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From liquid barium strontium titanate thin films to ferroelectricity

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Among the functional oxides, Barium Strontium Titanate (BST) has been intensively studied due to its important applications in sensors, microwave, and energy-harvesting. The BST films are typically elaborated by sintering, sputtering, or sol-gel. The advantages of sol-gel elaboration are simplicity, possible deposition on large surfaces, and low cost. Although sol-gel films are widely used, previous studies have not fully explained the differences in growth morphology as a function of the elaboration process. $Ba_{0.7}Sr_{0.3}TiO_3$ thin films elaborated by sol-gel were investigated by *in situ* and *ex situ* Grazing Incidence Small-Angle X-ray Scattering, X-ray diffraction, and Scanning Electron Microscope as a function of the annealing conditions.[1] During low-temperature annealing of the liquid thin film, a phase separation occurs between organic and inorganic species. The domains can be self-organized in the direction parallel to the surface. At higher temperature, the inorganic-rich and organic-rich domains grow and finally lead to nanocrystals and pores respectively after solvent evaporation. Moreover, the BST films are polycrystalline with the perovskite structure. According to the annealing conditions, BST thin films may have the same crystallographic structure but different morphologies (columnar/granular growth). A nanofluidic model and surface energy considerations [2] allow explaining such growth behavior. Finally, ferroelectric hysteresis loop was obtained after full removal of organic constituents. Thus, our findings allow tailoring sol-gel thin films at the nanoscale with optimized structures, morphologies and properties.

[1] C. Mansour, M. Benwadih, G.A. Chahine, C. Revenant, AIP Advances **10**, 065204 (2020).
[2] C. Revenant, M. Benwadih, Thin Solid Films **616**, 643-648 (2016).

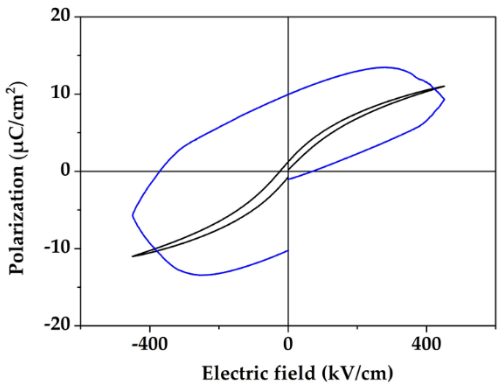

Figure : *P-E* graph for sol-gel $Ba_{0.7}Sr_{0.3}TiO_3$ with a columnar growth (black line) or granular growth (blue line). A ferroelectric hysteresis loop is obtained for $Ba_{0.7}Sr_{0.3}TiO_3$ thin films with a columnar growth.