DS 20: Poster II

Time: Thursday 18:00–20:30 Location: Poster D

DS 20.1 Thu 18:00 Poster D

MBE-Growth Optimization and Optical Switching of Sb_2Te_3/GST-124 Superlattices — •Lucas Bothe[1], Peter Kerres[1], Lukas Conrads[2], Thomas Taubner[2], and Matthias Wuttig[1,2] — [1]Peter Grünberg Institute - JARA-Institute Energy Efficient Information Technology (PGI-10), Forschungszentrum Jülich GmbH, 52428 Jülich, Germany — [2]I. Institute of Physics (IA), RWTH Aachen University, 52056 Aachen, Germany

Phase change materials (PCMs) are promising candidates for future data storage and neuromorphic computing solutions. In these applications drastic property changes between the amorphous (covalent) and the crystalline (metavalent) phase are exploited to encode data. The practical disadvantage of PCMs is the high energy necessary to switch from the crystalline to the amorphous phase (RESET) due to the melt-quench step. Previous studies revealed that replacing a single-layer PCM, e.g. GST, by alternating layers of Sb_2Te_3/GST, called superlattices (SL), reduces the reset current by an order of magnitude.

Highly textured Sb_2Te_3/GST-124 superlattices were grown via Molecular Beam Epitaxy (MBE) and their structure was investigated with $\theta/2\theta$-scans. The structural investigation revealed that the grown superlattices coincidence with the targeted superlattice stoichiometry and periodicity indicating optimized MBE-growth. Furthermore, a laser switching set-up was used to locally switch the as-grown SLs to the amorphous phase. The laser switching results will be discussed regarding the energy efficiency of the superlattices in comparison with ordinary phase change materials.

DS 20.2 Thu 18:00 Poster D

Investigation of Ultrafast Carrier Dynamics in ScN Using Pump-Probe Time-Resolved Spectroscopic Ellipsometry — •Younes Slimi[1,3], Johannes Laurenz Wolf[1], Martin Zahradník[2], Shirly Espinoza[2], Mateusz Rebarz[2], Rebecca Petrich[1], Mohamed Bouafia[3], Jakob Andreasson[2], and Stefan Krischok[1] — [1]Technische Universität Ilmenau, Fachgebiet Technische Physik I, Weimarer Straße 32, 98693 Ilmenau, Germany — [2]ELI Beamlines Facility, The Extreme Light Infrastructure ERIC, Za Radnici 835, 25241 Dolni Brezany, Czech Republic — [3]Applied Optics Laboratory, Institute of Optics and Precision Mechanics, University of Setif 1, 19000, Setif, Algeria

Scandium nitride (ScN) is a promising material for optoelectronic applications owing to its wide band gap, high melting point, and chemical stability. With a band gap exceeding 2 eV, ScN serves as a suitable semiconductor for optoelectronics. Further investigation is warranted to comprehensively characterize its dielectric function, which is crucial for device development. Spectroscopic ellipsometry (SE) and pump-probe time-resolved SE (tSE) are employed to unravel the dielectric properties of ScN thin films, encompassing optical absorption, refractive index, and dielectric constant. Our findings reveal transient features in the dielectric function, shedding light on ultrafast carrier dynamics and relaxation processes. This comprehensive analysis advances our understanding of the material's fundamental behavior.

DS 20.3 Thu 18:00 Poster D

Design of lithium niobate on silicon surface acoustic waveguide for hybrid integrated phononic circuits — •Matthias Volz, Emeline Denise Sophie Nysten, Matthias Weiss, and Hubert Krenner — Universität Münster, Physikalisches Institut, Wilhelm-Klemm-Str. 10, 48149 Münster

Surface acoustic waves (SAWs) have proven to be effective in the control and manipulation of elementary excitations in condensed matter [1, 2]. In particular, SAWs have been efficiently used to interact with spin waves in magnetic thin film, which shows great potential for the realization of novel microwave devices [3]. In this work, the design of a lithium niobate on silicon (LNoSi) phononic waveguide is presented. The localization of the SAW propagation inside a phononic waveguide will enhance the coupling to hybrid quantum mechanical systems, such as spin waves. Furthermore, the used LNoSi platform offers many other advantages such as high piezoelectric coupling, the capability of photonic waveguiding in addition to the phononic modes, as well as the possibility of non-linear optics. The fundamental phononic waveguide modes determined by the waveguide geometry will be simulated using finite element methods and the phononic dispersion will be studied by varying the waveguide width and height. [1] Delsing et al., J. Phys. D: Appl. Phys. 52(35):353001 (2019) [2] Bühler et al., Nat. Commun. 13:6998 (2022) [3] Küß et al., Phys. Rev. B 107:024424 (2023)

DS 20.4 Thu 18:00 Poster D

Proton exchange on thin-film lithium niobate — •Maranatha Andalis, Ioannis Caltzidis, Oscar Camacho Ibarra, Hermann Kahle, Tobias Henksmeier, and Klaus D. Jöns — PhoQS Institute, CeOPP, and Department of Physics, Paderborn University, Paderborn

Lithium niobate-on-insulator (LNOI) is an ideal platform for integrated optics due to its strong electro-optical and acousto-optic properties, wide transparency window, and relatively high refractive index. However, the fabrication of low-loss LNOI waveguides, attributed to the redeposition of by-products, remains a challenge today. One way to overcome this challenge is to replace lithium ions with protons, which can reduce the redeposition during dry etching. Although proton exchange has been utilized previously for bulk lithium niobate, studies on its application in thin films are not fully clarified. In this study, an x-cut LNOI was used to investigate proton exchange. The results will provide an overview of the most recent discoveries.

DS 20.5 Thu 18:00 Poster D

Growth and Characterisation of V_2O_5 and VO_x Phase Mixtures for Memristive Device Applications. — •Aisling Hussey, Brian Walls, and Igor Shvets — School of Physics and Centre for Research on Adaptive Nanostructures and Nanodevices (CRANN), Trinity College Dublin, Dublin 2, Ireland

Vanadium oxides exhibit a range of oxidation states, from +3 to +5. Many of these states have metal-insulator transitions, which makes them candidate materials for memristive devices and resistive random access memory. V_2O_5 is the highest oxidation state and is a semiconductor with no metal-insulator transition. It can be reduced to form regions of V_6O_{13} and VO_2. The formation of these phases in a reduced single crystal leads to a reduction in resistance, as a conductive path through these phases is formed. [1] This work aims to investigate whether conducting filaments of these phases will form in V_2O_5 and reduced mixed phase thin films. V_2O_5 and mixed phase VO_x films have been grown using magnetron sputtering. The films have been structurally characterised using XRD and x-ray reflectivity, and electrically characterised by resistance measurements. Electric field driven reduction and formation of conducting filaments will be investigated and characterised using electrical measurements. The films will be structurally characterised following filament formation, to identify phases present in the conducting filament.

[1] Walls, Brian, et al. "VO_x Phase Mixture of Reduced Single Crystalline V_2O_5: VO_2 Resistive Switching." Materials 15.21 (2022): 7652.

DS 20.6 Thu 18:00 Poster D

Watching hydrogen diffusion into Lutetium thin films with thin Pd cap layers — •Zahra Hojjati[1,2], Harald Giessen[1,2], and Philipp Flad[1] — [1]4th Physics Institute — [2]Stuttgart Research Center of Photonic Engineering

Hydrogenated Lutetium is one of the materials that might have a potential to be used as high-temperature superconductor under high pressure. Recently three have been reports that the system Lu-H-N undergoes a phase transition to blue when hydrogenated, and unconfirmed reports indicate superconductivity. We therefore investigate hydrogen-lutetium interactions and the dynamics of hydrogen diffusion within lutetium, which is influenced by the ambient temperature, the crystal structure and the hydrogen concentration. Hydrogen diffusion in metals involves interstitial diffusion through the lattice and surface absorption. We use samples that consists of a thin Lutetium film with a stripe of Palladium as a catalyst on top. They were placed in a gas cell with 10% H_2 in N_2. The sample was heated to 70-80 degrees Celsius in the presence of H_2. The Lutetium-Palladium surface is getting dark within minutes. The color in Lutetium close to the Pd changes to blue, and this hydrogenation front advances over hours and days. Eventually, the Lutetium-Pd surface is transformed from black to brown, exhibiting cracks. We analyze the progression of the blue hydrogenation front in Lutetium was measured, and our evaluation

indicates a drift rather than a diffusion process. We determine drift velocity and the detailed hydrogenation dynamics, which is important for advancements in energy storage technology.

DS 20.7 Thu 18:00 Poster D

Racetrack memory devices based on freestanding thin films — •Ke Gu, Binoy Krishna Hazra, Yicheng Guan, Peng Wang, Andrea Migliorini, Hakan Deniz, and Stuart Parkin — Max Planck Institute of Microstructure Physics, Halle (Saale), Germany

One of the most promising future memory devices is magnetic racetrack memory (RTM), in which data is encoded in magnetic nanoobjects, e.g. magnetic domain walls (DWs), which are moved along nanowires by current pulses. RTM is promising due to its high packing density, low energy consumption and high speed. However, so far it has only been explored in two dimensions. Here, we show that by using a water membrane based freestanding technique, freestanding racetracks formed from heavy metal/ferromagnetic (HM/FM) and synthetic antiferromagnetic (SAF) heterostructures can be fabricated even in a 3D form. The structures and magnetic properties of freestanding heterostructures are largely preserved throughout the entire process. We show that the current induced DW motion in 3D racetracks formed from HM/FM heterostructures can be modulated by the local geometry and an efficient CIDWM can be realized in 3D racetracks formed from SAF heterostructures. In addition, we fabricate freestanding HM/FM racetracks without any buffer layer. We show that they have almost identical performance to the devices formed from conventional HM/FM heterostructures. As we demonstrated here, freestanding magnetic heterostructures thin films may enable future DW logic and 3D spintronic devices with high data capacity.

DS 20.8 Thu 18:00 Poster D

Evaluation of thin Pd layers used in a sensor system for the continuous measurement of high hydrogen concentrations in a fuel cell — •Christopher Bickmann[1], Lucas Viriato[2], Peter Schwotzer-Uhlig[2], Christoph Meinecke[1,3], Danny Reuter[1,3], Thomas von Unwerth[2], and Harald Kuhn[1,3] — [1]Center for Microtechnologies, University of Technology Chemnitz, Chemnitz 09126, Germany — [2]Department of Advanced Powertrains, University of Technology Chemnitz, Chemnitz 09126, Germany — [3]Fraunhofer Institute for Electronic Nanosystems (ENAS), Chemnitz 09126, Germany

The focus of this study is to evaluate the potential use of thin palladium layers for integration within a sensor system designed for use in a hydrogen fuel cell and to enable continuous measurement of high hydrogen concentrations. The functional principle is based on an increase in electrical resistance caused by the diffusion of hydrogen atoms into the metal lattice of the palladium. The methodology used involves the production of these thin-film structures using lithographic processes, which include techniques such as lift-off processes and physical vapor deposition. The characterization of the electrical resistance as a function of hydrogen concentration, humidity and temperature is carried out in a specially designed test chamber. It can be shown that the structures enable a continuous and reproducible measurement of the hydrogen concentration, whereby the measuring range is dependent on the layer thickness. An outlook on a sensor prototype is given, which is to be tested under real conditions in the further course.

DS 20.9 Thu 18:00 Poster D

Floating-base OPBTs for non-volatile memories — •Amric Bonil and Hans Kleeman — TU Dresden, Germany

In an effort to follow the organic electronics trend with its advantages of flexibility, portability, low-power consumption and biocompatibility, new designs for an organic non-volatile memory are being investigated. These devices could make up a path toward in-memory computing applications based on organic transistors.

Organic Permeable Base Transistors (OPBTs) have already demonstrated their excellent performance regarding high current and speed, good On/Off ratios and gain [1]. Here we show that OPBTs with a supplementary floating base can be used as a medium-term memory device. The vertical device architecture with thin, naturally formed, passivated layers of aluminum oxide surrounding both bases allow for a very small program voltage (+3V) with a memory window of 0.7 V. A retention time of up to 10^5 s can be reached for a very simple fabrication process that could be further enhanced to allow for reversible behavior (erasing).

[1] E. Guo, F. Dollinger, B. Amaya, A. Fischer, H. Kleemann, *Adv. Optical. Mater.* 9, 2002058 (2021).

DS 20.10 Thu 18:00 Poster D

Electric-field induced SHG (EFISHG) in graphene? — •Jonas Woeste[1,5], Klaas-Jan Tielrooij[2,3], Sergey Kovalev[4], Nikola Stojanovic[5], and Michael Gensch[5,1] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Berlin, Germany. — [2]Catalan Institute of Nanoscience and Nanotechnology (ICN2), BIST and CSIC, Campus UAB, Bellaterra, Barcelona, Spain. — [3]Department of Applied Physics, TU Eindhoven, Eindhoven, The Netherlands. — [4]Institute of Radiation Physics, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany. — [5]DLR - Institute of Optical Sensor Systems, Berlin, Germany.

High harmonics generation (HHG) allows to study the nonlinear THz properties of e.g. single layer graphene by means of THz emission spectroscopy which can be explained by a simple thermodynamic model. Recently our collaboration successfully showed that (i) the nonlinearity of graphene can be controlled over two orders of magnitude by applying moderate gate voltages in the sub-Volt regime and (ii) that a specifically designed grating-graphene meta-material enables further increase in the THz nonlinearity via plasmonic field enhancement. Therein we have focused on odd-order nonlinearities, since monolayer graphene is a centrosymmetric material, where even-order susceptibilities cancel out. As a next step we plan to investigate if an effective 2nd order nonlinearity can be efficiently generated by applying appropriate in-plane DC electric fields, thus breaking the inversion symmetry, such as what has recently been demonstrated and observed in GaAs. Preparations for this experiment and its feasibility are discussed.

DS 20.11 Thu 18:00 Poster D

2D Layer MOCVD Growth of GaS on Sapphire: Insights on the Mechanism using TPD, AES and XPS — •Stefan Renato Kachel[1,2], Robin Günkel[2], Leonard Neuhaus[1], Johannes Glowatzki[2], Lukas Erlemeier[1], Kassandra Zoltner[1], Florian Münster[1], Carsten von Hänisch[1], Kerstin Volz[2], and J. Michael Gottfried[1] — [1]Department of Chemistry, Philipps-Universität Marburg, Germany — [2]Material Sciences Center and Department of Physics, Philipps-Universität Marburg, Germany

The utilization of 2D layers of GaS with its ultraviolet bandgap holds promise for applications in solar-blind photodiodes and LEDs. However, the growth of these 2D layers poses a significant challenge, resulting in the formation of 3D Ga droplets covered by GaS instead of the desired single layers. There is a keen interest in understanding the growth mechanism of the metal-organic chemical vapor deposition (MOCVD) process to achieve a high yield of 2D layers. This study focuses on investigating the growth of the precursors di-tert-butylsulfide (DTBS), tri-tert-butylgallium (TTBGa), and the single-source precursor diethylgallium-2-(ethylthio)ethane-1-thiolate (DEGEET) on sapphire. In the absence of Ga atoms on the sapphire surface, DTBS desorbs intact without forming S layers or replacing substrate oxygen. Conversely, TTBGa allows the deposition of Ga atoms, even at significantly lower temperatures than those commonly used in MOCVD processes. DEGEET enables the deposition of thin layers of Ga and S on the sapphire surface at low temperatures. Refining such single-source precursors could pave the way to growing 2D GaS.

DS 20.12 Thu 18:00 Poster D

Growth, Structural and Mangetic Properties of High Entropy Perovskite ($La_{0.2}Nd_{0.2}Gd_{0.2}Sm_{0.2}Y_{0.2}$)$MnO_3$ Thin Films — •Maximilian Mihm, Aladin Ullrich, David Stein, Christian Holzmann, Helmut Karl, and Manfred Albrecht — Institute of Physics, University of Augsburg, Universitätsstraße 1, 86159 Augsburg, Germany

High entropy manganite-perovskites such as ($La_{0.2}Nd_{0.2}Gd_{0.2}Sm_{0.2}Y_{0.2}$)$MnO_3$ (LNGSYMO) are typically produced as a powder and can exhibit interesting magnetic properties. We have grown thin films of LNGSYMO via pulsed laser deposition on $SrTiO_3$ (001) (STO) at 700°C. X-ray diffraction data confirmed epitaxial growth of LNGSYMO. Wide-range reciprocal space mapping and electron backscattered diffraction revealed, that LNGSYMO has three different crystal orientations. LNGSYMO grows in two different out-of-plane directions (001) and (110). The (001) orientated crystals are rotated by 45° with respect to the substrate, while the (110) crystals are aligned either to the substrate lattice or are also rotated by 45°. Zero-field cooled and field cooled (FC) measurements revealed a magnetic transition temperature at around 38 K for LNGSYMO grown on STO. This is in good agreement with the magnetic measurements on corresponding powder samples. Below 25 K the rare earth elements couple antiferromagnetic

to the Mn, which is indicated by a decrease of the magnetization in the FC curve.

DS 20.13 Thu 18:00 Poster D

Microphase Separation in Thin Films of a Sphere Forming PS-*b*-PDMS Block-Copolymer — •Janna X. Friebel, Alexander Stratmann, Harikrishnan Venugopal, and Jörg K. N. Lindner — Nanopatterning - Nanoanalysis - Photonic Materials, Department of Physics, Paderborn University, Germany

According to the bulk phase diagram by Bates et al. [1], block-copolymers (BCP) with a combined Flory-Huggins-parameter $\chi N > 10$ can form ordered nanostructures even with small degrees of polymerization (N), enabling sub-10nm nanostructures suitable for applications like nanomasks in microelectronics [2]. However, the bulk phase diagram is not applicable to thin films because of interfacial energy effects.

This investigation focuses on BCP thin films of PS-*b*-PDMS with a high χ and NB/NA ≈ 0.25, expected to form a bulk-state bcc arrangement of PDMS spheres in a PS matrix. Spin-coated onto Si substrates with native oxide films, the films undergo microphase separation in a solvent vapor atmosphere. After etching of the PS phase, AFM and SEM investigations reveal lamellar structures or cylinders oriented parallel to the surface. The morphology of these features and their arrangements are observed to be highly sensitive to slight changes in layer thicknesses and annealing conditions.

[1] F. S. Bates et al., Physics Today 52 (1999) 32-38.

[2] Y. Chen, S. Xiong, Int. J. Extrem. Manuf. 2 (2020) 032006.

DS 20.14 Thu 18:00 Poster D

Investigation of the atomic arrangement of ultra thin MVB films using LEED-IV — •Maximilan Buchta[1], Peter Kerres[1], Christoph Ringkamp[1], and Matthias Wuttig[2] — [1]Forschungszentrum Jülich — [2]RWTH Aachen

The metavalent bond (MVB) is a newly proposed type of bond, that is fundamentally different from the ionic, metallic or covalent bonds. For many materials that possess MVB, like sesquichalcogenides, monochalcogenides or pnictogens (e.g., Sb2Te3, GeTe or Bi) the atomic arrangement within the unit cell significantly changes with increasing film thickness. Ex-situ techniques like X-ray diffraction (XRD) can easily determine the atomic arrangement for films above 3 nm. Yet, alternatives are needed for thinner films. Emerging from the need to measure the effects in ultra-thin films, Low Energy Electron Diffraction Intensity vs Electron Energy (LEED-IV) curves of MBE grown films have been obtained. Using dynamical LEED theory, the atomic arrangement of thin films of metavalent solids has been determined for different film thicknesses. This analysis reveals significant changes of the atomic arrangement as compared to bulk samples.

DS 20.15 Thu 18:00 Poster D

Tuning the magnetic properties of Fe_3O_4 thin films driven by electric field — •Yifan Xu[1,2], Patrick Schoeffmann[3], Connie Bednarski-Meinke[2], Chenyang Yin[1,2], Steffen Tober[2], Asmaa Qdemat[2], Oleg Petracic[2,1], and Mai Hussein Hamed[2,4] — [1]Heinrich Heine University Düsseldorf, Faculty of Mathematics and Natural Sciences, Düsseldorf, Germany — [2]Jülich Centre for Neutron Science (JCNS-2) and Peter Grünberg Institut (PGI-4), JARA-FIT, Forschungszentrum Jülich GmbH, Jülich, Germany — [3]Synchrotron SOLEIL, Saint-Aubin, France — [4]Faculty of Science, Helwan University, Cairo, Egypt

Tuning magnetic oxide phases at heterointerfaces is a compelling strategy for advancing spintronic and memristive device applications. Specifically for iron oxides, we have shown that we can tune the magnetic and electrical properties of thin films upon initiating a phase transition between magnetite, maghemite and wüstite. Here we show the preparation and characterization of epitaxial Fe_3O_4 thin films grown on TiO_2 - terminated Nb:$SrTiO_3$ substrates via pulsed laser deposition (PLD). We observe a change in the Verwey transition - a critical indicator of the oxygen content in the Fe_3O_4 films and in particular, the disappearance of the Verwey transition when positive electric field is applied. In addition, using X-ray Magnetic Circular Dichroism (XMCD), we observed a shift in the Fe Edge. This could be explained by oxygen diffusion through the interface leading to a reversible phase transition from Fe_3O_4(magnetite) to γ-Fe_2O_3(maghemite).

DS 20.16 Thu 18:00 Poster D

Analysis of 3D check board pattern formation in NiCoMnAl shape memory alloys with alternating austenitic and martensitic layers — •Dario Stierl, Andreas Becker, Laila Bondzio, Inga Ennen, and Andreas Hütten — Universität Bielefeld

NiMnX (X=Al,Ga,Sn,In) magnetic shape memory Heusler alloys are considered as promising materials for magnetocaloric cooling applications due to their magnetoelastic coupling near room temperature. The thermal hysteresis could be reduced in NiCoMnAl thin films with alternating active transforming austenitic layers and martensitic intercalations. The stoichiometry of these two layers is chosen in such a way that their thermal hysteresis does not overlap. In addition, a 3D check board pattern becomes visible in HRTEM cross section images if the austenite active layers and martensite intercalations possess similar thicknesses.

In this contribution we aim for an improved understanding of the 3D check board pattern formation. Therefore, we varied the number of the alternating layers in one series and changed the ratio between the thicknesses of the two different layers in a different series. Furthermore, we analyzed the samples with temperature dependent XRD measurements. Additionally freestanding films were prepared and measured.

DS 20.17 Thu 18:00 Poster D

Biocompatible High-Entropy Alloys Thin Films with Antibacterial Properties — •Anna Benediktová, Lucie Nedvědová, and Ján Minár — New Technologies - Research Centre, University of West Bohemia, Plzeň, Czech Republic

High-entropy alloys (HEAs) represent an intensively studied group of metallic materials. Due to their unique properties and their potential to be very stable, wear-resistant, and hard, in addition to the possibility of tailoring some of their properties, HEAs have also become the subject of study as biomaterials. Commonly used metal biomaterials for implants still have many drawbacks such as low wear and corrosion resistance or lack of antibacterial properties, which can even result in the loss of the implant. In the case of porous polymer implants used in maxillofacial and plastic surgery, there is excellent ingrowth of soft tissues, but not osseointegration, which could be solved by applying a suitable implant coating. To improve the surface properties, novel HEAs thin films, with various amounts of silver to achieve antibacterial properties, have been prepared by magnetron sputtering, and their structure has been determined using scanning and transmission electron microscopy. Various substrates have been used such as cp-Ti or HDPE.

DS 20.18 Thu 18:00 Poster D

Epitaxial CVD growth of MoS2 on sapphire — •Blagovest Napoleonov[1], Dimitrina Petrova[1,2], Daniela Karashanova[1], Peter Rafailov[3], Vladimira Videva[1,4], Velichka Strijkova[1], Dimitre Dimitrov[1,3], and Vera Marinova[1] — [1]Institute of Optical Materials and Technologies-BAS Sofia, Bulgaria — [2]South-West University "Neofit Rilski", Blagoevgrad, Bulgaria — [3]Institute of Solid State Physics-BAS, Sofia, Bulgaria — [4]Sofia University, Sofia, Bulgaria

We present the epitaxial growth of MoS2 on sapphire substrate using low-pressure CVD method. The research focuses on optimizing the growth conditions to achieve reproducible results and explores the potential of conventional epitaxy for synthesizing crystalline nanoclusters/flakes of MoS2. By performing targeted substrates surface modification, we successfully achieve the desired epitaxial growth as confirmed by HRTEM. This research contributes to the development of scalable and high-quality Transition Metal Dichalcogenide (TMD) growth techniques, for practical applications.

Acknowledgements This work is supported by the Bulgarian National Science Fund under the grant number KP-06-COST/15; Research equipment of distributed research infrastructure INFRAMAT (part of Bulgarian National roadmap for research infrastructures) supported by Bulgarian Ministry of Education and Science; the European Regional Development Fund within the Operational Programme "Science and Education for Smart Growth 2014-2020" under the Project CoE "National Centre of Mechatronics and Clean Technologies" BG05M2OP001-1.001-0008-C01.

DS 20.19 Thu 18:00 Poster D

Low energy ion-solid interactions: a quantitative experimental verification of binary collision approximation simulations — •Hans Hofsäss[1], Felix Junge[1], Patrick Kirscht[1], and Koen van Stiphout[2] — [1]II. Physikalisches Institut, Universität Göttingen, Germany — [2]Department of Physics, KU Leuven, Belgium

Ultra-low energy ion implantation has become an attractive method for doping of 2D materials. The dynamic binary collision approximation

Monte Carlo program IMINTDYN [1,2] allows a reliable prediction of low energy implantation profiles and target compositional changes, as well as efficient simulation of high energy light ion scattering. To demonstrate the quality of these simulations, we present implantation of W ions into tetrahedral amorphous carbon with low (10 keV) and ultra-low (20 eV) energies and high resolution Rutherford backscattering spectrometry (HR-RBS) to analyze the W implantation profiles with[1]. The experiment is compared with a complete simulation of all aspects of ion-solid-interactions of the experiment using the IMINTDYN. A unique novel simulation option is the inclusion of the vacancy as target species with dynamic vacancy generation and annihilation. We find excellent agreement between simulated and measured HR-RBS spectra if vacancy formation is included.

[1] H. Hofsäss, F. Junge, P. Kirscht and K. van Stiphout, Material Research Express (2023) DOI 10.1088/2053-1591/ace41c

[2] H. Hofsäss and A. Stegmaier, Nucl. Instr. Meth B 517 (2022) 49-62

DS 20.20 Thu 18:00 Poster D

Growth study of the altermagnet MnTe — •Marco Dittmar, Hannes Haberkamm, Philipp Kagerer, Maximilian Ünzelmann, and Friedrich Reinert — Exp. Physik VII and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Germany

Next to ferromagnetism and antiferromagnetism, a new type of magnetic order, called altermagnetism, has recently been predicted and has since attracted great attention. It is characterized by antiferromagnetic spin alignment combined with rotational lattice symmetry. Based on a profound symmetry analysis, various materials have been predicted to exhibit this type of magnetic order, one of which is MnTe in its hexagonal NiAs-type crystal structure [1].
Here, we present a growth study of MnTe on different substrates based on molecular beam epitaxy. Using X-ray diffraction, atomic force microscopy and photoemission spectroscopy, we will discuss e.g. the influence of the growth parameters on the observed films and the effect of substrate-induced lattice strain on the resulting crystal phase.
[1] L. Šmejkal *et al.*, Phys. Rev. X **12**, 031042 (2022)

DS 20.21 Thu 18:00 Poster D

Fast simulation of ion beam analysis spectra using binary collision approximation — •Hans Hofsäss, Felix Junge, and Patrick Kirscht — II. Physikalisches Institut, Universität Göttingen, Germany

The dynamic binary collision approximation program IMINTDYN [1,2] allows a reliable prediction of ion solid interaction. We have extended the IMINTDYN program to efficiently simulate high energy ion scattering as well as ion induced nuclear reaction spectra. This includes RBS, LEIS, ERDA, coincidence ERDA, ERCS, NRA and SIMS. The optimization includes (i) adjustable mean free path of high energetic ions (ii) enforced large angle scattering with scattering cross sections stored in weight factors, and (iii) enhanced data handling to identify coincident scattering events. The program runs on a AMD Ryzen Threadripper PRO 5965WX workstation. Typical simulations with millions of projectiles are finished within 2-20 minutes, faster than the duration of the experiment. The simulations provide details of the spectra, like single, dual and multiple scattering events, energy versus depth information, isotope information etc. We present selected examples for He ion RBS [1], Low energy He ion scattering (LEIS) as well as non-Rutherford backscattering of MeV H ions.

[1] H. Hofsäss, F. Junge, P. Kirscht and K. van Stiphout, Material Research Express (2023) DOI 10.1088/2053-1591/ace41c

[2] H. Hofsäss, A. Stegmaier, Nucl. Instr. Meth B 517 (2022) 49

DS 20.22 Thu 18:00 Poster D

Influence of post-growth temperature treatment on the surface structure of ion-beam sputtered vanadium oxide — •Yan Ravil Wollenweber-Bienerth, Antonia Krieger, Martin Becker, Sangam Chatterjee, and Peter J. Klar — Institute of Experimental Physics I , Heinrich-Buff-Ring 16, Justus-Liebig-Universität Giessen, D-35392 Giessen, Germany

Thermochromic (TC) smart windows are a type of fenestration whose transmittance switches as a function of the ambient temperature. Vanadium dioxide (VO_2) is by far the most studied TC material. Its insulator-to-metal transition is correlated with a crystalline phase transition accompanied by the change of transmittance/reflectance in the infrared region. To grow crystalline vanadium oxide thin films, usually high substrate temperatures are necessary. In an industrial process, however, post-growth annealing may be more desirable than in-situ heating during the deposition process. Furthermore, a post-growth temperature treatment may allow for a reduction of the growth temperature. Moreover, not only the material's phase is crucial, but also the evolution of the surface morphology of the functional layers.

Here, we employ ion-beam sputter deposition (IBSD) for the growth of VO_x and investigate different annealing routes for obtaining VO_2. We show that there is a temperature dependence of layer thickness and surface morphology of vanadium oxide as well as of its phase transition on annealing atmosphere, annealing pressure and annealing time. Thus, post-growth annealing enables further tuning the material's properties.

DS 20.23 Thu 18:00 Poster D

Plasma enhanced pulsed laser deposition of metal nitride and oxide thin films Dual radio frequency plasma enhanced pulsed laser deposition of metal nitride and oxide thin films — Heman Bhuyan[1], Rodrigo Villegas[1], Valentina Ureta[1], Miguel Escalona[1], Maria Jose Retamal[2], Maria Jose Inestroza[3], José Ignacio Fernández[1], Loïk Gence[1], •Ulrich G. Volkmann[1], and Yayoi Takamura[4] — [1]Instituto de Física, Pontificia Universidad Católica de Chile, Santiago, Chile — [2]Facultad de Ingenieria, Universidad Finis Terrae, Santiago, Chile — [3]Comisión Chilena de Energía Nuclear, Santiago, Chile — [4]Department of Materials Science and Engineering, University of California Davis, CA, USA

In this work, physics and application of a plasma enhanced pulsed laser deposition (PEPLD) system using dual radio frequency (RF) source will be presented. The dual radio frequency (RF) source has an additional benefit of controlling the ion energy and ion flux independently only by tuning the low frequency (LF) and high frequency (HF) components, respectively. Electrical and optical diagnostics, including time-resolved images, optical emission spectroscopy, and interferometry have been used to study the physics behind this PEPLD configuration. The results obtained from the deposition of titanium nitride and titanium dioxide thin films will be correlated with the interaction between the laser plum and the background RF plasma at different experimental conditions. The PEPLD system has successfully used to fabricate wrinkled titanium nitride nanocomposite for robust bendable electrodes. Acknowledgements: ANID FONDECYT 1220359.

DS 20.24 Thu 18:00 Poster D

Non-destructive analysis for ScAlN based MEMS — •Rebecca Petrich[1], Younes Slimi[1], Hauke Honig[2], Daniel Glöss[3], Stephan Barth[3], Hagen Bartzsch[3], Raphael Kuhnen[4], Dietmar Frühauf[4], Rüdiger Schmidt-Grund[1], Stefan Krischok[1], and Katja Tonisch[1] — [1]TU Ilmenau, FG Technische Physik I, IMN MacroNano, 98693 Ilmenau — [2]TU Ilmenau, FG Werkstoffe der Elektrotechnik, IMN MacroNano, 98693 Ilmenau — [3]Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP, 01277 Dresden, Germany — [4]Endress+Hauser SE+Co. KG, TTD Technologieentwicklung, 79689 Maulburg

ScAlN is an attractive alternative to traditional quartz- or lead-based piezoelectric materials due to its high piezoelectric coefficients and technological compatibility with MEMS processes. Non-destructive analysis is ideal for future system integration, as process and quality control can be carried out directly during production. Optical and spectroscopic methods are generally used for this, but these require an established material model, which is not available for new material compositions such as ScAlN, especially as they have to be adapted to different stoichiometries. In this contribution, ScAlN thin films are characterized by non-destructive methods such as EDX, XRD, Spectroscopic Ellipsometry and verified by established methods such as SEM, AFM and GDOES. The dielectric properties are investigated by means of plate capacitor structures using Pt, TiN and Ni as contact materials.

DS 20.25 Thu 18:00 Poster D

Understanding the thickness-dependent dielectric permittivity of oxide thin films — •Alessio Zaccone — University of Milan, Department of Physics, 20133 Milan, Italy — Institute of Theoretical Physics, University of Göttingen, Germany

The dielectric properties of thin films are of paramount importance in a variety of technological applications, from thin film capacitors and field-effect transistors to 5G technologies, and of fundamental importance for solid state research. In spite of this, there is currently no theoretical understanding of the dependence of the dielectric permittivity on the thickness of thin films. We develop a confinement model within

the Lorentz-field framework for the microscopic Langevin-equation description of dielectric response in terms of the atomic-scale vibrational modes of the solid. Based on this, we derive analytical expressions for the dielectric permittivity as a function of thin film thickness, in excellent agreement with experimental data of Barium-Strontium-Titanate (BST) thin films of different stoichiometry. The theory shows that the decrease of dielectric permittivity with decreasing thickness is directly caused by the restriction in k-space of the available eigenmodes for field-induced alignment of ions and charged groups.

DS 20.26 Thu 18:00 Poster D

Characterization of electrical and structural properties of ultrathin substoichiometric NiO_x films — •Tobias Pollenske, Laurenz Hüffmeier, and Joachim Wollschläger — Inst. of Physics, Univ. Osnabrück, Barbarastr. 7, 49076 Osnabrück, Germany

Ultrathin, substoichiometric NiO_x films offer promising applications in electronics and optoelectronics. The electronic structure of these films, whith transition from conductive (x=0) to insulating (x=1) state, enables targeted control of electrical conductivity and opens up potential for switching elements in electronics and transparent conductive layers in optoelectronics. In addition to transparency in the visible spectral range, the antiferromagnetic nature of nickel oxide (x=1) and ferromagnetism of Ni (x=0) makes these layers interesting for applications in spintronics. The holistic research of these material properties aims to develop a deep understanding and lay the foundation for innovative electronic devices, optoelectronic devices and high-performance sensors.

Hence, in this work, ultrathin NiO_x films with varying stoichiometries ($0 < x < 1$) were grown on insulating MgO(001) substrates using reactive molecular beam epitaxy (RMBE). The investigation focused on the temperature-dependent conductivity and charge carrier density of these films. Additionally, the structural characteristics of the films were determined through XRR and (HE)XRD. Complementary insights into the chemical composition of the films for both near surface and bulk, were obtained by Soft XPS and HAXPES measurements, respectively.

DS 20.27 Thu 18:00 Poster D

Freestanding (K,Na)NbO_3 thin films grown by metal-organic vapor phase epitaxy — •Jeremy Maltitz, Saud Bin Anooz, Jens Martin, and Jutta Schwarzkopf — Leibniz-Institut für Kristallzüchtung, Berlin, Germany

Pulsed Laser Deposition (PLD) is one of the most suitable deposition techniques used to deposit heterostructures with sacrificial layer to obtain freestanding oxide thin films. However, it suffers from the low oxygen partial pressure and high energetic particle bombardment during film growth, typically leading to oxide films with high structural and compositional defect density which results in inferior functional properties for the oxide film. In contrast, Metal-Organic Vapor Phase Epitaxy (MOVPE) provides films with significantly lower defects density due to growth conditions at higher oxygen partial pressures and nearby thermodynamic equilibrium. Thus, the combination of PLD and MOVPE is a promising approach to realize freestanding complex oxide membranes with high structural quality. Specifically, the ferroelectric material (K,Na)NbO3 is interesting since its properties are crucially determined by the application of strain. Traditionally this is achieved by heteroepitaxial growth of (K,Na)NbO3 thin films on lattice-mismatched substrates. More flexibility however, is given by detaching the (K,Na)NbO3 film from its growth substrate and transfer on a flexible support. However, the growth of (K,Na)NbO3 directly on the sacrificial layer is challenging due to the hygroscopic properties of the Sr3Al2O6 material system, which have to protected by introducing a thin buffer layer on the sacrificial layer.

DS 20.28 Thu 18:00 Poster D

A time-domain perspective on the structural and electronic response in epitaxial ferroelectric thin films — •Matthias Rössle[1], Christelle Kwamen[1], Wolfram Leitenberger[2], Pedro Rojo Romeo[3], Bertrand Vilquin[3], Catherine Dubourdieu[1,4], and Matias Bargheer[2,1] — [1]Helmholtz-Zentrum Berlin, Berlin, Germany — [2]Universität Potsdam, Potsdam, Germany — [3]Ecole Centrale de Lyon, Ecully, France — [4]Freie Universität Berlin, Berlin, Germany

Using synchrotron-based time-resolved X-ray diffraction and simultaneously measured electrical data, we investigate the frequency-dependent operando response of epitaxially grown $Pb(Zr_{0.48}Ti_{0.52})_3$ capacitors epitaxially grown on Silicon substrates in the frequency range $2 < \nu \leq 200$ kHz. We find that the electrical and structural hysteresis loops deform at high frequencies above 40 kHz, leading to a lower saturation polarization at high frequencies. We explain these observations in a time-domain perspective: The polarization and the structural motion within the unit cell are coupled to the strain along the *c*-axis by the piezoelectric effect. The solution of this coupled oscillator system is derived experimentally from the simultaneously measured electronic and structural data.

DS 20.29 Thu 18:00 Poster D

time-resolved x-ray diffraction studies on ferroelectric thin film — •rekikua alemayehu[1], david pesquera[2], matthias rössle[3], and matias bargheer[1,3] — [1]Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany — [2]Catalan Institute of Nanoscience and Nanotechnology, Catalonia, Spain — [3]Helmholtz Zentrum Berlin, BESSY II, Berlin, Germany

Polarization switching in ferroelectrics involves the motion of atoms in the crystal structure. Time-resolved x-ray diffraction is a powerful experimental technique to study the structural changes that occur during this process. Here, we show the simultaneous structural and electrical response of a barium titanate epitaxial thin film during and after the application of electric field pulses with amplitudes above and below the coercive field of the ferroelectric film. We will discuss how the transient strain encodes the influence of imprint phenomena on the switching dynamics.

DS 20.30 Thu 18:00 Poster D

Room temperature reversible colossal volto-magnetic effect in all-oxide metallic-magnet/topotactic-phase-transition material heterostructures — •Sourav Chowdhury[1,3], Supriyo Majumder[2,3], Rajan Mishra[3], Arup Mandal[4,3], Anita Bagri[3], Deodatta Phase[3], Moritz Hoesch[1], Ram Choudhary[3], Satish Yadav[3], and Suman Karmarkar[3] — [1]DESY, Hamburg, Germany — [2]Northwestern University, IIIinois, USA — [3]UGC-DAE CSR, Indore, India — [4]IISC, Bengaluru, India

Multiferroic materials have undergone extensive research in the past two decades to produce a sizable room-temperature magneto-electric effect [1]. Here, we developed an innovative way is to tune the functional properties based on the tremendous modulation of electronics and magnetization by the electric field of the topotactic phase transitions (TPT) in heterostructures composed of metallic-magnet/TPT-material. The application of a nominal potential difference of 2-3 Volts induces gigantic changes in magnetization by 100-250% leading to colossal Volto-magnetic effect, which would be tremendously beneficial for low-power consumption applications in spintronics [2,3]. Switching electronics and magnetism by inducing TPT through applying an electric field requires much less energy, making such TPT-based systems promising for energy-efficient memory and logic applications.

[1] G. Catalan et al. Adv. Mater. 2009, 21, 2463, [2] N. A. Spaldin et al. Nat. Mater. 2019, 18, 203, [3] A. Bagri et al. ACS Appl. Mater. Interfaces 2013, 15, 18391.

DS 20.31 Thu 18:00 Poster D

Preparation and electrochemical characterization of laminar GO/WS_2 membranes — •Ann-Sophie Meyer, Yossarian Liebsch, and Marika Schleberger — Universität Duisburg-Essen, Fakultät für Physik, Germany

Ion-selective membranes are needed for various technical applications such as electrodialysis, fuel cells, desalination and biomedical applications. Nowadays, polymer membranes are mainly used for these applications, but the special properties of 2D materials offer the possibility to produce more efficient membranes. In particular, graphene oxide (GO) membranes are attracting a lot of interest from the scientific community.

In this work, stable GO membranes and GO membranes with an additional amount of WS_2 were prepared by vacuum filtration and tested for their morphology as well as ionic conductivity. It was found that ionic conductivity can be improved by incorporating WS_2 in the GO membranes, however, neither the exact WS_2 content nor a uniform distribution in the resulting membrane could yet be obtained.

Thus, the question of how the introduction of WS_2 into GO membranes changes their electrochemical properties and, in particular, increases their conductivity, could only be partially answered within our study.

In order to ensure a homogeneous distribution of WS_2, possibilities for optimization of the fabrication method will be discussed. Future experiments can then determine the WS_2 content for optimal ionic conductivity.

DS 20.32 Thu 18:00 Poster D

Epitaxial stabilization of perovskite ATeO3 thin films — •Andreas Herklotz[1], Florina Stefania Rus[2], David P Cann[3], and Kathrin Dörr[1] — [1]Institute for Physics, Martin-Luther-University Halle-Wittenberg, Halle, Germany — [2]National Institute for Research and Development in Electrochemistry and Condensed Matter, Timisoara, Romania — [3]Oregon State University, Corvallis, OR

Tellurium oxides of the form ATeO3 typically do not crystallize in perovskite structures. Here, we show that perovskite-like ATeO3 (A = Ca, Sr, Ba) thin films can be grown on perovskite single-crystal substrates via epitaxial stabilization. The films are stable with high optical bandgaps, low dielectric losses and high electric breakdown strength. Hysteretic dielectric behavior in SrTeO3 and BaTeO3 strongly suggest the presence of antiferroelectricity and ferroelectricity, respectively. These properties make perovskite tellurium oxides a possibly appealing class as thin film coating or insulator material in advanced microelectronics. Tellurium oxides constitute a largely unexplored class of materials that might show new and interesting functionalities in epitaxial thin film form. Our work encourages new work within this field.

DS 20.33 Thu 18:00 Poster D

Mapping the lateral homogeneity of semiconducting monolayer 2D polar Ag using spectroscopic imaging ellipsometry — •Ulrich Limberg[1], Jakob Henz[1], Siavash Rajabpour[2], Alexander Vera[2], Joshua Robinson[2], and Ursula Wurstbauer[1] — [1]Institute of Physics, University of Muenster, Germany — [2]MatSE; Center for 2DLM; Atomic; 2D Crystal Consort, PennState University, USA

2D polar metals are a novel family of atomically thin plasmonic quantum materials, which are synthesized by confinement heteroepitaxial growth (CHet)[1]. Hereby, metal atoms such as silver or gallium are intercalated between bilayer graphene and a silicon carbide substrate. In the case of 2D polar silver, a stable monolayer structure forms which has been shown to be an indirect bandgap semiconductor[2]. However, Raman imaging seems to indicate the existence of a second, possibly metallic, phase[3].

We investigated 2D polar silver samples of varying growth conditions via spectroscopic imaging ellipsometry, in order to access lateral inhomogeneities by modifications in the dielectric functions sensitive to different phases.

1 N. Briggs, et al. Nature materials 19.6 (2020): 637-643.
2 W. Lee, et al., Nano letters, 22(19) (2022): 7841-7847.
3 M. Wetherington et al., 2D Materials, 8.4 (2021): 041003.

DS 20.34 Thu 18:00 Poster D

Dielectric function of Rubi in static and lasing operation — •Noah Stiem, Younes Slimi, Clara Köhler, Stefan Krischok, and Rüdiger Schmidt-Grund — TU Ilmenau, Fachgebiet Technische Physik I, Weimarer Straße 32, 98693 Ilmenau

In a future study of the transient dielectric function of the classic laser material ruby by time-resolved spectroscopic ellipsometry (TRSE) we plan to investigate the influence of stimulated emission on the TRSE results and their analysis. Here we lay the groundwork by determining the steady-state dielectric function tensor of ruby samples via Mueller-matrix ellipsometry in reflection and transmission configuration. The data presented is not only necessary for the analysis of subsequent time-dependent measurements, but already allows insight into the changes of the dielectric function due to pump excitation. When pumping with a blue laser, the static dielectric function shows a change in intensity of the chromium states responsible for lasing at 692.80 nm and 694.25 nm caused by laser action in the material.

DS 20.35 Thu 18:00 Poster D

Optical Analysis of Sputtered $(IST)_{1-x}(SnTe)_x$ Thin Films — •Thomas Schmidt[1], Christian Stenz[1], Michael Dappen[1], and Matthias Wuttig[1,2] — [1]1. Institute of Physics (IA), RWTH Aachen University, 52074 Aachen, Germany — [2]JARA Institute Green IT (PGI-10), Forschungszentrum Jülich, 52428 Jülich, Germany

Phase-change materials (PCMs) are characterized by a strong contrast in optical properties between amorphous and crystalline phases. Unlike other PCMs, crystalline In_3SbTe_2 (IST) shows metallic behavior. Therefore, IST arouses interest in nanophotonic applications. However, the optical property contrast is mainly limited to the infrared spectrum. Alloying IST with other compounds is an attempt to expand the optical contrast to the visible spectrum. One of those alloy-candidates is SnTe, which is characterized by a negative real part of the dielectric function $\epsilon = \epsilon_1 + i \cdot \epsilon_2$, a high maximum value of ϵ_2 at around 2.2 eV and the same rocksalt-like structure in the crystalline phase as IST. Metavalently bonded (MVB) materials, like SnTe, are characterized by significantly different properties compared with compounds employing one of the fundamental well-established bonding mechanisms (e.g. ionic, metallic, covalent). In order to link optical properties with chemical bonding, spectroscopic ellipsometry and Fourier transform infrared spectroscopy (FTIR) was performed on sputtered thin films of approx. 75 nm thick $(IST)_{1-x}(SnTe)_x$. From this, the dielectric function of the amorphous and crystalline samples can be extracted. The changes in the dielectric function ϵ of the crystalline phase can be assigned to a transition of chemical bonding from metallic to MVB.

DS 20.36 Thu 18:00 Poster D

Quantum Corrections to the Transport Properties in Thin Films of $BaPbO_3$ — •Alexander Schmid, Robert Bartel, Patrick Seiler, Thilo Kopp, and German Hammerl — Chair of Experimental Physics VI, Center for Electronic Correlations and Magnetism, University of Augsburg

The paper reports on the characterization of transport properties of epitaxial $BaPbO_3$ thin films grown on $SrTiO_3$ by pulsed laser deposition, taken at low temperatures and high magnetic fields.

The electric resistance in these films shows deviations from classical transport behavior at low temperature due to dimensional effects and pronounced spin-orbit coupling. Such corrections to the classical electric resistance can be understood in the framework of weak localization and electron-electron interaction [1]. Considering both of these impurity-driven quantum effects is essential to quantitatively understand the electric transport in $BaPbO_3$ thin films [2].

Here, we present recent results regarding the influence of a systematical change of the oxygen background pressure during growth of $BaPbO_3$ thin films by pulsed laser deposition on the quantum corrections to the electric resistance at low temperatures [3].

[1] P. Seiler, R. Bartel, T. Kopp, G. Hammerl, Phys. Rev. B 100, 165402 (2019). [2] R. Bartel, E. Lettl, P. Seiler, T. Kopp, G. Hammerl, physica stat. sol. (b) 259, 2100154, (2021). [3] A. Schmid, Master's Thesis, University of Augsburg (2023).