DS 30: Application of Thin Films I

Time: Thursday 14:15–16:00 Location: GER 37

DS 30.1 Thu 14:15 GER 37

Extraction of nitride trap density distribution in SONOS (silicon-oxide-nitride-oxide-silicon) structures based on an advanced thermal emission model — •Kerstin Bernert[1], Jonas Schönlebe[2], Christiane Oestreich[2], and Thomas Mikolajick[2] — [1]Forschungszentrum Dresden-Rossendorf, Bautzner Landstraße 128, 01328 Dresden — [2]Institut für Elektronik- und Sensormaterialien, Technische Universität Bergakademie Freiberg, 09599 Freiberg

As a result of continued scaling and the emphasis on low power and low voltage operation, silicon-oxide-nitride-oxide-silicon (SONOS) nonvolatile memory has received more attention recently. In this talk we investigate the charge decay characteristics of SONOS devices at elevated temperatures. Based on the thermal emission model as the dominant charge loss mechanism, the trap density energy distribution is determined. Furthermore, we present an advanced model which includes the influence of subsequent tunneling through the bottom oxide after thermal excitation in the conduction band of the nitride.

DS 30.2 Thu 14:30 GER 37

Liquid Injection Atomic layer deposition of metallic Ru and RuO_2 thin films for electrode applications — •Susanne Hoffmann-Eifert, Seong Keun Kim, and Rainer Waser — Forschungszentrum Jülich, IFF-IEM and JARA-FIT, 52425 Jülich, Germany

In this project we studied the liquid injection atomic layer (LI-ALD) deposition of metallic Ru and RuO_2 thin films for application as electrode layers. The new capacitors will be built up from ultra thin films of higher-k materials like $SrTiO_3$ or (Ba, Sr)TiO_3 in order to decrease the equivalent oxide thickness. In order to have a conducting metallic or oxide electrode available for 3D integrated capacitor structures, we investigated the ALD growth process for Ru/RuO_2 thin films in detail. In this study, RuO_2 films were deposited using traveling wave type ALD reactor. Tris(2,2,6,6-tetra-methyl-3,5-heptanedionato)ruthenium(III)(Ru(TMHD)3) dissolved in ethylcyclohexane was used as a metal source. The Ru-solution was pulse injected and evaporated in a vaporizer at a temperature of 200 °C. The growth behavior of the ALD Ru/RuO_2 films was studied as a function of the substrate temperature and the type of oxidant. The films were characterized with respect to their structural, morphological and resistance properties. Special interest is layed on the effect of the solvent on the oxidation state of the conducting Ru based thin films. A model is suggested which explains the different growth behavior of Ru/RuO_2 films in "bubbler-type"and LI-ALD-type processes.

DS 30.3 Thu 14:45 GER 37

Liquid Injection Atomic Layer Deposition of Lead Zirconate Titanate Thin Films for Three Dimensional Ferroelectric Capacitor Structures — •Susanne Hoffmann-Eifert[1], Takayuki Watanabe[1], Cheol Seong Hwang[2], and Rainer Waser[1] — [1]Forschungszentrum Jülich, IFF-IEM and JARA-FIT, 52425 Jülich, Germany — [2]Dept. of Materials Science and Engineering, Seoul National University, Seoul, Korea

In order to combine the functionality of ferroelectric oxides with semiconductor memory devices, thin films with a thickness in the range of about 10 nm have to be integrated onto 3D stack structures with lateral diameter of about 100 nm and a height in the micrometer regime. The thin films have to be homogeneous in thickness and in composition. A fully conformal deposition onto extreme 3D structures can only be achieved by means of an atomic layer deposition (ALD) process. Here, we present an approach by which uniform coverage of multi-component oxide films over complex structures can be achieved in both, the cation composition and the film thickness. Quaternary PZT films were deposited using a combination of liquid injection ALD steps of binary PbO, ZrO_x, and TiO_x films. $Pb(TMHD)_2$, Ti(Oi-Pr)$_4$, and $Zr(DIBM)_2$, dissolved in ethylcyclohexane, and H_2O were used as source materials. PZT films were grown on Pt or Ir-covered Si substrates at 240°C. A further annealing step after deposition was performed to crystallize the material. ALD-PZT films were grown onto 3D structures with homogeneous thickness and cation composition, even after crystallization.

DS 30.4 Thu 15:00 GER 37

Effect of the interface roughness on the performance of nanoparticulate zinc oxide field-effect transistors — •Koshi Okamura, Norman Mechau, Donna Nikolova, and Horst Hahn — Forschungszentrum Karlsruhe, Institute of Nanotechnology, Karlsruhe, Germany

Field-effect transistors (FETs) based on nanocrystalline inorganic materials have been attracting interests as a candidate for printable electronics. Nanocrystalline FETs take the advantage of compatibility with low-temperature and high throughput processes. However, the critical parameter of nanocrystalline FETs is the interface roughness between the nanocrystalline semiconductor and the insulator, where the channel of the FET is formed. Therefore, the correlation between the interface roughness and the performance of nanoparticulate ZnO FETs is systematically investigated. ZnO nanoparticles were dispersed in 2-methoxyethanol with stabilizer at a fixed concentration and processed by ultrasonic treatments. The agglomerate sizes were changed by the duration time, so that the resulting films had different degree of roughness at the interface. The FETs in the bottom-gate configuration were fabricated from suspensions, consisting of a Si substrate, a SiO_2 layer, a spin-coated nanoparticulate ZnO layer and Al source and drain electrodes. The FET with the lowest average roughness of 47.4 nm showed the best mobility of $8.4\cdot10^{-3}cm^2/Vs$. In contrast, the FET with the highest roughness of 70.6 nm showed two orders of magnitude lower mobility of $8.7\cdot10^{-5}cm^2/Vs$. These results indicate the strong correlation between the interface roughness and the FET performance.

DS 30.5 Thu 15:15 GER 37

Influence of Stabilizers in ZnO nanodispersions on the FET device performance — •Simon Bubel, Donna Nikolova, Norman Mechau, and Horst Hahn — Institute of Nanotechnology, Forschungszentrum Karlsruhe, 76021 Karlsruhe, Germany

In order to build printable inorganic electronic devices, semiconducting suspensions which can be processed at low temperatures and low-cost manufacturing techniques are needed. Stabilized suspensions made of zinc oxide nanoparticles were used to fabricate field-effect transistors (FETs) by spin coating. The performance of the devices is strongly affected by the nature and concentration of the compounds added to stabilize the nanodispersions. An increase of the field-effect mobility by more than one order of magnitude is observed by increasing the stabilizer concentration from 3 to 13 wt %. A further increase of the concentration above 13 wt % results in a decrease of the field-effect mobility. This behaviour can be explained by changes in the morphology, the particle-particle junction, and the passivation of surface defect sites.

DS 30.6 Thu 15:30 GER 37

Anomalous Nitrogen Diffusivity During Plasma Nitriding of CoCr Alloys at High Temperatures — •Johanna Lutz[1,2], Stephan Mändl[1], and Bernd Rauschenbach[1] — [1]Leibniz Institute of Surface Modification, Leipzig, Germany — [2]Translational Centre for Regenerative Medicine, University of Leipzig, Germany

Plasma immersion ion implantation is an important method to tailor and to increase the physical and chemical properties of numerous materials. In this presentation, the diffusion of nitrogen and the phase formation is investigated for face-centred-cubic CoCr alloys in the temperature range from 230 - 580 °C. Plasma immersion ion implantation was carried out using 10 kV pulse voltage and a process pressure of 0.5 Pa. X-ray diffraction patterns show two different phase structures depending on the temperature: a lattice expansion at temperatures lower than 450 °C while the decomposition of the base material into CrN precipitates and another Co-rich phase is observed at the upper end of the temperature range. A two-step nitriding process at different temperatures shows clearly that at a previous implantation at a temperature of 560 °C, no nitrogen diffusion is observed for a subsequent nitriding at any temperature. For preimplantation at 450 °C, normal diffusivities are observed during the latter process. This clearly indicates that the phase decomposition at elevated temperatures leads to a radical change in the nitrogen diffusivity.

DS 30.7 Thu 15:45 GER 37

Self-Aligned Field Emission Device Prepared by Swift Heavy

Ion Irradiation. — •Han-Gregor Gehrke[1], Anne-Katrin Nix[1], Johann Krauser[2], Christina Trautmann[3], Alois Weidinger[4], Jürgen Bruns[5], Frank Wünsch[4], and Hans Hofsäss[1] — [1]Georg-August Universität, Göttingen, Deutschland — [2]Hochschule Harz, Wernigerode, Deutschland — [3]Gesellschaft für Schwerionenforschung, Darmstadt, Deutschland — [4]Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Deutschland — [5]Technische Universität, Berlin, Deutschland

Swift heavy ion irradiation of tetrahedral amorphous carbon (ta-C) results in conductive ion tracks with a diameter of about 8 nm. The goal of our work is the fabrication of self-aligned field emission devices. The ion tracks embedded in the insulating ta-C film form nanosized field emitters. The gate structure is produced by a thin insulating SiN_X and a chromium layer on top of the carbon film. Finally, a spin coated polycarbonate layer is placed on top of the sample. The irradiation of the layer package leads to latent tracks in the polycarbonate above each conducting track in the ta-C. Therefore, after opening the polycarbonate mask with chemical wet etching, the pores are well aligned with the ion track underneath. Finally, the chromium and the SiN_X can be opened by sputtering or plasma etching to create the complete structure. The advantage of this approach is stability of the layer package; no free standing nanowires can be damaged. We present first results of experiments with the described self-aligned field emission structure.