Digital Holographic Tomography of Periodically Poled Lithium Niobate: A Challenge for Artificial Neural Networks

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It is known that the presence of ferroelectric domain patterns tremendously affects macroscopic properties of ferroelectric samples. The effects can be both positive and negative. The presence of antiparallel domains in a pyroelectric sensor kills its ability to respond to temperature changes. On the other hand, the motion of pinned domain walls greatly enhances the dielectric and electromechanical response. For this reason, the methods for the visualization of domain patterns in ferroelectric materials are gaining in importance. Such methods are essential not only for the characterization and testing of ferroelectric devices but also for the study of physical phenomena responsible for the link between the domain pattern geometry and the quantitative effects on the macroscopic properties of ferroelectric samples. Unfortunately, most of the contemporary methods for the visualization of domain patterns (based on the atomic force microscopy) allows the observation of domain patterns on the surface of the sample. In this work, we report on the novel method for the three-dimensional observation of ferroelectric domain patterns called digital holographic tomography (DHT). The method is based on the measurement of the spatial distribution of refractive index, which is known to be a function of the spontaneous polarization due to the linear electro-optic effect. The method is thus applicable to all transparent ferroelectric single crystals and ceramics. We demonstrate the applicability of our constructed DHT microscope on the observation of domain-engineered periodically-poled lithium niobate. Since the DHT microscope generates a large number of numerical data that has to be processed by means of iterative methods, a great attention must be paid to the efficiency of the numerical processing methods. One of the powerful approaches is offered by the use of artificial neural networks.