DS 21: High-k Dielectric Materials - Synthesis, Properties, Applications

Time: Wednesday 14:30–16:30 Location: H 2032

Invited Talk DS 21.1 Wed 14:30 H 2032

Challenges and Chances with new materials in semiconductor device applications — •Stefan Jakschik and Karl-Heinz Küsters — Qimonda Dresden GmbH & Co. OHG, Königsbrücker Strasse 180, 01099 Dresden, Germany

With entering sub 50nm nodes transistor scaling is leaving the era of traditional scaling and performance gain as well as miniaturization is achievable only by introducing further innovative performance boosters. A continuous key question of scaling is leakage control and voltage scaling which is answered nowadays by introducing materials with a high dielectric constant in MOS transistors, DRAM capacitors and FLASH storage devices. Opening the integration choice to new materials gives the chance to choose the effective oxide thickness and the work-function according to specific device requirements. On the other hand many new questions have to be answered.

We will show ways to design the threshold voltage of MOS devices with the right material choice, highlighting here Hf-oxide and scaled silicon oxide based systems with Titanum and Tantalum containing electrodes. Special attention is given to channel design options like fluorine and nitrogen implants as well as silicon germanium quantum wells. Investigating more thoroughly the dielectric, traps and charges has to be taken into account. These influence the leakage current as well as the reliability of the devices. Especially FLASH devices have a rigid leakage requirement though scaling is driving the application of high dielectric constant materials here as well. Among others Aluminiumoxide and Dysprosiumoxide based solutions are presented.

Invited Talk DS 21.2 Wed 15:00 H 2032

Are Optical Measurements Sensitive to Quantum Confinement? — •Alain Diebold — College of Nanoscale Science and Engineering, Albany, NY USA

Nanofabrication methods have produced ultra-thin films, nanowires of various cross-sectional shapes, and quantum dots. Characterization of nano-scale materials has proven the existence of quantum confinement or quantum size effects (QSE). Of note to the characterization community is observation of QSE in thin metal films using X-ray Photoelectron Spectroscopy. This presentation emphasizes optical observation of quantum confinement in ultra-thin silicon semiconductor films. The first step in identifying changes in optical properties, especially the dielectric function, is demonstrating that the data is not due to other phenomena such as stress. We show that the blue shift E1 critical point of thin silicon on insulator films is not due to stress. This blue shift is attributed to quantum confinement. We also discuss why energy shifts in E1 smaller than KT can be observed optically.

DS 21.3 Wed 15:30 H 2032

Broadband dielectric response of $CaCu_3Ti_4O_{12}$: significant intrinsic properties — •Stephan Krohns[1], Christian Kant[1], Torsten Rudolf[1], Franz Mayr[1], Peter Lunkenheimer[1], Stefan Ebbinghaus[2], and Alois Loidl[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany — [2]Solid State Chemistry, Universitiy of Augsburg, 86135 Augsburg, Germany

For applications, e.g., in wireless electronics, materials with colossal dielectric constant are in great demand. Since first reports of very large ("colossal") dielectric constants ϵ' up to the order of 10^5 in $CaCu_3Ti_4O_{12}$ (CCTO), this material is in the focus of scientific and technical interest [1,2]. Not only the understanding of the origin of the most likely extrinsic colossal ϵ' values is important, but also the clarification of the intrinsic dielectric properties is of high relevance. By combining dielectric and optical methods, we provide dielectric spectra of CCTO covering 15 decades in frequency. Aside of its colossal dielectric constant, CCTO behaves unusual also in other respects. For example, we report an unusual temperature dependence of the low lying phonon modes, revealing a softening that may point to an underlying ferroelectric instability in this material. In addition, information on electronic excitations in CCTO is provided [3].

[1] C.C. Homes et al., Science 293, 673 (2001). [2] S. Krohns et al., Appl. Phys. Lett. 91, 022910 (2007). [3] Ch. Kant et al., arXiv:0709.1065

DS 21.4 Wed 15:45 H 2032

Modelling a nanoscale ferroic OFET — •Sibylle Gemming[1], Gotthard Seifert[2], Andrey Enyashin[2] und Lukas M. Eng[3] — [1]Forschungszentrum Dresden-Rossendorf, D-01314 Dresden, Germany. — [2]Fachbereich Chemie, Technische Universität Dresden, D-01062 Dresden, Germany. — [3]Institut für Angew. Physik und Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany.

The present study describes an approach for the scale-bridging modelling of ferroic materials as functional elements in micro- and nanoelectronic devices. Ferroic materials are characterised by temperature-dependent complex ordering phenomena of the internal magnetic, electronic, and structural degrees of freedom with several involved length and time scales. Hence, the modelling of such compounds is not straighforward, but relies on a combination of electronic-structure-based methods like ab-initio and density-functional schemes with classical particle-based approaches given by Monte-Carlo simulations with Ising, lattice-gas, or Heisenberg Hamiltonians, which incorporate material-specific parameters both from theory and experiment. The interplay of those methods is demonstrated for device concepts based on electroceramic materials like ferroelectrics and multiferroics, whose functionality is closely related with their propensity towards structural and magnetic polymorphism. In the present case, such scale-bridging techniques are employed to aid the development of an organic field effect transistor on a ferroelectric substrate generated by the self-assembly of field-sensitive molecules on the surfaces of ferroic oxides.

DS 21.5 Wed 16:00 H 2032

Molecular beam deposition of $LaLuO_3$ thin films with high dielectric constant and low leakage current — •J. M. J. Lopes, U. Littmark, M. Roeckerath, St. Lenk, J. Schubert, and S. Mantl — Institute of Bio- and Nanosystems and Center of Nanoelectronic Systems for Information Technology, Research Centre Juelich, D-52425 Juelich, Germany

Although the introduction of hafnium-based high-κ dielectrics in the next CMOS generation has been announced, the implementation of materials with a dielectric constant even higher than 20 will be required in order to satisfy the future demands in CMOS applications. In this contribution, we report on lanthanum lutetium oxide, a ternary rare-earth based material that has recently appeared as a promising candidate[1]. $LaLuO_3$ thin films were grown on (100) Si substrates by molecular beam deposition and electrically characterized by capacitance-voltage (C-V) and current-voltage (I-V) measurements. Additionally, a combination of characterization methods such as Rutherford backscattering spectrometry, transmission electron microscopy, X-ray reflectometry, and X-ray diffraction were used to study their composition and microstructural characteristics. We will present results of a systematic investigation on the film preparation, which allowed the deposition of $LaLuO_3$ thin films with EOT $\leq 1.5\,nm$, low leakage current densities of about $5\,mA/cm^2$ at -1 V gate bias, and higher κ-values around 30.

[1]J. M. J. Lopes et al. Appl. Phys. Lett. 89, 222902 (2006).

DS 21.6 Wed 16:15 H 2032

Preparation, morphology and physical properties of nano-$Ln_{1*x}Sr_xMnO_3$ perovskites — •Rafal J. Wiglusz[1], Wieslaw Strek[1], Dariusz Hreniak[1], Glikeria Kakali[2], Anna Gaki[2], and Miroslaw Miller[3] — [1]Institute of Low Temperature and Structure Research, Polish Academy of Sciences,, ul. , Okolna 2, 50-422 Wrocław, Poland — [2]Chemical Engineering Department National Technical University of Athens 9 Heroon, Polytechniou Str., 15773 Athens, Greece — [3]Chemical Department, Wroclaw University of Technology, Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland

The nano-$Ln_{1*x}Sr_xMnO_3$ perovskites (where Ln is La, Sm or Tb) are the important materials for the Solid Oxide Fuel Cells (SOFC). In present work, the glycine/nitrate powder synthesis has been described using a unique combination of metal nitrates and glycine stoichiometrically, which produces nano-particles. The obtained nano-powders have been characterized by X-Ray Diffraction (XRD) and Transmission Electron Microscopy (TEM) studies. The effect of grain sizes of nano-crystallites on the optical, magnetic and electrical properties has been studied and discussed.