NANOSCOPIC CONTROL OF THE POLARIZATION IN FERROELECTRIC THIN FILMS

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Ferroelectric memories take advantage of the non-volatile reversible nature of the ferroelectric polarization. In this work, we combine high quality materials, epitaxial atomically smooth ferroelectric perovskite films, and atomic force microscopy (AFM) to control and modify the ferroelectric domain structure at nanoscale. This approach allows new fundamental studies of ferroelectrics at nanoscale and might be a way to develop ultra-high density non-volatile memories.

In ferroelectric $Pb(Zr_{0.2}Ti_{0.8})O_3$ thin films, a metallic AFM tip was used as a local electric field source to study individual nanoscale ferroelectric domains. Control of domain size was achieved by varying the strength and duration of the voltage pulses used to polarize the material, permitting the creation of sub-20nm wide lines and ultra-high density arrays reaching ~30 Gbit/cm^2 [1]. The AFM approach developed also allowed us to investigate switching dynamics in ferroelectric thin films. Our data suggest a two step process of domain growth, in which initial nucleation under the AFM tip is followed by radial domain wall motion, perpendicular to the polarization direction. The electric field dependence of the domain wall velocity demonstrates that this motion is a creep process [2]. Our analysis [2,3] shows that the previously proposed bulk nucleation model of domain growth [4] cannot explain the observed behavior in thin films, but rather that disorder is at the origin of ferroelectric domain wall motion.

References:

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