DF 6: Poster I

Time: Tuesday 9:30–12:30 Location: P5

DF 6.1 Tue 9:30 P5

Atomic layer deposition and characterization of bismuth oxide thin films — •Philipp Moritz Leufke[1], Nicole Donia[2], Sanjay Mathur[3], and Horst Hahn[1] — [1]Institute of Nanotechnology, Karlsruhe Research Centre, D-76344 Eggenstein-Leopoldshafen, Germany — [2]Leibniz-Institute for New Materials, D-66123 Saarbruecken, Germany — [3]University of Cologne, Institute of Inorganic Chemistry, D-50939 Cologne, Germany

We report on the deposition of thin films of bismuth oxide by atomic layer deposition (ALD). We used bismuth *tert*-butoxide [Bi(O*t*Bu)$_3$] [1] as a bismuth precursor for the first time. H_2O serves as oxidizing precursor. Our aim was to overcome the problems caused by known precursors for bismuth containing oxides, which are often thermally unstable and require liquid-injection techniques or do not decompose entirely, leaving impurities in the resulting film [2].

Surface morphology and crystal structure of the prepared thin films are investigated by means of scanning electron microscopy and X-ray diffraction. Energy-dispersive X-ray spectroscopy and X-ray Photoelectron Spectroscopy are employed for chemical analysis. In our studies we show that the morphology dependends on various substrates and deposition parameters in these thin films.

[1] M. Mehring, *Coordination Chemistry Reviews, 19th Main Group Chemistry* **251**, 974-1006 (2007)

[2] M. Vehkamäki *et al.*, *Journal of Materials Chemistry* **14**, 3191-3197 (2004)

DF 6.2 Tue 9:30 P5

Electronic defect state mapping in strontium titanate by surface photovoltage and photoconductivity spectra — •Jana Becherer, Elke Beyreuther, Andreas Thiessen, Stefan Grafström, and Lukas M. Eng — Institut für Angewandte Photophysik, Technische Universität Dresden, D-01062 Dresden, Germany

Within the current interest in the field of oxide electronics, strontium titanate ($SrTiO_3$, STO) plays a crucial role as a substrate for the epitaxy of a wide variety of perovskite oxide films on the one hand and as a functional oxide by itself on the other hand. However, the electronic properties of STO – though having been the subject of research for several decades – are still not well understood for several reasons: (i) Firstly, the electronic properties change dramatically as a function of oxygen content, doping, or surface treatments, while (ii) secondly, standard electrical characterization methods fail due to the wide band gap and the consequently low carrier concentration. Thus optical techniques are the methods of choice for this kind of material.

In order to gain a more systematic understanding of surface and bulk electronic defect states, we performed a comparative study of the spectral, temporal, and temperature dependence of the surface photovoltage and the photoconductivity of undoped and doped STO single crystals. We discuss the defect state distribution within the framework of a classical band scheme.

DF 6.3 Tue 9:30 P5

Hyperfeinwechselwirkung in dünnen Schichten von HfO_2 — •Michael Steffens und Reiner Vianden — Helmholtz-Institut für Strahlen- und Kernphysik, Nußallee 14-16, 53115 Bonn

Der Einsatz von sogenannten "high-κ"-Dielektrika als Gate-Oxide in MOSFET-Strukturen gilt als eine der Möglichkeiten den Miniaturisierungsprozess in der Halbleiter-Industrie voranzutreiben. Als aussichtsreichstes Material wird dabei HfO_2 angesehen, wobei die thermische Stabilität problematisch bleibt.

In dieser Arbeit wird die Hyperfeinwechselwirkung des Hf in dünnen Schichten HfO_2 mit der gestörten γ-γ-Winkelkorrelation (PAC) untersucht. Die PAC eignet sich besonders für die Bestimmung der lokalen Umgebung eines Sondenkerns im Material. Die PAC-Sonde ^{181}Hf wird dabei entweder durch Neutronenaktivierung von ^{180}Hf erzeugt oder direkt in das Material implantiert. Zusätzliche Messungen werden mit der Sonde ^{111}In durchgeführt.

Die 100 nm bzw. 10 nm dünnen Filmproben sind mit ALCVD und MOCVD auf einem (100) Si-Substrat gewachsen. Im Mittelpunkt der Messungen stehen die Änderungen der Kristallstruktur in der Umgebung der Sonden während eines isochronen Ausheilprogramms und während temperaturabhängigen Messungen, die 'in-situ' stattfinden. Die Ergebnisse der Messungen an diesen dünnen Schichten werden mit Messungen an reinem HfO_2 verglichen.

DF 6.4 Tue 9:30 P5

Development of a precisely tuneable continuous-wave THz spectrometer with interferometric frequency control — •Holger Schmitz[1], Joachim Hemberger[1], Anselm Deninger[2], Axel Roggenbuck[2], and Markus Grüninger[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, D-50937 Köln, Germany — [2]TOPTICA Photonics AG, Lochhamer Schlag 19, D-82166 Gräfelfing, Germany

We will report on the development of a precisely tuneable continuous-wave THz spectrometer with interferometric frequency control. The system is based on mixing two near-infrared distributed feedback diode lasers, the beat of which can be tuned continuously from 0 to 1.2 THz. Each laser is stabilized by electronic feedback from a low-finesse Fabry-Perot etalon, yielding a laser linewidth of roughly 1 MHz and a frequency precision of a few MHz. The laser beat is converted into THz radiation by a photoconductive switch, which efficiently generates THz radiation from 20 GHz to 1.2 THz. The THz radiation is detected via a second photoconductive switch via homodyne mixing of the THz signal and the laser beat. The coherent homodyne detection preserves the phase information of the THz electric field, so that both the real and the imaginary part of the dielectric function, ε_1 and ε_2, can be determined. Making use of different optical path lengths for the laser beam and the THz radiation, the phase shift due to the sample can be determined by sweeping over an interference fringe, typically a few 100 MHz. Thus ε_1 and ε_2 can be determined without mechanically moving parts. First results obtained with this system will be reported.

DF 6.5 Tue 9:30 P5

The electronic band diagram of thin PrO2(111) / Pr-silicate buffers on Si(111) and its relevance to dielectric properties — •Olaf Seifarth[1], Christian Walczyk[1], Grzegorz Lupina[1], Peter Zaumseil[1], Dieter Schmeisser[2], Hans-Joachim Müssig[1], and Thomas Schroeder[1] — [1]IHP, 15236 Frankfurt, Im Technologiepark 25 — [2]BTU Cottbus, 03046 Cottbus, Konrad-Wachsmann Allee 17

Thin dielectric buffers of cubic PrO2(111) on Si(111) are ideally suited to integrate Ge onto Si by moderating the lattice mismatch between the materials. The leakage current across this dielectric buffer is strongly influenced by the electronic band diagram and defects inside the band gap. Therefore, we measured the band offsets, band gaps and defect positions by means of synchrotron radiation based photoemission spectroscopy techniques (XPS and XAS) with special emphasis on the Pr-silicate interface. In a next step we compare the spectroscopic data with information from dielectric studies, based on temperature dependent leakage current studies. We observe a close relation between dielectric properties and the electronic structure.

DF 6.6 Tue 9:30 P5

Post deposition annealing induced transition from Pr_2O_3 to PrO_2 films on Si(111) — •Thomas Weisemoeller[1], Florian Bertram[1], Sebastian Gevers[1], Andreas Greuling[1], Carsten Deiter[2], Holger Tobergte[1], Manfred Neumann[1], Joachim Wollschläger[1], Alessandro Giussani[3], and Thomas Schroeder[3] — [1]Fachbereich Physik, Universität Osnabrück, Barbarastr. 7, D-49069 Osnabrück, Germany — [2]HASYLAB at DESY, Notkestr. 85, D-22607 Hamburg, Germany — [3]Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Films of hexagonal praseodymium sesquioxide (Pr_2O_3) were deposited on Si(111) by molecular beam epitaxy and thereafter annealed in oxygen at different temperatures, ranging from 100°C to 700°C. XRR, XRD and GIXRD measurements were performed at beamlines W1 and BW2 at HASYLAB/DESY to analyze the structure of oxide films and interfaces. The films of the samples annealed at 300°C or more were transformed to PrO_2 with B oriented $Fm\bar{3}m$ structure, while films annealed at lower temperatures keep the hexagonal structure. The films compose of coexisting PrO_2 and $PrO_{2-\delta}$ species which coexist lateral. The oxygen vacancies are partly ordered lateral and increase the vertical lattice constant of the film, whereas the horizontal lattice constant is almost identical for both species and on all samples. The latter lattice constant matches the lattice constant of the originally crystallized hexagonal praseodymium sesquioxide. That means that no long range

reordering of the praseodymium atoms takes place.

DF 6.7 Tue 9:30 P5

Pulsed laser deposition of praseodymium oxide on silicon at oxygen background — •Biwang Yang, Markus Ratzke, and Jürgen Reif — LS Experimentalphysik II, BTU Cottbus und IHP/BTU JointLab, Konrad-Wachsmann-Allee 1, D-03046 Cottbus

Praseodymium oxide thin films, as a potential high-k candidate for future silicon microelectronics, can be produced by Pulsed-Laser Deposition (PLD).

However, in contrast to expectation, the procedure does not transfer the stoichiometry of the target material, the films appear to be oxygen deficient. To compensate for this loss of oxygen, the reason of which is not yet clear, we applied an additional oxygen background in our deposition chamber at different pressures.

While both the growth rate and the oxygen content of the layers, produced in this way, show a distinct dependency on oxygen pressure, the electrical properties are not significantly different from films deposited without background gas.

DF 6.8 Tue 9:30 P5

Structure and Physical Properties of $A_{2/3}Cu_3Ti_4O_{12}$ (A = Rare Earth) — •Stefan Riegg[1], Jürgen Sebald[3], Stephan Krohns[3], Stefan G. Ebbinghaus[2], Peter Lunkenheimer[3], Alois Loidl[3], and Armin Reller[1] — [1]Solid State Chemistry, Institute for Physics, University of Augsburg, 86135 Augsburg, Germany — [2]Solid State Chemistry, Institute for Chemistry, Martin-Luther University Halle-Wittenberg, 06120 Halle, Germany — [3]Experimental Physics V, Center for Electronic Correlations and Magnetism, University of Augsburg, 86135 Augsburg, Germany

Many materials based on the $ACu_3Ti_4O_{12}$ structure-type provide very high dielectric constant ε', like the most famous member A = Ca with a value of greater than 10^3. These materials with so called "collossal dielectric constants"(CDC) are very useful for technical application and thus of special scientific interest. Structurally related systems with lanthanide ions on the A position can be used to study the CDC mechanism. Due to the +3 (Ce: +4) valence of the rare earth ions, in comparison to the +2 valence of Ca, only two thirds (Ce: half) of the A position are occupied in the crystal. Samples with A = Y^{3+}, La^{3+}, Ce^{4+}, Pr^{3+}, Nd^{3+}, Sm^{3+} to Yb^{3+} were prepared by solid state reaction of the binary oxides. X-ray diffraction in combination with Rietveld analysis was used to investigate the structure. The measured dielectric properties show the CDC behaviour of this material. In addition the band gap energy was determined by UV-Vis spectroscopy. Measurements of the magnetic susceptibility were carried out to study the magnetic behaviour.

DF 6.9 Tue 9:30 P5

Influence of rare earth doping on the phase transition characteristic of strontium barium niobate and a comparison to calcium barium niobate — •Alexander Niemer[1], Urs Heine[1], Uwe Voelker[1], Klaus Betzler[1], and Manfred Muehlberg[2] — [1]University of Osnabrück, Department of Physics, Barbarastr. 7, 49076 Osnabrück — [2]University of Cologne, Institute of Crystallography, Zülpicher Str. 49b, 50674 Cologne

The ferroic relaxor strontium barium niobate (SBN) shows interesting dielectric properties foremost in the region of its smeared phase transition. Here, the influence of rare earth doping on the relaxor characteristic is studied for SBN by analyzing the complex dielectric constant. As dopants, Erbium (0 to 1.04 mol%), Ytterbium (0 to 1.56 mol%), and Europium (0 to 1.14 mol%) were used. As a result the rare earth doping has significant impact on the phase transition behavior, regarding both, temperature and smearing. Since the use of SBN in technical applications is constrained due to the low phase transition temperature, we analyzed the dielectric behavior of the unfilled tungsten bronze calcium barium niobate (CBN). Congruently melting CBN (28.1 mole fraction calcium [1]) exhibits a phase transition at about 540 K, nearly 200 K higher than the one of SBN61. A comparison between the dielectric constant of SBN and CBN yields, that these two materials show a substantially different phase transition behavior, despite the crystal structures show similarities.

[1] M. Burianek, B. Joschko, I. Kerkamm, T. Schoenbeck, D. Klimm, M. Muehlberg: J. Crystal Growth 229, 413-417 (2007)

DF 6.10 Tue 9:30 P5

Strain and electric field effects on the dielectric permittivity of epitaxial $SrTiO_3$ thin films — •Sebastian Engmann, Veit Grosse, Robert Haehle, Janine Fischer, and Paul Seidel — Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena, Helmholtzweg 5, 07743 Jena

We present measurements of the dielectric permittivity of epitaxial $SrTiO_3$ (STO) thin films. Therefore we prepared capacitor structures based on the multilayer system $YBa_2Cu_3O_{7-x}$/STO/Au grown by pulsed laser deposition on $LaAlO_3$ substrates. Rocking curves prove good c-axis orientation of the STO crystallites. Due to epitaxial strain for thin films the c-axis is enlarged up to values of 3.932 Å and relaxes to bulk values for a film thickness of 170 nm. From capacitance measurements in the temperature range from 293 to 4.2 K we determined the dielectric permittivity for different film thicknesses. An external electric bias field was varied to compensate for internal fields caused by band alignment due to the difference in work function of both electrodes. We discuss the results as a series connection of the film and interface capacitances involving strain effects.

DF 6.11 Tue 9:30 P5

Micro- and nano-patterning of lithium niobate — •Thomas Gischkat[1], Frank Schrempel[1], Holger Hartung[2], Ernst-Bernhard Kley[2], Andreas Tünnermann[2], and Werner Wesch[1] — [1]Institut für Festkörperphysik, Friedrich-Schiller-Universität Jena — [2]Institut für Angewandte Physik, Friedrich-Schiller-Universität Jena

In order to manipulate light on the nanoscale, the engineering and fabrication of novel photonic nanomaterials and devices (e.g. photonic crystals, micro-resonators and Bragg-gratings) using micro- and nanoscale patterning technologies is of growing interest. We report on the patterning of $LiNbO_3$ by means of Ion Beam Enhanced Etching (IBEE), which is based upon the fact, that the chemical resistance of the crystal is reduced due to ion irradiation induced defects. Thus the irradiated regions can be removed without affecting the non-irradiated crystal. The principle of the method is introduced and the influences of fundamental parameters like ion fluence, irradiation and etching temperature are discussed. Lateral patterning is performed by creation of a damaged- commonly amorphous - layer starting from the surface. To define the lateral geometry, masks prepared by standard lithographic processes applying photo- or electron-beam-lithography are used providing the opportunity for a selective irradiation with ions. Vertical patterning is obtained, if the damage is established as a buried layer. Actually three dimensional patterning is possible if lateral and vertical patterning is performed together. This is exemplarily shown for microdiscs and 2D-photonic crystals with underlying air gap, respectively.

DF 6.12 Tue 9:30 P5

Ultra-fast detection of multi-wave mixing on optically induced microstructures — •Annika Kruse, Bettina Schoke, and Mirco Imlau — Department of Physics, University of Osnabrück, Germany

The ultra-fast detection of multi-wave mixing on optically induced microstructures was examined with iron-doped lithium niobate ($LiNbO_3$:Fe) for test purposes. The aim of this work is to analyse contributions of index and absorption gratings in short-living mixed diffraction gratings with a decay time below 10 ms. A standard holographic two-beam setup allowing for the recording and simultaneous reading of elementary gratings in $LiNbO_3$:Fe (λ_{rec} = 514 nm: $\theta_{rec} = 20°$, λ_{read} = 633 nm: $\theta_B = 25°$) was applied and expanded by a fast motorized rotationary stage (rotation velocity 720°/s) for sample rotation. This enabled the determination of the rocking curve from recorded diffraction gratings, i.e. the angular dependence of the diffraction efficiency on the angular deviation from the Bragg angle was measured. Appropriate photo diodes and a digital storage oscilloscope for data collection were used in order to match for the high scan speed. As a result, the rocking curves could be detected with excellent resolution in an angular range of $\pm 0.3°$ within < 1 ms. The results are successfully compared with theoretical expectations of mixed diffraction gratings. The continuative development of this technique for a comprehensive two-beam coupling analysis is discussed. *Financial supported by the Deutsche Forschungsgemeinschaft (Projects IM37/5-1 and GRK 695).

DF 6.13 Tue 9:30 P5

A Versatile Surface Modification Method for Mesoporous TiO_2 — •Dereje Hailu Taffa, Kathiresan Murugavel, and Lorenz Walder — Institut für Chemie, Universität Osnabrück, Barbarastr. 7, 49069 Osnabrück

Mesoporous titanium dioxide is a large-area, dielectric material used

in many applications such as photovoltaics, electrochromics, catalysis and sensors. Many of these applications require a functional molecule anchored to the inner walls of the porous system. We present a new method for the anchoring of such molecules using a combination of hydrophobic and electrostatic interactions. For this purpose we prepared alkyl phosphonic acids of different chain length (6, 10, and 14 carbons) bearing neutral, positive and negatively charged head groups. They were anchored to the inner walls of randomly sintered, mesoporous titanium dioxide thin films. Quartz crystal microbalance and FT-IR measurements show that a monolayer coverage was achieved. Different charged guest molecules (metal complexes and N-alkyl viologens with variable chain length) were incorporated on top or into the supported membranes. The assemblies were characterized by cyclic voltammetry and FT-IR. The new surface modification technique simplifies the molecular requirements for functional surface modifiers considerably. Using a limited set of organic anchors with orthogonal coordination properties and adjustable hydrophobicity, a broad range of electrochromophores, redox active wiring compounds or sensitizers can be adsorbed onto titania.

DF 6.14 Tue 9:30 P5

Preparation and characterization of $[Fe(CN)_5NO]^{2-}$ electrostatically attached to TiO_2 surfaces — Volker Dieckmann[1], •Sebastian Eicke[1], Mirco Imlau[1], Dereje Hailu Taffa[2], Lorenz Walder[2], and Theo Woike[3] — [1]Department of Physics, University of Osnabrück, Barbarastr. 7, D-49069 Osnabrück, Germany — [2]Institute of Chemistry, Center of Interface Science (CIS), Universtity of Osnabrück, Barbarastr. 7, D-49069 Osnabrück, Germany — [3]I. Physikalisches Institut, Universität zu Köln, Zülpicher Str. 77, 50937 Köln, Germany

Sodium nitroprusside ($Na_2[Fe(CN)_5NO]$) undergoes a photoinduced NO ligand linkage isomerism in bulk crystal and in solution. In the latter case the complex can release NO and CN^- after photoexcitation with UV or blue-green light. So far nothing is known on the behavior of nitroprusside in thin films. We have introduced a new technique for holding highly charged complexes in a film, and applied it to $[Fe(CN)_5NO]^{2-}$ ions. They are electrostatically attached to a 14-phosphonotetradecane-1-pyridinium, which acts as spacer to the inner walls of a mesoporous TiO_2-film. A characterization of the system is performed by infrared absorption spectroscopy as well as by electrochemical studies. We are discussing spectral changes during and after light illumination on the background of the photoinduced linkage isomerism, as well as NO and CN^- release.

DF 6.15 Tue 9:30 P5

$BaTiO_3$ nanotubes grown by a sol-gel template method — •Richard Boucher, Peter Renz, and Ki Yoon — Institut für Werkstofwissenschaft, Helmholtzstr. 7, 01062 Dresden

The growth of nanostructures has been thrust into the limelight in recent years due to the great potential that these structures show. Several production strategies exist such as chemical vapour deposition, microlithography and sol-gel. Several advantages exist for the sol-gel route, but here we are concentrating on the possibility that we can produce nanotubes. This growth occurs because during the production process the material is deposited on the template wall and growth occurs from outside inwards. Our interests led us to the investigation of $BaTiO_3$ in track etched polycarbonate templates. In this work we have used the chemical route of Limmer as the basis. An example of some nanotubes is shown. In our contribution we will discuss the production route, its optimisation, and the use of other templates and/or materials.

DF 6.16 Tue 9:30 P5

Laser Light Scattering by 3D Phase Lattices — •Björn Brüser and Ullrich Pietsch — Universität Siegen, Siegen, Deutschland

We have investigated recently developed three-dimensional phase lattices with lattice constants in the μ m - regime by means of laser-light diffraction. The samples have been manufactured by multiple beam interference into light-sensitive polymers resulting in a three-dimensional sinusoidally modulated refractive index distribution which differs by no more than $\Delta n = 0.001$ between maximum and minimum. For reasons of stability these holograms are sandwiched in between two glass-plates. Because of their 3D periodicity and the fact that the lattice parameters are in the micron range the structures can also be described as photonic crystals. The realized crystallographic structure is of hexagonal or rhombohedral (trigonal) symmetry. Due to crystalline symmetry the sampleséxposure with a coherent white beam of visible light will result in Laue spots of different colour at different incident angles. The degree of colour separation depends on the diffraction order and on the number of periodically stacked hexagonal planes within the sample, in our case ranging from 10 to 30. Experimentally, we have measured the intensity distribution of single Laue-spots in transmission geometry for different incident angles by rotating the sample. Our experimental setup, including a high resolution diffractometer, enables us to obtain extremely precise angular measurements. The diffraction curves have been recorded and compared to a theoretical model based on an x-ray kinematical scattering approach. The validity of this model arises from the fact that there is only little change in the refractive index variation.