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Probing the Electric-Field Induced Antiferroelectric-Ferroelectric Phase Transition in PbZrO3 with Second Harmonic Generation Imaging

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The physics of electric-field-induced phase transitions in ferroelectric materials has attracted considerable attention for promising future use in a variety of new-generation electronic devices. Even more, control of the antiferroelectric-ferroelectric phase transition of antiferroelectric thin films is necessary for highly efficient data storage, sensing, and energy harvesting applications. Consequently, there is a need for the development of thorough characterization methods of thin antiferroelectric films. In this study, we present an innovative approach utilizing second harmonic generation (SHG) imaging to probe and image the field-induced antiferroelectric-ferroelectric phase transition in PbZrO3.
Second harmonic generation (SHG) imaging has emerged as a robust and non-invasive technique that enables the direct observation of structural and polarization changes in materials exhibiting ferroic order. Through the analysis of the symmetry in the second-order nonlinear optical response, SHG imaging provides exceptional insights into the domain structure and polarization states associated with specific ferroic phases. In this work, we study a high-quality single crystal of PbZrO3 with a thickness of 50 nm, grown using the PLD technique on a SrTiO3 substrate. By employing a state-of-the-art SHG microscope in the transmission geometry, we recorded the dynamics of the antiferroelectric-ferroelectric phase transition. The experimental setup involved illuminating the sample with 900 nm pulses and capturing an intensity map at 450 nm wavelength using a photon multiplied camera. The controlled in-plane electric field strength and direction allow for comprehensive investigations of the phase transition dynamics in PbZrO3.
Our preliminary findings provide valuable insights into the underlying mechanisms governing the phase transition conditions, where we image the dynamics of the field-induced transition between the polar and nonpolar phases in PbZrO3. These findings could be beneficial for the development of advanced materials with tailored functionalities, such as high-performance dynamic-random access memory and energy storage systems.

Topics

Session A. Physics of condensed matter and spectroscopy

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