Abstract

Title: Spectroscopic investigations of lattice dynamics in multidomain ferroelectrics

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Abstract: Lead based ferroelectric perovskites exhibit attractive physical and structural properties. Ferroelectric domains are known to have a very essential impact on dielectric and piezoelectric properties of ferroelectrics. Tailoring of domain structures allows to change the macroscopic symmetry of the material and to purposely modify its average tensor properties.

Ferroelastic domains play also a key role in physics of epitaxial ferroelectric films. Here we studied signature of domain structure in $PbTiO_3$ thin film grown by metalorganic chemical vapor deposition technique on different substrates, namely $LaAlO_3$, MgO, $NdGaO_3$, $SrTiO_3$ (100), $SrTiO_3$ (110), $SrTiO_3$ (111) doped with 0.5% Nb and LSAT. Certain aspects of domain structure can be conveniently revealed by using infrared reflectance and Raman spectroscopic techniques. Differences in domain pattern are associated with different aspects related to the thin film like the film thickness, lattice mismatch between substrate and thin film, etc. A local insight into the complex nanodomain architecture can be seen using piezoresponse force microscopy imaging techniques. A detailed study of 250 nm and 110 nm thick PTO/LAO thin film has shown different patterns of ferroelectric domain structure with all six tetragonal ferroelectric domain states and both 180^0 and 90^0 ferroelectric walls.

The far-infrared reflectance and theoretical investigation of complex dielectric permittivity on $PbTiO_3$ ceramics reveals the presence of several additional modes identified as the so called geometrical resonances (i.e., extraneous hybrid excitations created by

inhomogeneous depolarization fields) besides the well-known polar modes of bulk $PbTiO_3$. A comparison of our experiment and model calculations suggests that the strong geometrical modes located near 300 and 500 cm^{-1} are associated with the presence of 90^0 ferroelectric walls. This work also investigates the anisotropy of the macroscopic dielectric response of poled PZT ceramics in the phonon frequency region, introduced due to the poling processes. The results are discussed in terms of distinct polar phonon contributions and effective medium theory.

Keywords: Ferroelectric domains, Infrared Spectroscopy, Raman Spectroscopy, PFM imaging, $PbTiO_3$ thin films, $PbTiO_3$ ceramics and PZT.