

# Hydrothermal Synthesis, Core-Level Photoemission and X-ray Absorption of Nanocrystalline Oxides

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The effect of reduced size and dimensionality (“finite size” effects) on crystal structure, phonons, binding energy, and electronic properties has been a subject of curiosity for some decades. However, a clear understanding of the origin of shifts in core-level binding energy as the result of surface relaxation, or nano-solid formation, has remained a challenge. This is partly due to lack of sufficient experimental data, mainly from complex nano-structures, which can give credence to theories and calculations based upon information about the intra-atomic trapping energy and crystal binding strength.

Recent advances in materials synthesis techniques have made it possible to explore nanostructures of materials such as complex oxides in different nano-solid shapes and sizes. With this in mind, we have recently developed a series of solution-derived low temperature techniques to synthesize complex nano-sized single crystalline oxides of partially reduced dimensionality (nanoparticles, nanotubes and nanowires). Here, we report our studies of high-quality single-crystalline  $\text{PbTiO}_3$ , which exhibits magnetoelectricity upon substitution with Fe or Tb, and which is structurally and electronically analogous to other families of magnetoelectrics. We discuss the synthesis of tetragonal  $\text{PbTiO}_3$  from oxide precursors using a hydrothermal route at a low temperature within unprecedented short time scales (as short as 4 hours), with an alkali as a mineralizer. We also report results on nano-crystalline  $\text{TiO}_2$  and  $\text{CeO}_2$  grown by us using hydrothermal techniques. We present transmission electron microscopy, crystal structure information, x-ray photoemission and x-ray absorption performed on the 10-meter and HERMON beamlines at the SRC.