Fatigue in ferroelectric ceramics as nonuniform kinetic imprint

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Evolution of spatial distribution of ferroelectric properties during electrical fatigue has been measured in PZT ceramics and explained on the basis of recently proposed model of fatigue as nonuniform kinetic imprint.
The hysteresis loops of local strain, polarization and small signal piezoelectric constant were recorded in the PZT ceramics after different switching cycle number. One of the electrodes was separated into pads by wire saw in order to avoid the rejuvenation during measurements. Spatial resolution for polarization measurement (about 1 mm) was defined by the pad sizes, while for strain (1 mm) and small signal piezoelectric constant (0.1-0.2 mm) by the tip sizes.
Essential spatial inhomogeneity of ferroelectric properties appeared after cycling in completely uniform samples. The inhomogeneity of remnant polarization, coercive and bias fields, amplitude and asymmetry of strain loop was characterized by distribution functions. The obtained broadening of the distribution functions during cycling is in a good agreement with predictions of our nonuniform kinetic imprint approach to fatigue phenomenon. Similar behavior had been observed recently in thin PZT films by piezoresponse scanning probe microscopy.
Asymmetry in the frozen domains orientation (offset polarization) has been extracted from small signal piezoelectric constant measurements with variable DC offset field by lock-in technique and strain loops. The obtained preferable orientation of the frozen domains arising during cycling correlates with the tendency which has been shown by us using computer simulation.
All obtained results confirms our approach to fatigue phenomena in ferroelectrics as the nonuniform kinetic imprint based on the crucial role of the retardation of bulk screening of depolarization field during cyclic switching.
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