DS 9 Functional thin films II

Time: Tuesday 11:15–13:00 Room: GER 37

DS 9.1 Tue 11:15 GER 37

Characterization of Chemical Bonding in Low-K Dielectric Materials for Interconnect Isolation: XAS and EELS Study — •P. Hoffmann[1], D. Schmeisser[1], F. Himpsel[2], H.-J. Engelmann[3], E. Zschech[3], H. Stegmann[4], and J.D. Denlinger[5] — [1]LS Angewandte Physik, BTU Cottbus, Conrad-Wachsmann-Allee 17, 03046 Cottbus — [2]University of Wisconsin / Madison (USA) — [3]AMD Saxony LLC & Co KG, Dresden (Germany) — [4]Carl Zeiss NTS GmbH, Oberkochen (Germany) — [5]ALS Berkley / California (USA)

The use of low dielectric constant materials in the on-chip interconnect process reduces interconnect delay, power dissipation and crosstalk noise. In CVD deposited organo-silicate glass (OSG) the substitution of oxygen in SiO_2 by methyl groups ($-CH_3$) reduces the permittivity significantly (from 4.0 in SiO_2 to 2.6-3.3 in the OSG). However, plasma processing removes C and H containing molecular groups. Therefore, compositional analysis and chemical bonding characterization of structured films with nanometer resolution is necessary. OSG thin films as-deposited and after plasma treatment are studied using XAS and EELS. In both techniques, the fine structure near the C1s edge allows to identify C-H, C-C, and C-O bonds. XAS spectra have been recorded for non-patterned films and EELS spectra for patterned structures. The chemical bonding is compared for as-deposited and plasma-treated low-k materials. The fluorescence and the electron yield recorded while XAS measurement are compared. Examination of the C 1s near-edge structures reveal a modified bonding of the remaining C atoms in the plasma-treated sample regions.

DS 9.2 Tue 11:30 GER 37

High-k Metal-Insulator-Metal Capacitors for Radio Frequency Mixed-Signal Application — •Christian Wenger, Anil U. Mane, Roland Sorge, Guenter Weidner, Thomas Schroeder, Jarek Dabrowski, Gunther Lippert, Peter Zaumseil, and Hans-Joachim Muessig — IHP microelectronics

RF (radio frequency) SiGe technologies make it possible to integrate the RF section of wireless devices with baseband processors. The RF circuits convert the input radio signals into signals that can be converted into digital data for the baseband processor. The ADC/DAC conversion is integrated into the SiGe technology, furthermore MIM capacitors occupy a large area of the signal conversion part. Thus the introduction of high-k materials into MIM capacitors to reduce the area attracts much attention. Due to the restrict capacitance voltage linearity requirements, the electrical performance of MIM capacitors with a single layer high-k dielectric miss these requirements. However, the voltage linearity can be engineered by using a stacked structure of high-k and Silicondioxide dielectrics. Stacked MIM capacitors with high capacitance density and engineered voltage linearity will be presented.

DS 9.3 Tue 11:45 GER 37

Growth and stress evolution of reactively sputtered ZrN films — •Patrick Karimi and Matthias Wuttig — I. Institute of Physics (1A), Aachen University, 52056 Aachen, Germany

In this study we present the growth, in-situ stress evolution as well as optical properties of DC sputtered ZrN thin films grown on Si substrates. The variation of N_2 flow during the Zr deposition processes results in ZrN with different properties. Film characterization has been done by Rutherford backscattering spectroscopy (RBS), x-ray diffraction (XRD), x-ray reflectometry (XRR), in-situ stress measurements and spectroscopic ellipsometry. From the deposition characteristics it has been shown that ZrN exhibits a weak hysteresis. The deposition rate initially increases and then characteristically drops with increasing N_2 flow. RBS and GXRD studies show structure evolution from hexagonal Zr, to cubic understoichiometric ZrN and stoichiometric ZrN films. We have shown that the drop in the sputter rate by 41.5 % after the transition point is accompanied by significant drop of the (111) texture coefficient while (200) texture coefficient starts to rise sharply. Film thickness, density, surface and interface roughness were deduced from XRR experiments. The stress evolution has been explained in-terms of the bombardment and subplantation mechanism, which induces the observed increase in cell volume. Optical constants of ZrN films have been investigated by spectroscopic ellipsometry and the results are correlated with RBS and XRR experiments.

DS 9.4 Tue 12:00 GER 37

Stöchiometrische Eigenschaften von, in Atmosphärendruckplasma abgeschiedenen, SiOx-Schichten — •Marcel Hähnel, Volker Brüser, and Holger Kersten — INP Greifswald, F.-L.-Jahn Straße 19, 17489 Greifswald

Schichten, die aus siliziumorganischen Monomeren abgeschieden wurden, können zum Beispiel als UV- und Kratzschutz, als Antireflexschichten, als hydrophobe Schichten sowie für physikalisch und chemisch stabile dielektrische Schichten dienen. Ebenso zahlreich wie die Anwendungen sind auch die Untersuchungen der Eigenschaften in Abhängigkeit von den verschiedensten Prozessparametern. Die bei den PECVD-Verfahren ablaufende Plasmachemie ist, in Abhängigkeit vom eingesetzten Monomer, kaum oder gar nicht verstanden.

Das Anliegen dieser Arbeit ist die Untersuchung solcher Schichten, die aus HMDSO als Monomer in verschiedenen Argon-Sauerstoff Gemischen abgeschieden wurden sowie der Vergleich mit den in der Literatur beschriebenen Schichteigenschaften. Die Depositionen erfolgten unter Atmosphärendruck in einer dielektrisch behinderten Oberflächenentladung. Neben der starken Abhängigkeit der Kohlenstoffkonzentration in den Schichten von der Sauerstoffkonzentration des Prozessgases, werden auch Zusammenhänge der auf Silizium normierten Kohlenstoff- und Sauerstoffkonzentrationen in den Schichten vorgestellt. Aus dem Vergleich mit der Literatur wird deutlich, dass die Schichteigenschaften (z.B. SiOx-Stöchiometrie) bei den verschieden PECVD-Verfahren gleiches Verhalten in den Kohlenstoff -zu Sauerstoffkonzentrationen zeigen.

DS 9.5 Tue 12:15 GER 37

Titanium at the interface between Si and high-k silicates — •Jarek Dabrowski, Grzegorz Lupina, Gunther Lippert, Anil Mane, and Hans-Joachim Müssig — IHP, Im Technologiepark 25, 15236 Frankfurt(Oder), Germany

When a high-k film containing a high concentration of fast interface states is covered with a Ti overlayer and subsequently annealed, most of the fast states disappear. By analysing the behavior of Ti at SiO_2/Si(001) interfaces as revealed by ab initio calculations, we discuss the mechanism of this effect. Passivation by substitution is excluded because a Ti atom substituting a Si atom with a dangling bond has similar electrically active states in the gap as a Si dangling bond. Moreover, the Ti atom would not stop at the interface to substitute the Si atom, but would advance into the substrate to form a seed of a metallic Ti silicide inclusion. We may also exclude that Ti dissolved in the film induces a recombination of interfacial dangling bonds indirectly, through strain field. This is because the recombination would require a long-range reconstruction of the oxidized Si, but the passivation occurs already at 200°C. We argue that the electrically active interfacial defects passivated by Ti are valence-alternation defects associated with high compressive stress. Such defects are expected to appear in SiO_x at the very interface because the oxidation of Si occurs in a constrained manner under the high-k film. Titanium atoms dissolved in the interfacial silicate layer expell Si atoms, while the metallic Ti overlayer drains oxygen from the defected interfacial sites. This results in Si regrowth in previously strained areas

DS 9.6 Tue 12:30 GER 37

Quantenkinetic description of the electron-phonon-interaction in intersubband systems — •Stefan Butscher and Andreas Knorr — Institut für theoretische Physik, Nichtlineare Optik und Quantenelektronik, Technische Universität Berlin Hardenbergstr. 36, 10623 Berlin, Germany

The effect of quantum kinetic (non-Markovian) electron-phonon for semiconductor intersubband transitions is investigated. At low temperatures and even in weakly coupled systems we find that electron phonon interaction leads to a suppression of Coulomb binding effects. Furthermore, for the case of strong electron-phonon interaction a quantum kinetic description is important even at room temperatures.

DS 9.7 Tue 12:45 GER 37

Preparation and characterization of rare earth scandate thin films for high-κ applications — •M. Wagner[1], T. Heeg[1], J. Schubert[1], C. Zhao[2], M. Caymax[2], St. Lenk[1], and S. Mantl[1] — [1]Institute of Thin Films and Interfaces and CNI, Research Centre Jülich, D-52425 Jülich, Germany — [2]IMEC, Kapeldreef 75, B-3001 Leuven, Belgium

Rare earth scandate thin films ($GdScO_3$ and $DyScO_3$) were deposited on a native SiO_2 or HF last surface of (100) silicon substrates using either pulsed laser deposition or electron beam evaporation. The films were investigated by means of Rutherford backscattering spectrometry, high temperature X-ray diffractometry, X-ray reflectometry, transmission electron microscopy and atomic force microscopy. Capacitor stacks with metal contacts have been electrically characterized. With both deposition techniques stoichiometric amorphous films with smooth surfaces (roughness RMS $<$ 1 Å) were achieved. The amorphous phase of the films proved to be stable up to 1000°C. The films grown by pulsed laser deposition revealed featureless C-V-curves with nearly no hysteresis and a κ-value around 20 extracted from a CET plot. An interfacial SiO_2 grown during deposition could be observed. Films grown by electron beam evaporation show nearly no interfacial layer. A dielectric constant of 23 was determined. Consequently, a CET value of 1.5 nm along with a low leakage current density of 2.5×10^{-4} A/cm^2 could be achieved. The main advantage of the evaporation technique is that particulate free films can be homogeneously deposited over a wide area. A deviation of $< 5\%$ in film thickness over a 2"-wafer was obtained.