time-resolved x-ray microdiffraction to measure structural transformations in a thin PZT film during polarization switching. Structural changes in the PZT film during switching can be understood in the context of nucleation and domain wall propagation models. Both the nucleation kinetics and the speed of polarization domain walls depend on the magnitude of the electric field applied to a ferroelectric PZT capacitor. The polarization switching process is highly reproducible including the nucleation sites and time of nucleation as well as the growth speed and directions of the formed domain. This is evidenced by the sharpness of the time-resolved structural signature of switching acquired over thousands of switching cycles in our experiments. The switching kinetics change noticeably when increasing the electric field from around the coercive field, ~200 kV/cm, to higher fields of ~300 to 500 kV/cm. At low fields the kinetics is largely governed by a growth of polarization domains from scarce distributed nucleation sites whereas at high fields the nucleation density is greatly enhanced.