KFM 3: Dielectric, Elastic and Electromechanical Properties

Time: Monday 9:30–11:10 Location: PHY 5.0.21

KFM 3.1 Mon 9:30 PHY 5.0.21

Piezotronic material based on ZnO-ZnO interfaces — •Maximilian Gehringer — Technische Universität Darmstadt, Darmstadt, Deutschland

In recent years, the research field piezotronics gained a lot of attention. It has been shown to have huge potential for applications like nanogenerators, gated field effect transistors and sensors. Zinc oxide nanowires that allow extensive deformation were the focus of many investigations of metal-semiconductor Schottky-barriers. However, ZnO is also well known for polycrystalline ceramics with grain boundary potential barrier. In this case, the barriers at grain boundaries inhibit electrical transport until breakdown at high voltages. Therefore, ZnO is often used for surge protection or for voltage regulation.

In this work, the possibility of using bicrystals or polycrystalline materials with high grain boundary potential barrier for piezotronic applications will be discussed. Our investigations show a large impact of mechanical stress on the linear leakage current in polycrystalline ZnO samples and bicrystals. Extensive conductivity changes could be induced in this low voltage region via application of uniaxial pressure. Hence, very high possible gauge factors (figure of merit for the use in strain/stress sensors) around 1000 can be obtained. Commercial sensors can reach only a factor of 200 so far. A physical model will be introduced to explain the observed behavior and the results are compared with single crystal metal-ZnO Schottky barrier investigations. Evidence will be provided for varistor boundaries showing enhanced piezotronic properties compared to metal-ZnO Schottky barriers.

KFM 3.2 Mon 9:50 PHY 5.0.21

Characterization of extremely small nonlinearities of dielectric response in glasses and glass ceramics — •Florian Bergmann[1,2], Martin Letz[1,2], Gerhard Jakob[1], and Holger Maune[3] — [1]Johannes Gutenberg Universität Mainz — [2]Schott AG Mainz — [3]TU Darmstadt

The 5G mobile communication standard aims to provide massive data rates to an increasing number of devices. This requires the use of higher frequencies and the efficient use of the available frequencies. A major challenge in the efficient use of frequencies is cross talk between channels due to passive intermodulation (PIM). Due to the large differences in the intensity of receiving and transmitting channels, even tiniest intermodulation levels need to be controlled. One source of intermodulation is the nonlinear response of dielectrics to the electric field. However, it is hard to characterize the intrinsic material nonlinearity as the nonlinearity of the setup itself produces intermodulation. Following a resonator method exciting eigenresonances of three coupled cylindrical dielectric resonators enables to measure nonlinear behavior at high field strengths and allows isolating the resonators' material nonlinearities from other intermodulation sources. The setup enables to measure a third order nonlinear term being 10^{-10} times smaller than the linear response at electric field amplitudes of a few V/mm. We report on the characterization measurements of the nonlinearity of glasses and glass ceramics.

Break 20 min

KFM 3.3 Mon 10:30 PHY 5.0.21

Nonlocal Electrostatics: Lorentzian Kernels or Gradient Theories? — •Jakob Leck — Institut für Festkörperphysik, Technische Universität Darmstadt, Hochschulstraße 6, 64289 Darmstadt

Nonlocal electrostatics is a continuum theory to be used on small length scales when effects of spatial dispersion become relevant. A common ansatz for the kernel in the nonlocal material law is the so-called Fourier-Lorentzian-model, a sum of a local term and the Green function of a Helmholtz-type operator. This leads to a fourth order differential equation for the potential. A different approach consists in a moment expansion of the material law, which leads to a gradient theory, implying similar equations for the potential. In this talk both approaches are compared and it is argued that the gradient theory is to be preferred because it does not require ad hoc assumptions about the kernel. The gradient theory is discussed up to second order and leads to a modified and non-singular near field behaviour in potentials and fields of point charges.

KFM 3.4 Mon 10:50 PHY 5.0.21

Aligning In-Plane Polarization Multiplies Piezoresponse In P(VDF-TrFE) Films On Graphite — •Robert Roth[1], Martin Koch[1], Jakob Schaab[2], Martin Lilienblum[2], Frank Syrowatka[3], Tino Band[1], Thomas Thurn-Albrecht[1], and Kathrin Dörr[1] — [1]Institute of Physics, Martin Luther University Halle-Wittenberg, Halle, Germany — [2]Department of Materials, ETH Zürich, Zürich, Switzerland — [3]Interdisciplinary Center of Materials Science, Martin Luther University Halle-Wittenberg, Halle, Germany

Ferroelectric polymers are attractive candidates for functional layers in electronic devices like non-volatile memories, piezo- and magnetoelectric sensors. However, thin films often reveal reduced di- and piezoelectric responses due to crystalline disorder and resulting non-aligned electrical dipoles leading to compensation effects. We will present results on controlled aligning of both in-plane and out-of-plane ferroelectric polarization in several 10 nm thick poly(vinylidene fluoride-co-trifluoroethylene) (P(VDF-TrFE)) films on graphite with a force microscope [1]. Micron-sized domains with well-defined shape can be written by a combined procedure of electrical poling and mechanical tip pressure scanning. The achieved uniform polarization orientation leads to strong enhancement in both, vertical and lateral piezoresponse. By variation of parameters, domain walls with defined angle can be formed within these areas and diverse special domain structures can be generated. This allows one to overcome compensation effects and get distinct domain patterns beneficial for various device applications.

[1] R. Roth et al., New J. Phys. 20 (2018), 103044.