DF 1: Tutorial "Basics of Dielectric Solids"

Time: Sunday 14:00–17:00 Location: H11

Tutorial DF 1.1 Sun 14:00 H11

Fundamentals of dielectric solids — •Horst Beige — Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Physik ferroischer Materialien, Friedemann-Bach-Platz 6, 06108 Halle/S.

Dielectric solids have received increasing attention in recent years, both from a fundamental perspective and from a novel applications viewpoint. There are three major trends which led to this emphasis.

One trend concerns the fact that advanced functional components are made of material systems rather than of discrete materials. Material integration issues play an increasing important role driven by the interest in integrating functions of dielectric solids into conventional semiconductor chips as well as for the evolution of multifunctional components and systems.

A second trend is the scaling of the structure size into the sub 100nm regime.

A third trend concerns the role of theory and modeling. The materials and device design are more and more accompanied and guided by modeling, e.g. by thermodynamics, finite-element methods, and ab-initio calculations.

This lecture gives an introduction to basic principles of symmetry classification, dielectric polarization, elastic, dielectric and electromechanical properties. The Landau-Ginzburg-Devonshire theory and the soft mode concept for the phase transition from an unpolar to a polar phase are also topics of this paper.

Tutorial DF 1.2 Sun 15:00 H11

Experimental determination of linear and nonlinear material properties of dielectric solids — •Martin Diestelhorst — Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, Friedemann-Bach-Platz 6, 06108 Halle

Dielectrics are interesting for many applications due to their elastic, electromechanic and dielectric properties. Often it is sufficient to know the linear coefficients like elastic compliance, piezoelectric coefficient and dielectric permittivity. A wide variety of experimental methods exist to determine these linear properties. Increasing the accuracy of measurements it becomes obvious that all of these properties are nonlinear. They depend on the amplitudes of external influences, e.g. the dielectric permittivity depends on the amplitude of the external electric field as well as on the external elastic stress. These higher order coefficients may be measured applying high electric fields or/and high elastic stresses to the samples under test. Additionally the progressive miniaturization often causes nonlinear behaviour, since e.g. even a small voltage applied to a dielectric film of few nanometers thickness corresponds to a high electric field strength along this direction. In practice nonlinear properties may be undesirable for many applications, but on the other hand there are special applications which could not be realized without these nonlinearities. Therefore it is necessary to characterize dielectric materials both concerning their linear and their nonlinear properties. The talk presents some experimental methods to allow for the determination of linear and nonlinear elastic, electromechanic and dielectric properties.

Tutorial DF 1.3 Sun 16:00 H11

Nanoscale dielectrics: Preparation, microstructure, properties — •Dietrich Hesse and Marin Alexe — Max Planck Institute of Microstructure Physics Halle, Germany

Nanoscale dielectrics, i.e. thin films, multilayers, and artificial superlattices of individual layer thicknesses in the sub-100 nm range, and small dielectric objects laterally structurized down to sub-100 nm lateral dimensions (e.g. nanowires and nanotubes, or regular arrays of nanostructures) are in the center of research due to their interesting properties, which are relevant under both fundamental and application aspects. Due to the large interface-to-volume ratio in such nanoscale structures, the properties of nanoscale dielectrics are particularly sensitive to the preparation method, and also to microstructural details like lattice defects. Thus interrelations between preparation, microstructure, and properties need particular attention and are currently a subject of intensive research. Relations of this type will be highlighted on the example of various dielectric, in particular ferroelectric, nanostructures and nano-objects, like pulsed-laser deposited thin films, superlattices, and nanostructure arrays, epitaxial nano-islands grown by chemical solution deposition, and ferroelectric nanotubes prepared using negative or positive templates. The role of interfaces and lattice defects for the properties, possible origins of ferroelectric size and imprint effects, and the influence of the crystallographic orientation will be demonstrated. The problem of distinguishing between intrinsic (material-related) and extrinsic (defect- and microstructure-related) properties of nanoscale dielectrics will be discussed.