DS 26: Oxides

Time: Thursday 15:00–17:45 Location: H34

DS 26.1 Thu 15:00 H34

XPS study of Pr-aluminate high-k dielectric layers on titanium nitride — •Grzegorz Lupina, Thomas Schroeder, Christian Wenger, Gunther Lippert, Jarek Dabrowski, and Hans-Joachim Müssig — IHP, Im Technologiepark 25, 15236 Frankfurt/Oder

To extend the scalability of deep trench capacitor-based dynamic random access memories (DRAM), the introduction of high-k dielectrics-based metal-insulator-metal (MIM) storage capacitors is required. Pr-enriched Al_2O_3 dielectrics with TiN electrodes appear as a promising materials system for this application. Electrical measurements performed on this materials combination show that the development of a capacitor with a very high capacitance density and low leakage current requires a very careful control of the electrode/dielectric interface. For this purpose, we carried out a synchrotron radiation x-ray photoelectron spectroscopy (SR-XPS) study to non-destructively investigate interface reactivity of the $Pr_xAl_{2-x}O_3$ (x = 0, 1, 2) dielectrics with TiN metal electrodes. The depth profiling study using SR-XPS shows that the TiN substrate is covered with a native TiO_2. Additionally, a thin interfacial TiON layer is present between these compounds, resulting in a $TiN/TiON/TiO_2$ materials stack. Molecular beam deposition of Al_2O_3 onto substrates of this structure leads to the reduction of the native TiO_2. In contrast, in the same way deposited $PrAlO_3$ and Pr_2O_3 dielectrics are significantly less reactive towards TiO_2.

DS 26.2 Thu 15:15 H34

Structural Determination of thin Manganese Oxide Films on Ag(001) — •Christian Langheinrich[1], Angelika Chassé[1], Frank Müller[2], and Stefan Hüfner[2] — [1]Martin-Luther-Universität Halle-Wittenberg, Institut für Physik, D-06099 Halle/Saale — [2]Universität des Saarlandes, Institut für Experimentalphysik, D-66041 Saarbrücken

X-ray photoelectron diffraction (XPD) has been applied to study thin manganese oxide films (∼7 ML) on an Ag(001) surface. Calculations with the multiple scattering cluster model (MSCM) show that the film grows in a high crystalline order. At least the top 5 MLs have to be in such a crystalline order to reproduce the experimental spectra properly.

Furthermore, it is insufficient to analyze the spectra with a simple forward scattering picture, which usually dominates the XPD spectra for high kinetic energies (here ∼850 eV for Mn-2p excitation and ∼970 eV for O-1s excitation). Due to the small next-neighbour distance in a NaCl-like lattice interference effects change the peak form drastically. Thus a combination of forward scattering and interference is necessary to understand these XPD spectra.

In order to find optimized lattice constants, both the lattice constant in the surface and the lattice constant in perpendicular direction have been varied independently. An r-factor analysis of these spectra indicates that the system is close to pure MnO bulk within a small tetrahedral distortion. This is in accordance with low energy electron diffraction (LEED) results.

DS 26.3 Thu 15:30 H34

Epitaxially stabilized growth of orthorhombic $LuScO_3$ thin films — •Tassilo Heeg[1], Martin Roeckerath[1], Jürgen Schubert[1], Willi Zander[1], Christoph Buchal[1], Han Yuan Chen[2], Chunlin Jia[2], Yunfa Jia[3], Carolina Adamo[3], and Darrell G. Schlom[3] — [1]Institute of Bio- and Nanosystems (IBN1-IT), and Centre of Nanoelectronic Systems for Information Technology (cni), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Ernst-Ruska-Centre for Microscopy and Spectroscopy with Electrons (ER-C), and Institute of Solid State Research (IFF), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]Department of Materials Science and Engineering, The Pennsylvania State University, University Park, Pennsylvania 16802-5005, USA

Lutetium scandate ($LuScO_3$) thin films of 10 - 800 nm in thickness have been prepared by molecular beam epitaxy and pulsed laser deposition on different substrates. Stoichiometry and crystallinity were investigated using Rutherford backscattering spectrometry/channelling, X-ray diffraction and transmission electron microscopy. The results indicate that $LuScO_3$, which normally only exists as solid solution of Sc_2O_3 and Lu_2O_3, could be grown in the orthorhombically distorted perovskite structure. A good crystalline quality (rocking curve FWHM of 0.05°) was gained, and a critical film thickness of around 200 nm for the epitaxial stabilization of the perovskite phase of $LuScO_3$ on $NdGaO_3(110)$ substrates was determined.

DS 26.4 Thu 15:45 H34

Tunable Electron Gases in Oxide Hetrostructures — •Stefan Thiel[1], German Hammerl[1], Christoph Richter[1], Andreas Schmehl[2], Christof Schneider[1], and Jochen Mannhart[1] — [1]Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg, Universitaetsstrasse 1, D-86159 Augsburg, Germany — [2]Department of Materials Science and Engineering, Penn State University, University Park, Pennsylvania 16802-5005, USA

Multilayers of complex oxides can show physical properties that are not found in either of their constituents. For example, a conducting, quasi-two dimensional electron gas is formed at the interface between the two insulating, dielectric perovskites $LaAlO_3$ and $SrTiO_3$ [1].

Here we report that the electron gas can be tuned to a very large extent by altering the thickness of the $LaAlO_3$ layers on the unit cell level. For $LaAlO_3$ layers that are up to 3 unit cells thick, highly insulating interfaces are obtained. In field effect transistor configurations using such interfaces as drain-source channels a quantum phase transition to the conducting state is readily achieved by gate fields. [2]. Upon change of their carrier densities with applied electric fields, the electron gas reacts with a pronounced memory effect.

[1] A. Ohtomo, H.Y. Hwang, A high-mobility electron gas at the $LaAlO_3/SrTiO_3$ heterointerface, Nature **427**, 423-426 (2004)

[2] S. Thiel, G. Hammerl, A. Schmehl, C.W. Schneider, J. Mannhart, Tunable Quasi-Two-Dimensional Electron Gas in Oxide Heterostructures, Science **313**, 1942-1945 (2006)

DS 26.5 Thu 16:00 H34

Unusual Enhancement of Laser Induced Voltages in (LPMO/YBCO)n Multilayer Thin Films — •Pengxiang Zhang[1,2], Hui Zhang[1], Lilan Xie[1], Xinkun Zhu[1], Songlin Tan[1], and Hanns-Ulrich Harbermeier[2,1] — [1]Institue Advanced Materials for Photoelectronics, KUST, Kunming, China 650051 — [2]FKF, MPI, Stuttgart, Heisenberg Str. 1 D-70569 Germany

Laser induced voltages were observed in $(YBa_2Cu_3O_7/La_{1-x}Pb_xMnO_3)_n$ multilayer thin films grown on vicinal cut $LaAlO_3$ single crystal substrates by pulsed laser deposition. The induced voltages were proved to be due to an anisotropic thermoelectric property, which was evidenced by the tilting angle dependence of the induced signals in these films. The peak voltages obtained are about one order of magnitude stronger than that obtained from single layer films. The possible mechanisms for the largest signals observed so far in these multilayer thin films are discussed and the enhanced large Seebeck anisotropy by the layered anisotropic structure is most likely the reason. The new finding not only enriches the experimental observations involved in strongly correlated oxides, but also provides great potentials for applications.

DS 26.6 Thu 16:15 H34

Ag-doped $LaPbMnO_3$ thin films and laser induced thermoelectric voltages — •Pengxiang Zhang[1,2], Songlin Tan[2], Hui Zhang[2], and Hanns-Urlich Habermeier[1] — [1]Max-Planck Institut for Solid State Research, Stuttgart, D-70569 — [2]IAMPE, KUST, Kunimng, China 650051

Ag-doped $LaPbMnO_3$ thin films were grown on vicinal cut substrates by PLD technique. Laser induced voltages were measured for the first time in these thin films. It was proved that the laser induced voltages are due to the anisotropic thermoelectric effect, similar to that observed in $YBa_2Cu_3O_7$ by Chang et al in 1990 and that in $LaCaMnO_3$ by H.-U. Habermeier et al in 1998. It was found that with increasing Ag-doping from 0 to 10 wt%, the laser induced thermoelectric voltages (LITV) are firstly increased and then reduced, while the FWHM (to) of the time response of the induced voltages become smaller than that of pure $LaPbMnO_3$ thin film, and demonstrate a minimum at 6 wt% of Ag-doping. Defining a figure of merit (Fm) for the performance of LITV devices used in pulsed laser detection: Fm = Up/to, where Up is the peak value of LITV, it was found that 6 wt% Ag-doping sample shows a maximum Fm. The short time response of the Ag-doped

$LaPbMnO_3$ thin films in LITV was explained by the increased electric conductivity, hence the higher thermo-conductivity in these thin films.

DS 26.7 Thu 16:30 H34

$GaPO_4$ epitaxial thin films: Growth and thermal stability — •Johannes Pedarnig, Stefan Roither, Martin Peruzzi, and Dieter Bäuerle — Institut für Angewandte Physik, Johannes Kepler Universität Linz, A-4040 Linz

Gallium orthophosphate ($GaPO_4$) is an outstanding novel piezoelectric material that remains piezoelectric up to a temperature of 970°C. Crystalline $GaPO_4$ films have not been reported so far due to the complex materials chemistry.

We are reporting on solid phase epitaxial growth of $GaPO_4$ thin films on alpha - quartz (SiO_2) substrates. Amorphous stoichiometric precursor layers are fabricated by pulsed-laser deposition on (001) SiO_2 substrates and are subsequently transformed to crystalline $GaPO_4$ by post-annealing in air at elevated temperature. Epitaxial films with thicknesses up to 300 nm exhibit strong in-plane and out-of-plane textures (angular widths $< 0.6°$). Long-term annealing in air at temperatures above the alpha - to beta - phase transition of the quartz substrate (573°C) does not degrade these films.

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DS 26.8 Thu 16:45 H34

The amorphous to crystalline phase transition of chemical solution deposited $PbZr_{1-x}Ti_xO_3$, studied by soft-x-ray spectroscopy — Timorthy Learmonth[1,4], Jinghua Guo[1], Jonathan Denlinger[1], Per Glans[1,4], •Hermann Kohlstedt[2], Theo Schneller[3], Adrian Petraru[2], Rainer Waser[2,3], Kevin Smith[4], and Ramamorthy Ramesh[5] — [1]Advanced Light Source, Lawrence Berkeley National Laboratory, USA — [2]Inst. für Festkörperforschung, Germany — [3]Inst. für Werkstoffe der Elektrot. II, RWTH Aachen, Germany, — [4]Depart. of Physics, Boston University,Massachusetts 02215, USA — [5]Depart. of Mat. Sci. and Eng.,Berkeley, CA 94720 USA

Chemical solution deposited (CSD) complex oxide thin films attract considerable interest in various emerging research fields. Here we present our results of soft-x-ray spectroscopy between 100 eV and 2 keV on the amorphous to crystalline phase transition of ferroelectric $PbZr_{0.3}Ti_{0.7}O_3$ thin films. Five samples from the same wafer were annealed to different temperatures between 350°C and 700°C. The soft-x-ray absorption and emission experiments were performed at the undulator beamline 8.0 of the Advanced Light Source of the Lawrence Berkeley National Laboratory. The soft-x-ray spectra were acquired for the Ti L2,3-, O K-and C K-edge thresholds. For two samples, annealed up to 400°C and 700°C, respectively, the resonant inelastic soft-x-ray spectroscopy (RIXS) was applied for various excitation energies near the Ti L-, O K- and C K-edges. Current models of the PZT (111) microscopic texture selection will be discussed.

DS 26.9 Thu 17:00 H34

Structure Formation and Phase Composition of Zirconia Films grown by High Power Pulsed Magnetron Sputtering (HPPMS) — •Christian Klever, Kostas Sarakinos, and Matthias Wuttig — I. Institute of Physics (1A), RWTH Aachen University, 52056 Aachen, Germany

We have employed the novel HPPMS deposition technique for the deposition of ZrO_2 films. ZrO_2 is a polymorphic material, which in thin film form exhibits exceptional mechanical and optical properties and is therefore widely used as a functional coating. In HPPMS unipolar pulses of high–peak power/current and low duty cycle are applied to the target. As a result of the unique properties of the deposition process, several film properties can be improved.

In this study, pulses with pulse off–times t_{off} ranging from 450 to 2450 μs (pulse on–time t_{on} kept constant at 50 μs) are applied to a Zr target (cathode). The films are deposited in a mixed Ar–O_2 ambient on unheated silicon substrates at a constant working pressure (1.5 Pa). Ion saturation current measurements are performed using a flat electrostatic probe. They manifest an increase of the ion flux to the growing film when t_{off} is increased. The changes of the duty cycle settings are accompanied by changes in the film structure. It is shown that monoclinic films are obtained when t_{off} is higher than 950 μs, while films with a mixed monoclinic/cubic phase composition are deposited for lower t_{off}. Also, the effects of the sputtering pressure and substrate temperature on the structure of films grown for t_{off} below 1450 μs are investigated.

DS 26.10 Thu 17:15 H34

Light-induced processes on electrochromic WO_3 layers — •Thomas Leichtweiss[1], Bruno K. Meyer[1], Angelika Polity[1], Thomas Löwenstein[2], Derck Schlettwein[2], Jeremy Matthews[3], and Dirk Jödicke[3] — [1]Justus- Liebig- Universität Gießen, I. Physikalisches Institut, Heinrich-Buff-Ring 16, 35392 Gießen — [2]Justus- Liebig- Universität Gießen, Institut für Angewandte Physik, Heinrich-Buff-Ring 16, 35392 Gießen — [3]EControl-Glas GmbH & Co. KG, 93437 Furth im Wald

Electrochromic materials such as tungsten oxide in contact with a suitable electrolyte change their transmission upon the application of a potential. Technical applications include switchable mirrors and smart windows. The latter are made up of thin-film layers containing at least one electrochromic active material and make it possible to control the light- and energy-input of a building.

This work concerns the influence of UV-A and UV-B light on tungsten oxide layers. WO_3 films have been irradiated in an electrochemical cell containing different electrolytes and in atmosphere. Transmission spectra and the open circuit potential have been recorded. All layers show a photochromic behavior, they colour blue upon UV-irradiation due to partial reduction of tungsten atoms without application of an external potential. The films have been bleached electrochemically in order to determine the photogenerated charge and the colouration efficiency of the photochromic process. The reactions taking place place in irradiated films and their influence on the electrochromical switching behaviour of smart windows will be discussed.

DS 26.11 Thu 17:30 H34

Characterization of $GdScO_3$ layers by Spectroscopic Ellipsometry — Martin Roeckerath, •Jürgen Moers, Jürgen Schubert, and Siegfried Mantl — Institut of Bio- und Nanosystems, Forschungszentrum Jülich, D-52425 Jülich

For further improvement of MOSFET devices high-κ materials for gate dielectrics are under investigation. Rare earth scandates are drawing increasing attention due to their favorable material properties. The κ-value is above 20, the band offsets to silicon are larger than 2 eV and the layers are stable up to 1000°C. To investigate the properties of those materials, Gadolinium scandate ($GdScO_3$) was selected exemplarily. Layers with different thickness were deposited on silicon (HF last) and oxidized (2 nm) silicon by electron beam evaporation. Their stoichiometry and morphology were characterized by Rutherford Backscattering (RBS), X-ray reflectometry (XRR) and transmission electron microscopy (TEM).

In order to provide a quick and non-destructive characterization method, the samples were measured at angles of 50°, 60° and 70° by spectroscopic ellipsometry (SE) and the results were compared to the other measurements. The optical data of $GdScO_3$ were described analytically by a Sellmeier formula with 5 parameters. It was found that the measured thicknesses of SE and XRR are in agreement for film thicknesses above 10 nm. Below 10 nm SE overestimates the thickness by far, indicating the increasing influence of the substrate/$GdScO_3$ interface.