DF 5: High-k and low-k Dielectrics

Time: Monday 15:00–17:00 Location: WIL B321

DF 5.1 Mon 15:00 WIL B321

Dielectric properties of $A_{2/3}Cu_3Ti_4O_{12}$ (A = La, Pr, Nd, Sm, Eu, Gd, Tb, Dy) — •Jürgen Sebald[1], Stephan Krohns[1], Peter Lunkenheimer[1], Stefan Riegg[2], Stefan G. Ebbinghaus[3], and Alois Loidl[1] — [1]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany — [2]Solid State Chemistry, University of Augsburg, 86135 Augsburg, Germany — [3]Institute for Chemistry, Martin-Luther University Halle-Wittenberg, 06120 Halle, Germany

New materials showing the phenomenon of a very high dielectric constant ($\epsilon' > 10^3$), similar to the famous $CaCu_3Ti_4O_{12}$ (CCTO), are in the focus of scientific interest. Materials with extremely high ("colossal") dielectric constants (CDC) are urgently needed for future electronics. Today it is more or less commonly accepted that the CDC is due to extrinsic effects like "internal barrier layer capacitors"(IBLC) or "surface barrier layer capacitors"(SBLC). Polarisation effects at grain boundaries or other internal barriers can generate nonintrinsic colossal values of ϵ' (IBLC). In addition, SBLCs, arising, e.g., from a formation of Schottky diodes at the contact-bulk interfaces, can generate a contribution to the colossal value of ϵ' as has been shown for $CaCu_3Ti_4O_{12}$. To investigate these models and to search for alternatives for CCTO, frequency- and temperature-dependent dielectric measurements on differently treated samples of various CCTO related materials were performed. To check for possible correlations of magnetic structure and dielectric properties, magnetic-field dependent dielectric spectroscopy was carried out.

DF 5.2 Mon 15:20 WIL B321

Characterization of $(SrO)_x(ZrO_2)_{(1-x)}$ thin films for use in metal insulator metal capacitors — •Matthias Grube[1], Oliver Bierwagen[2], Dominik Martin[1], Lutz Geelhaar[3], and Henning Riechert[3] — [1]Namlab GmbH, 01187 Dresden — [2]University of California, Santa Barbara 93106 CA, USA — [3]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin

$(SrO)_x(ZrO_2)_{(1-x)}$ is a promising candidate as high-k dielectric for metal-insulator-metal capacitors of future memory cells. The dielectrics were grown by co-evaporating SrO from a high temperature effusion cell and ZrO_2 from an electron beam evaporator in a molecular beam deposition chamber. As substrates, n^{++}-Si-wafers were used that were covered with a pre-deposited 5 nm-thin TiN layer. In order to reveal the correlation between process conditions and film properties, especially high-k values and leakage currents, a series of samples with different thicknesses ranging form 10 to 40 nm were fabricated while the growth temperature was varied from 100°C to 800°C. X-ray fluorescence analysis (XFA) and X-ray reflectometry (XRR) were employed to determine the thickness and the stoichiometry of the films, while the electrical properties of the dielectrics were determined through current-voltage and capacitance-voltage measurements before and after a post deposition anneal.

DF 5.3 Mon 15:40 WIL B321

Ternary rare-earth based alternative gate-dielectrics for future integration in MOSFETs — •Jürgen Schubert, Joao Marcelo Lopes, Eylem Durgun Özben, Roman Luptak, Steffi Lenk, Willi Zander, and Martin Roeckerath — IBN 1-IT, Forschungszentrum Jülich, 52425 Jülich

The dielectric SiO_2 has been the key to the tremendous improvements in Si-based metal-oxide-semiconductor (MOS) device performance over the past four decades. It has, however, reached its limit in terms of scaling since it exhibits a leakage current density higher than 1 A/cm^2 and does not retain its intrinsic physical properties at thicknesses below 1.5 nm [1,2]. In order to overcome these problems and keep Moore's law ongoing, the use of higher dielectric constant (k) gate oxides has been suggested. These high-k materials must satisfy numerous requirements such as the high k, low leakage currents, suitable band gap und offsets to silicon. Rare-earth based dielectrics are promising materials which fulfill these needs. We will review the properties of $REScO_3$ (RE = La, Dy, Gd, Sm, Tb) and $LaLuO_3$ thin films, grown with pulsed laser deposition, e-gun evaporation or molecular beam deposition, integrated in capacitors and transistors. A k > 20 for the $REScO_3$ (RE = Dy, Gd) and around 30 for (RE = La, Sm, Tb) and $LaLuO_3$ are obtained. Transistors prepared on SOI and sSOI show mobility values up to 380 cm^2/Vs on sSOI, which are comparable to such prepared with HfO_2. [1] X. Gou, and T. P. Ma, IEEE Electron Device Lett. 19, 207 (1998). [2] D. A. Muller, T. Sorsch, S. Moccio, F. H. Baumann, K. Evans-Lutterodt, and G. Timp Nature 399, 758 (1999).

DF 5.4 Mon 16:00 WIL B321

The deposition of rare-earth oxide ultrathin-films with inorganic precursors — •Maraike Ahlf[1], Hanno schnars[1], Oliver Skibitzki[1], Marvin Zöllner[1], Katharina Al-Shamery[1], Mareike Ahlers[2], and Mathias Wickleder[2] — [1]University of Oldenburg, Institute for Pure and Applied Chemistry, Physical Chemistry I — [2]University of Oldenburg, Institute for Pure and Applied Chemistry, Inorganic Chemistry

Semiconductor industry is searching for new materials as gate-oxides in MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) because the goal to shrink the size is limited due to the quantum mechanical tunnelling of electrons through a very thin oxide layer. Therefore it is necessary to replace the conventionally used gate-oxide material SiO_2 by new metarials with higher κ-value and a bigger band gap, which could be rare-earth oxides (REO's) e.g..To prevent interfacial layers of SiO_2 in our investigation, the Si-wafers are prepared by a wet chemical etching using HF and NH_4F before depositing new RE-based inorganic precursors. The mechanism of decomposition of RE-nitrates is studied in UHV by using STM, XPS and TPD. The used precursors are expected to decompose carbonfree to form the REO and gaseous decomposition products under mild, sputter free heating conditions. Deposition is done by using a liquid injection doser, drop-cast and dip applying different organic solvents. SEM and HRTEM images are utilized to assess the effectiveness of the different deposition conditions to form uniform, defectfree REO-ultrathin-films on Si with filmthickness of less then 10 nm state of the art related to our research.

DF 5.5 Mon 16:20 WIL B321

High performance MIM capacitors with Atomic Vapour Deposited HfO_2 dielectrics — •Mindaugas Lukosius, Christian Wenger, Christian Walczyk, and Hans-Joachim Müssig — IHP, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Metal-Insulator-Metal (MIM) capacitors are widely used in ICs for Radio-Frequency (RF) applications. Currently, capacitors fabricated by performing MIM structures use silicon oxide or silicon nitride as an insulating layer. However the capacitance density of these materials is limited by low dielectric constant values. Therefore, for further integration of passive components such as capacitors into CMOS devices, dielectric materials with higher permittivity than SiO_2 (k = 3.9) are required. Using the high dielectric constant (high-k) material HfO_2 as a dielectric in MIM capacitor seems to be a very promising approach. Atomic Vapour Deposition (AVD*) technique was used for the preparation of hafnium oxide films on 20nm TiN/2nmSiO_2/Si (200mm) substrates using $Hf(NEtMe)_4$ precursor for MIM applications in back-end of line (BEOL). The influence of process temperature (320 - 425 °C) and process pressure (2-10mbar) on the structural and electrical properties of HfO_2 were investigated. The optimized dielectric layers obtained at 320 °C and 4 mbar possess k value of 18, capacitance density of 3.5 $fF/\mu m^2$ combined with required capacitance voltage linearity (<100 ppm/V^2) and quality factor of 50. Films with thickness of 35 nm exhibit leakage current density of $2\cdot10^{-7}$ A/cm^2 and breakdown strength of 5.8 MV/cm, therefore AVD* deposited HfO_2 layers are possible alternative dielectric candidates for MIM applications.

DF 5.6 Mon 16:40 WIL B321

Growth investigation of thin Ti-based high-k films — •Andreas Krause, Dominik Martin, Matthias Grube, and Walter M. Weber — namlab gGmbH, D-01187 Dresden

With the further increase in integration density of microelectronics, ordinary SiO_2-based stacks reach their limits as leakage currents increase significantly. Therefore, dielectric materials are required that combine a high dielectric constant (k) and low leakage currents, such as Ti-based oxides. Different titanates, like $HfTiO_x$ or $CaTiO_x$ with thicknesses up to 100 nm were deposited via an UHV sputtering tool. As substrates, n^{++}-Si-wafers were used as well as Si-wafers coated with TiN or noble metal (Ru, Pt) layers. The morphology was studied with atomic force microscopy and capacitor-voltage measurements were performed to extract the k-value.