Abstract for an Invited Paper
for the MAR10 Meeting of
The American Physical Society

Nonlinear dynamics of domain wall propagation in epitaxial ferroelectric thin films

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The dynamics of an elastic interface in random media is of crucial importance to understand numerous intriguing natural phenomena, including domain walls in ferromagnetics, surfaces of epitaxially grown films, contact lines in wetting, and so on. In such media, velocity of an interface should have a nonlinear behavior, classified with various dynamic phases such as creep, depinning, and flow [1]. Despite several significant theoretical progresses, there are few experimental works on it. Here, we present our recent studies on ferroelectric (FE) domain wall dynamics in the epitaxial $PbZr_{0.2}Ti_{0.8}O_3$ (PZT) thin films. We demonstrated that the data of domain wall velocity v driven by dc electric field E in FE film could be classified with the creep, depinning, and flow regimes [1]. First, we measured the data of v at room temperature T directly using the modified-piezoresponse force microscopy (PFM) [2]. To widen the accessible region of T and E, we used switching current measurements, combined with direct v data from PFM images. The measured values of velocity exponent $\theta \sim 0.7$ and dynamical exponent $\mu \sim 1.0$ indicate that the FE domain walls in the epitaxial films are fractal and pinned by a disorder-induced local field. In addition, we investigated domain wall dynamics driven by ac field in the epitaxial PZT films, using frequency f-dependent hysteresis loops under various T. We observed the novel f-dependence of coercive field E_C such that the slopes for log f vs. log E_C changed at all measured T. We found that this indicated the dynamic phase crossover from creep regime to flow regime. Based on these experimental results, we determined the dynamic phase diagram for ferroelectric domain walls driven by ac field.

[1] J. Y. Jo *et al.*, Phys. Rev. Lett. **102**, 045701 (2009).
[2] S. M. Yang *et al.*, Appl. Phys. Lett. **92**, 252901 (2008).