Spatially Resolved Mapping of Disorder Type and Distribution in Random Systems using Artificial Neural Network Recognition

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Abstract: The spatial variability of the polarization dynamics in thin film ferroelectric capacitors was probed by recognition analysis of spatially resolved spectroscopic data. Switching spectroscopy piezoresponse force microscopy (SSPFM) was used to measure local hysteresis loops and map them on a two dimensional (2D) random-bond, random-field Ising model. A neural-network based recognition approach was utilized to analyze the hysteresis loops and their spatial variability. Strong variability is observed in the polarization dynamics around macroscopic cracks because of the modified local-elastic and electric-boundary conditions, with the most pronounced effect on the length scale of ~100 nm away from the crack. The recognition approach developed here is universal and can potentially be applied for arbitrary macroscopic and spatially resolved data, including temperature- and field-dependent hysteresis, I-V curve mapping, electron microscopy electron energy loss spectroscopy (EELS) imaging, and many others.