DF 7: Dielectric and ferroelectric thin films

Time: Tuesday 14:00–16:00 Location: H11

DF 7.1 Tue 14:00 H11

Electrode polarization from a different point of view — •Björn Martin and Herbert Kliem — Saarland University, Germany

To investigate electrode and space charge effects thin film capacitance structures using ion-conducting polyethylene oxide contacted with metal electrodes are prepared.

In contrast to continuum models a discrete three-dimensional model is developed to describe the ionic motion. Single charges are regarded. Negative ions can fluctuate thermally activated over energy barriers in a multiwell potential. Positive immobile ions provide charge neutrality. Interactions of the ions with the electrodes using the method of images and all other electrostatic interactions are considered.

In simulations a coulombic attraction between the mobile ions and their image charges in the electrodes is found even in short circuit condition. The accumulated ions trapped at the electrodes together with their image charges yield dipole like fields repelling further ions towards the volume of the samples leaving behind a positive depletion zone. Thus, a maximum of the internal potential results in the middle of the sample which is verified experimentally.

With applied voltage the ions are partly detrapped. The mobile ions are shifted to the positive electrode and a broad depletion zone with positive immobile charges arises at the negative electrode. Therefore, a high potential drop is found here. In the bulk the potential increases only slightly indicating no space charges in this region.

DF 7.2 Tue 14:20 H11

Non-Kolmogorov-Avrami-Ishibashi switching dynamics in nanoscale ferroelectric capacitors — •Yunseok Kim[1], Hee Han[2], Woo Lee[3], Sunggi Baik[2], Dietrich Hesse[1], and Marin Alexe[1] — [1]Max Planck Institute of Microstructure Physics, D-06120 Halle (Saale), Germany — [2]Department of Materials Science and Engineering, Pohang University of Science and Technology (POSTECH), Pohang 790-784, Republic of Korea — [3]Korea Research Institute of Standards and Science (KRISS), Daejeon 305-340, Republic of Korea

The electrical polarization in ferroelectrics has two stable states which can be switched by applying an external electric field. The polarization switching mechanisms in macroscopic systems are usually treated within the framework of nucleation and growth theory, i.e. the Kolmogorov-Avrami-Ishibashi (KAI) model. Although there have been many efforts to understand switching dynamics, there is still lack of information on the switching dynamics mostly on nanoscale systems. The switching dynamics of nanoscale capacitors different from their macroscopic counterparts.Moreover, direct studies on nanoscale capacitors remain a challenge. Here we present switching dynamics of nanoscale capacitors with a radius of 35 nm using piezoresponse force microscopy. Polarization switching starts with only one nucleation event occurring only at a pre-determined place. The switching dynamics of nanoscale capacitors do not follow the classical KAI model. Based on the consideration of two separate (nucleation and growth) steps within a non-statistic finite system, we propose a new non-KAI model which is in good agreement with the experimental results.

DF 7.3 Tue 14:40 H11

Nonlinear Frequency Response of Ferroelectric Thin Films — •Kay Barz, Martin Diestelhorst, and Horst Beige — Martin Luther-Universität Halle-Wittenberg

The dielectric properties of ferroelectric thin films are commonly studied by means of low-frequency or quasi-static methods (capacitance-voltage, current-voltage, hysteresis). We pursue a different approach by investigating the frequency response of a LCR series-resonant circuit containing a ferroelectric thin film as capacitance. The talk presents amplitude-frequency responses observed at different types of thin film samples (Metal/Oxid,Semiconductor (MOS), Metal/Ferroelectric/Metal (MFM), Metal/Ferroelectric/Semiconductor (MFS)).

The results on MFM structures show, how hysteresis and its transient alterations due to fatigue manifest in a shift of resonance frequency under increasing or decreasing driving amplitude. In the circuit configuration used to obtain the time series data, the MOS and MFS structures become electrostatically charged by the ac amplitude. In case of the MFS capacitor, in this charged state, a strange non-chaotic attractor can be observed. Thus, ferroelectric thin films and ferroelectric/semiconductor heterostructures provide experimental access to some interesting phenomena known from theory of nonlinear dynamics.

DF 7.4 Tue 15:00 H11

Study of P3HT/PCBM based films by NEXAFS — •Matthias Richter, Daniel Friedrich, Shine Philip, Ioanna Paloumpa, Klaus Mueller, and Dieter Schmeisser — Brandenburg University of Technology Cottbus, Applied Physics and Sensors, K.-Wachsmann-Allee 17, 03046 Cottbus, Germany

In this contribution we report on investigations of the electronic structure and composition of regioregular poly(3-hexylthiophene) (P3HT) and phenyl-C_{61}-butyric acid methyl ester (PCBM) based films by using Near Edge X-Ray Absorption Fine Structure (NEXAFS). The measurements were done at the U49/2-PGM2 beam line of BESSY II, Berlin using TEY (total electron yield) and TFY (total fluorescence yield) detection. The samples were produced by spin casting a mixture of P3HT (dissolved in chloroform) and PCBM (dissolved in chlorobenzene) on ITO (indium tin oxide) coated glass slides. Measurements of pure P3HT and PCBM show all typical excitations, whereas the blended system is a weighted superposition of the related peaks. Analyzing these weighted superposition, we observe in the surface sensitive TEY data an accumulation of P3HT, whereas in the bulk sensitive TFY signal an as expected mixture is found. We also show angular dependent NEXAFS measurements of the P3HT/PCBM blend in order to measure the orientation and distribution of the P3HT polymer. Additionally, we will show a new approach for organic solar cell application by introducing ferroelectric nanoparticles into the mixture.

DF 7.5 Tue 15:20 H11

Untersuchungen zum elektrischen Durchschlag in weichen Elastomermaterialien — •Matthias Kollosche, Hristiyan Stoyanov und Guggi Kofod — Universität Potsdam, Potsdam, Deutschland

Der Einfluss von Materialeigenschaften auf das elektrische Durchschlagsverhalten in weichen Materialien ist von vielfältigen Interesse bei der Verwendung von Smart Materials. Durch die Verwendung von Mischungen aus zwei chemisch identischen thermoplastischen Elastomeren gelingt eine Variation der Materialeigenschaften bei konstanter Temperatur, ohne zusätzliche Wechselwirkungen. Kraft-Dehnungs Versuche belegen die Möglichkeit einer kontinuierlichen Variation des Youngs Moduls durch die gezielte Wahl des Massenverhältnisses der Elastomermaterialien. Für die Ausführung der elektrischen Durchschlagsversuche wurden die Elastomermaterialien in Lösung und anschließend auf einem Glasträger mit Elektrode gebracht und getrocknet. Die Untersuchungen an den präparierten Polymerfilmen zeigen die Abhängigkeit der Durchbruchsfeldstärke von den mechanischen Eigenschaften des verwendeten Polymerfilms. Diese Ergebnisse werden mit dem ursprünglichen Modell zur elektromechanischen Instabilität von Garton-Stark und dem Modell von X. Zhao und Z. Suo (Appl. Phys. Lett. 95, 031904 (2009)) verglichen und ein verbesserter Ansatz zur Materialbeschreibung präsentiert. Das vorgeschlagene Modell ermöglicht, durch die Verwendung des hyperelastischen Materialansatzes und angepasster Randbedingungen, eine Beschreibungsmöglichkeit für den elektrischen Durchschlag in weichen Materialien

DF 7.6 Tue 15:40 H11

$CaTiO_3$ as a high-k dielectric in thin MIM Capacitor stacks — •Andreas Krause[1], Walter M. Weber[1], Andreas Jahn[2], Ulrich Merkel[2], Matthias Albert[2], Uwe Schroeder[1], Johann W. Bartha[2], and Thomas Mikolajick[1] — [1]namlab gGmbh, D-01187 Dresden — [2]Institut fuer Halbleiter- und Mikroelektronik IHM, TU Dresden

With the further increase in integration density of microelectronics, ordinary SiO_2-based dielectrics reach their limits as leakage currents increase significantly. Therefore, dielectric materials are required that combine a high dielectric constant (k) and low leakage currents. Metal Insulator Metal (MIM) stacks with the perovskite calcium titantate ($CaTiO_3$) as a high-k oxide were sputter deposited with variing thicknesses and deposition temperatures. As electrodes, different work function materials were used: Pt, Ru, TaSiN, TiN. Optimizing the rough-

ness and deposition parameters of the electrodes, a k-value of 51 is reached with a capacitance equivalent thickness targeting 1nm. The leakage currents for 15 nm thick $CaTiO_3$ films are about $1 \cdot 10^{-7} A/cm^2$ at 1 V, which is in agreement with the ITRS roadmap of 2013. The morphology was studied with atomic force microscopy and scanning electron microscopy. Capacitor-voltage measurements were performed to extract the k-value. In addition, the crystallinity of the oxide and metal electrode was investigated with variable temperature x-ray defraction measurements, showing clearly the transition from the amorphous to the crystal state in dependence of the temperature.