

Ferroelectricity in thin perovskite films and artificial ferroelectric materials with tailored properties

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One long standing question is the problem of size effects in ferroelectrics or whether or not ferroelectricity survives in very thin films or small particles. Here, we have explored the properties of ultrathin epitaxial ferroelectric PbTiO₃ films and of PbTiO₃/SrTiO₃ ferroelectric/paraelectric artificial superlattices. The role of the finite thickness of the samples was first probed by measuring the evolution of tetragonality with thickness in a series of c-axis oriented PbTiO₃ perovskite films, with thicknesses ranging from 500 Å down to 4 Å or one unit cell [1]. High resolution x-ray diffraction and x-ray photoelectron diffraction showed a systematic decrease of the c-axis lattice parameter with decreasing film thickness below 200 Å, a decrease in tetragonality related to the reduction of the polarization. Analyses demonstrate that films as thin as 12 Å (3 unit cells) are ferroelectric and that the progressive reduction of the polarization in thin films is related to the depolarizing field resulting from imperfect screening. In a second step, ferroelectricity was probed in artificial ferroelectric superlattices. It turns out that this system is an attractive pathway towards materials with tailored properties [2]. We demonstrate in PbTiO₃/SrTiO₃ superlattices how one can experimentally control the ferroelectric polarization and dielectric constant by variation of the superlattice geometry. We also show the significant suppression of leakage current and fatigue that can be achieved by use of the superlattice geometry, eliminating two key sources of device failure for ferroelectrics.

[1] C. Lichtensteiger, J.-M. Triscone, J. Junquera, and P. Ghosez, *Physical Review Letters* **94**, 047603 (2005).

[2] M. Dawber, C. Lichtensteiger, M. Cantoni, M. Veithen, P. Ghosez, K. Johnston, K.M. Rabe, and J.-M. Triscone, *Physical Review Letters* **95**, 177601 (2005).