Domains and superdomains in ferroelectric lead titanate heterostructures and membranes

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$PbTiO_3$ exhibits a bulk paraelectric-ferroelectric phase transition at a critical temperature T_c of 765 K, developing a switchable polarization along the c-axis mostly driven by ionic displacements. Theoretical studies in $PbTiO_3$ thin films have revealed complex phase diagrams with different configurations of domains - regions with uniform polarization - that can be controlled in terms of size and shape by tailoring the electrostatic boundary conditions, film thickness, deposition temperature, and epitaxial strain [1]. Domains are separated by interfaces termed domain walls. At larger length scales, domains can self-organize into superdomains - periodic or hierarchical structures with characteristic sizes ranging from hundreds of nanometers to several micrometers. This implies the existence of superdomain walls, which may exhibit properties distinct from conventional domain walls.
We investigate domain and superdomain structures in $PbTiO_3$ heterostructures. We demonstrate that both domain and superdomain periodicities scale with the thickness of the ferroelectric layer, enabling precise control of their densities through thickness engineering [2,3]. We further show that ferroelastic domains can propagate structural distortions into adjacent layers [4]. Beyond epitaxial thin films, we explore domains and superdomains in membranes, where the constraints imposed by the substrate are removed [5].

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