Polarization Fatigue and Non-destructive Readout of Ferroelectric Memory

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Fatigue of ferroelectric materials refers the reduction of switchable polarization upon repetitive electrical cycling. It is detrimental to the performance and life time of ferroelectric base devices, and has been studied for decades.[1] Different mechanisms have been proposed, including defects redistribution,[2] charge injection[3] and second phase formation [4]. However, no consensus has been reached yet. The main problem is that most of the studies only investigate macroscopic properties, e.g. dielectric permittivity and polarization-electric field hysteresis loop. The microscopic origin is, in most cases, a conjecture. Until recently, direct microscopic study of ferroelectric fatigue has yet to be explored.

We have studied the fatigue of (001)-oriented $BiFeO_3$ films using piezoelectric force microscopy (PFM) and scanning Kelvin probe microscopy (SKPM) under a planar-electrode setup and made several interesting observations. [5] (1) Charged domain walls do appear during fatigue measurement, but they not impede the in-plane polarization rotation under electric field. They did not cause fatigue; (2) SKPM study revealed negative charge accumulation (e.g. electrons) at the electrode/film interface, where domain pinning occurred. When the pinned domains grew across the channel after further cycling, macroscopic fatigue was observed. All the evidence points to the conclusion that domain pinning and fatigue is caused by injected charges at the electrode/film interfaces. To circumvent the polarization fatigue problem, non-destructive readout of ferroelectric memory needs to be developed. I will also discuss our recent work in this direction using ferroelectric tunneling junction.

[1] N. Setter, D. Damjanovic, L. Eng, G. Fox, S. Gevorgian, S. Hong, A. Kingon, H. Kohlstedt, N. Y. Park, G. B. Stephenson, I. Stolitchnov, A. K. Taganstev, D. V. Taylor, T. Yamada, S. Streiffer, J. Appl. Phys. **100**, 051606 (2006).
[2] J. F. Scott, M. Dawber, Appl. Phys. Lett. **76**, 3801 (2000).
[3] A. K. Tagantsev, I. Stolichnov, E. L. Colla, N. Setter, J. Appl. Phys. **90**, 1387 (2001).
[4] X. J. Lou, J. Appl. Phys. **105**, 024101(2009).
[5] Xi Zou, Lu You, Lang Chen, Di Wu, and Junling Wang, submitted (2011).