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Project Title:

Digital Holographic Tomography of Ferroelectric Domain Walls

It would be practically impossible to construct an electronic device, such as a mobile phone, tablet, or computer, without progress in material science. Current requirements on miniaturization of electronic circuitry put enormous demands on the materials used, which have reached the limits of physical possibility. Miniaturization of capacitors is an example of this trend: It is known that capacitance is directly linked to the capacitor size; unfortunately, geometric means of miniaturization of a parallel plate capacitor have been practically exhausted because they have reached fundamental limits such as breakdowns and tunnelling between capacitor electrodes. Thus further progress in miniaturization of capacitors proceeds mainly through the use of materials with large dielectric response. A frequently used material in this category is ferroelectric barium titanate (BaTiO3). While dielectric response in conventional dielectrics is provided by the displacement of crystal lattice ions, in ferroelectrics, it is further enhanced by movements of domain walls, which separate regions with different configuration of crystal lattice.

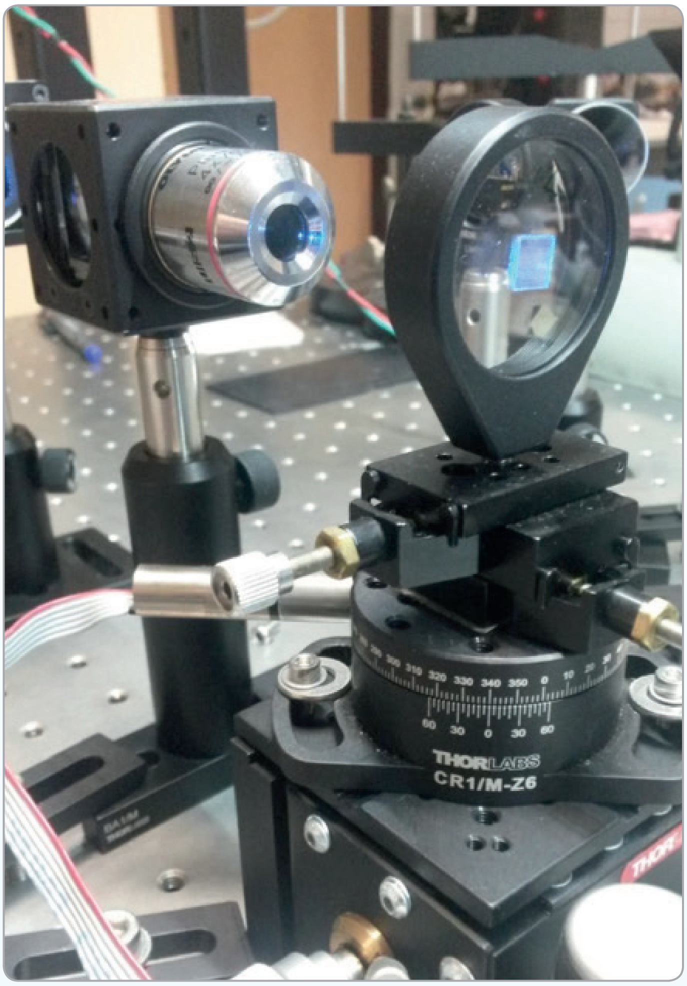

Figure 1: *Barium titanate single crystal in the sample holder with transparent electrodes fixed in the rotating stage of the digital holographic tomograph.*

The aim of the project was research into methods for visualization of ferroelectric domain walls using digital holographic tomography. Within the project, we developed, first, methods for optical visualization of static domain walls and, second, methods for numerical simulation of equilibrium domain patterns in ferroelectric materials.

During the work on the project, we achieved several important state-of-the-art results:

- a general thermodynamic model, which allows investigating the interaction of ferroelectric domain walls with crystal lattice defects
- application of the thermodynamic model in phase-field simulations, which enabled an analysis of novel methods for characterization of ferroelectric samples using measurements of nonlinear permittivity
- design and construction of a digital holographic tomograph, which allows three-dimensional observations of ferroelectric domain walls and opens new possibilities for characterization of domain patterns in ferroelectric single crystals by means of holographic measurements
- new methods of deposition of transparent electrodes on ferroelectric single crystal plates, which facilitate optical observations based on the linear electro-optic effect
- new inverse reconstruction algorithms for numerical processing of tomographic data

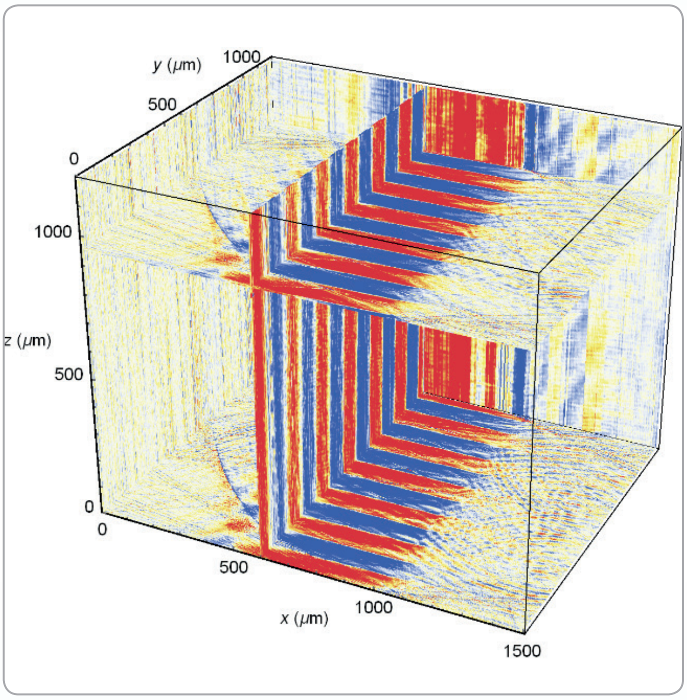

Figure 2: *Result of the observation of the domain pattern in the whole volume of the lithium titanate single crystal.*