DF 11: High-k and Low-k Dielectrics I (Joint Session DS/DF)

Time: Wednesday 9:30–11:00 Location: H8

DF 11.1 Wed 9:30 H8

Spectroscopic investigations of interaction between C_{60} fullerene and nitrogen atom from amine group — •Jolanta Klocek[1], Daniel Friedrich[1], Kostyantyn Zagorodniy[2], and Dieter Schmeisser[1] — [1]Brandenburgische Technische Universität, LS Angewandte Physik-Sensorik, Konrad-Wachsmann-Allee, 17, 03046, Cottbus, Germany — [2]Institute for Solid State and Materials Research, IFW Dresden, PF 270116, D-01171 Dresden, Germany

We investigated interactions between fullerene molecule and amine group from 3-aminopropyl-trimethoxysilane (3AT). Theoretical calculations show that the material obtained as a result of interactions between 3AT and C_{60} fullerene may have extremely low dielectric constant around 1.6, so it could be considered as a candidate for ultra low-k (ULK) material applications. We prepared films composed of 3AT and fullerene by using two preparation techniques: spin-coating and evaporation. Interactions between these two components were investigated by using X- ray photoelectron spectroscopy (XPS) and Near Edge X-ray Absorption Fine Structure Spectroscopy (NEXAFS). We found that there are strong chemical reactions between the nucleophilic nitrogen atom from 3AT and electrophilic fullerene molecule. Results of NEXAFS measurements suggest that due to direct interactions between 3AT and C_{60} the shape of fullerene molecule is changed.

DF 11.2 Wed 9:45 H8

The influence of elastic and inelastic processes on trap assisted tunnelling through thin dielectric films — •Grzegorz Kozlowski, Jarek Dabrowski, Piotr Dudek, Gunther Lippert, and Grzegorz Lupina — IHP, Im Technologiepark 25, 15236 Frankfurt (Oder) , Germany

Impurities or structural imperfections of the crystal may introduce discrete electronic states (or a band when defects interact with one another) into the band gap of the dielectric. Electrically active defects can be used in a trap assisted tunnelling (TAT) process giving a noticeable contribution to the leakage and to the total current.

We developed a simple quantum mechanical model to investigate the role of defects in leakage current through thin dielectric films for future DRAM applications. The influence of image force as well as a possible charge state of an empty trap was considered. The results of numerical simulation were used to characterize the electrical behaviour of thin dielectric films at different temperatures. The temperature dependence may come from two phenomena. The first one is the Boltzmann distribution of charge carriers in the electrodes. In a limited way one can reproduce the temperature dependence of the leakage by considering various distribution of defects in energy and position in the film. This approach is however insufficient to reproduce the dependence in the whole regime of applied voltages. We thus expanded our model by including an additional type of process, i.e. the electron-phonon coupling which gave rise to non-radiative multiphonon processes.

DF 11.3 Wed 10:00 H8

Electrically optimized high-κ metal gate MOSFET by specific modification of the band alignment — •Łukasz Starzyk, Massimo Tallarida, and Dieter Schmeisser — Brandenburgische Technische Universität, Angewandte Physik-Sensorik, Konrad-Wachsmann-Allee 17, Cottbus D-03046, Germany

The electrical optimization of metal/oxide/semiconductor gate stacks by specific modification of the band alignment for advanced MOS technology incorporating high dielectric constant (κ) materials is explored. Because of requirements concerning continued scaling of MOSFET transistors, gate oxides and cobalt electrode have been grown successively on Si substrate respectively by means of atomic layer deposition (ALD) and evaporation. The thicknesses of high-κ films were around 2 nm. In case of work function engineering, interfaces' chemistry plays a fundamental role. We applied synchrotron radiation based x-ray photoelectron spectroscopy (SR XPS) to characterize our samples, which allows step by step *in situ* investigations. Co 2p, Al 2p, Hf 4f, Si 2p and O 1s core levels spectra were measured and analyzed. From valence band (VB) spectra we determined Schottky barrier height and electronic bands offsets.

DF 11.4 Wed 10:15 H8

A comparison of $(SrO)_x(ZrO_2)_{(1-x)}$ and ZrO_2 as potential high-k dielectric for future memory applications — •Matthias Grube[1], Dominik Martin[1], Walter Michael Weber[1], Thomas Mikolajick[1], Lutz Geelhaar[2], and Henning Riechert[2] — [1]Namlab GmbH, 01187 Dresden — [2]Paul-Drude-Institut für Festkörperelektronik, 10117 Berlin

Following the demands of the aggressive downscaling of the capacitor area of dynamic random access memories, a material screening of novel high-k dielectrics with nanometer-scale thicknesses is required. Pure ZrO_2 and admixtures with SrO are promising examples as possible substitutes for the established materials. Their growth, their physical and electrical characterization is our contribution to the screening. We employed molecular beam deposition to grow thin layers of $(SrO)_x(ZrO_2)_{(1-x)}$ on n^{++}-Si substrates with a predeposited 5nm thin TiN layer as bottom electrode to realize metal-insulator-metal structures. An extensive physical characterisation consisting of X-ray diffraction, X-ray fluorescence analysis, X-ray reflectometry and atomic force microscopy was performed to verify the crystallinity, the stoichiometry, the physical thickness and the surface morphology of the dielectric film itself. The interface between the dielectric and the bottom electrode was investigated by transition electron microscopy. I-V and C-V measurements revealed k-values consistent to the literature for ZrO_2. However, for $(SrO)_x(ZrO_2)_{(1-x)}$ rather low k-values below 9 for films up to 20 nm and much higher k-values of about 50 for films of 40 nm thickness were observed. Those dependencies will be discussed.

DF 11.5 Wed 10:30 H8

Nanoscale analysis of the electric properties of ultra thin ZrO_2-, $(ZrO_2)_x(Al_2O_3)_{1-x}$- and $ZrO_2/Al_2O_3/ZrO_2$-films. — •Dominik Martin[1], Matthias Grube[1], Elke Erben[1], Wenke Weinreich[2], Uwe Schröder[1], Lutz Geelhaar[3], Walter Weber[1], Henning Riechert[3], and Thomas Mikolajick[1] — [1]namlab Gmbh, D-01187 Dresden — [2]Fraunhofer-CNT, D-01099 Dresden — [3]Paul-Drude-Institut für Festkörperelektronik, D-10117 Berlin

In order to achieve an high k-value in sub 10 nm thin films of ZrO_2 it is necessary to reach the tetragonal crystalline phase. This is done by either depositing the layer at higher temperatures or by a post deposition annealing step. Both however induce high leakage current through the layer. Small amounts of Al_2O_3 can be incorporated in ZrO_2 to reduce leakage current. In order to understand the detailed charge carrier transport mechanisms, thickness series of ultra thin ZrO_2-, $(ZrO_2)_x(Al_2O_3)_{1-x}$- and $ZrO_2/Al_2O_3/ZrO_2$-films were deposited by Atomic Layer Deposition and subjected to different rapid thermal annealing processes. These layers were examined by I-V-, C-V-Spectroscopy and conductive atomic force microscopy. It is shown that Al incorporation throughout the entire layer imposes the relatively low k value of Al_2O_3 onto the entire layer. Whereas incorporation of only to cycles of Al into the center of the ZrO_2 effectively reduces leakage currents while maintaining a higher k value.

DF 11.6 Wed 10:45 H8

Atomic Vapour Deposition of TiTaO for MIM applications — •Mindaugas Lukosius[1], Canan Baristiran Kaynak[1], Christian Wenger[1], Günther Ruhl[2], and Simon Rushworth[3] — [1]IHP, Technologiepark 25, 15236 Frankfurt Oder, Germany — [2]Infineon, Wernerwerkstr. 2, 93049 Regensburg, Germany — [3]SAFC HiTech, Bromborough, Wirral, Merseyside, U.K. CH62 3QF

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 SiO2 (k = 3.8) are required. Atomic Vapor Deposition (AVD*) technique was successfully applied for the first time for depositions of TiTaO oxide films on 8-inch wafers using two separate Ti(OPri)2(mmp)2 and TBTDET precursors for MIM applications in back-end of line (BEOL). Composition, crystalinity and electrical properties such as dielectric constant, capacitance and leakage currents were studied in Au/TiTaO/TiN/Si MIM capacitors. The effect of post deposition annealing (PDA) and investigation of different top electrode materials will be also presented.