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MULTIFERROICS UNDER THE SYNCHROTRON LIGHT

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Abstract content

Synchrotron-light investigation of multiferroics, from atomic- to meso-scales, is characterized. The information contained in diffraction peaks gives the long-range space-time average structure. It provides the general structure diagram, precise lattice parameters and average atomic positions. In synchrotron applications, diffraction is highly sensitive to symmetry breaking. Space/time deviations from mathematical periodicity decrease diffraction maxima and generate diffuse scattering. Research using ferroelectric diffuse scattering in the three-dimensional vicinity of Bragg peaks represents a current tendency aimed at clarifying the static and dynamic characteristics of ferroelectrics above the Curie temperature Tc. The final objective is to elucidate the gestation of ferroelectricity from the paraelectric state. Two models that represent extremes in the existing diversity of approaches are: a) (Solid state physics) –> Softening of the dynamic chains of correlated displacements that form the transverse optical (TO) modes. b) (Quantum chemistry) –> Static linearly ordered displacements that have short range in the paraelectric phase and show long-range order in the ferroelectric phase. Extended X-ray Absorption Fine Structure (EXAFS) investigation is briefly considered. This technique focuses on the determination of a few short-range structural characteristics invisible for the averaging eyes of diffraction techniques. X-ray Absorption Near Edge Structure (XANES) offers information on oxidation state of the absorbing element and in general on the electronic structure of the target element's bonds. Representative studies performed by the CIMAV Crystal Physics Group are presented. Considered cases include subtle symmetry break-downs in perovskite-related compounds, local-order phenomena and thin films texture analyses. Synchrotron-crystallography software development by the group is divulgued: - Software package "ANAELU" models 2D diffraction patterns produced by textured thin films, thus allowing the interpretation of complex patterns. - Program SAMZ permits the estimation of effective values for polycrystal dielectric, piezoelectric, magnetoelectric and elastic coefficients under the Voigt, Reuss and Hill approximations. Portions of this research were carried out at the Stanford Synchrotron Radiation Lightsource, a national user facility operated by Stanford University on behalf of the U.S. Department of Energy, Office of Basic Energy Sciences. Support from CONACYT-Mexico (Project 102171) is gratefully acknowledged.

Summary

Synchrotron radiation diffraction, scattering and absorption spectroscopy are among the most powerful tools employed today for the investigation of ferroic materials' fine structure. A comparative review of the mentioned techniques, as applied to bulk and nano-structured ferroelectric and magnetoelectric samples is presented and illustrated by means of practical examples. Crystallographic texture plays a significant role on multiferroic bulk and nano-structured materials. Texture analysis by means of two-dimensional (2-D) diffraction experiments and the role of texture on multiferroic physical properties are discussed.

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