DS 6: Thin Oxides and Oxide Layers

Time: Tuesday 9:30–11:45 Location: REC/C213

Invited Talk DS 6.1 Tue 9:30 REC/C213

Soft X-ray Microscopy of Ferroic Thin Films — •Tim A. Butcher[1], Simone Finizio[2], Michael Schneider[1], Jörg Raabe[2], Stefan Eisebitt[1], and Bastian Pfau[1] — [1]Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, 12489 Berlin, Germany — [2]Paul Scherrer Institut, 5232 Villigen PSI, Switzerland

Any technological advance involving ferroic thin films requires a clear picture of their domain structures at the nanoscale. These can be studied by soft X-ray microscopy at synchrotron lights sources, which combines high spatial resolution with sensitivity to ferroic order. This presentation will provide an overview of several ferroic thin films and the application of coherent diffractive imaging methods such as Fourier Transform Holography and soft X-ray ptychography to their study [1]. One example is the room-temperature multiferroic BiFeO3 for which ptychography can probe the magnetoelectric coupling by resolving both the antiferromagnetic spin cycloid and the ferroelectric domains in a single measurement [2,3]. Furthermore, an example of imaging dynamics will be provided with the ptychographic investigation of magnetic domain walls [4].

[1] T. A. Butcher et al., Rev. Sci. Instrum. 96, 123704 (2025) [2] T. A. Butcher et al., Adv. Mater. 36 (2024) [3] T. A. Butcher et al., Phys. Rev. Appl. 23, L011002 (2025) [4] T. A. Butcher et al., Phys. Rev. B 111, L220409 (2025)

DS 6.2 Tue 10:00 REC/C213

Atomic Scale Insights into the Polymorphism of Ruddlesden-Popper Nickelates and Titanates — Shihao Wei[1], Stefania Baronio[2], Bruce Davidson[2], Ke Zou[2], and •Nicolas Bonmassar[1] — [1]Materials Physics, Institute for Materials Science, University of Stuttgart, Heisenberstr. 3, 70569, Germany — [2]Quantum Matter Institute, University of British Columbia, Vancouver, Canada

Ruddlesden-Popper (RP) oxides provide an ideal platform for investigating coupled structural and electronic phenomena, as subtle variations in layering and cation coordination can significantly alter their functional properties. Using oxide molecular beam epitaxy, we can grow distinct nickelate and titanate RP phases with atomic-layer precision, demonstrating the controlled stabilization of distinct polymorphs by tuning the rock-salt and perovskite layers. Advanced scanning transmission electron microscopy provides insights into the resulting structures at an atomic scale, enabling the direct identification of the respective polymorph and the characterization of extended defects, such as stacking faults. By correlating local structure with electronic properties, we can establish clear structure-property relationships across all samples. Electron energy-loss and energy-dispersive X-ray spectroscopy reveal the differences in transition-metal oxidation states, defect density and oxygen orbital occupation between the different RP phases and polymorphs. Our results highlight how precise control of the individual layers leads to the control over the polymorphs in RP nickelates and titanates.

DS 6.3 Tue 10:15 REC/C213

Memristive behaviour in Nickelate Perovskite thin films — •Foelke Janssen[1,2] and Beatriz Noheda[1,2] — [1]Zernike Institute for Advanced Materials, University of Groningen, The Netherlands — [2]Groningen Cognitive Systems and Materials Center (CogniGron), University of Groningen, The Netherlands

Memristive devices can adopt multiple resistance states depending on the history of the electric signal applied, emulating the basic behavior of synapses and neurons. They hold great promise as low energy consumption devices for in-memory and brain-inspired computing. Materials that undergo a metal-to-insulator phase transition (MIT) are interesting as volatile memristors and can also be used as neuristors by being the active component in self-oscillating circuits. Rare-earth (RE) nickelates ($RENiO_3$) display a MIT at temperatures that can be tuned by changing the RE cations, the strain state, the film thickness or the oxygen vacancy content. Compared to other transition-metal oxides, nickelates are especially interesting as memristive devices due to the robustness of the perovskite structure under intense local heating. In this work, we demonstrate that nickelates can also be used to mimic short term memory in synapses via multilevel resistance states that can be achieved in $SmNiO_3$ thin film structures upon voltage pulsing, harnessing the metal-insulator phase transition, without involving ionic transport. Furthermore, we also demonstrate $SmNiO_3$ as a neuron and discuss the mechanisms behind both devices.

15 min. break

DS 6.4 Tue 10:45 REC/C213

Structure and optical properties of Ga2O3 thin films deposited by reactive and non-reactive sputtering — •Marcell Gajdics, Ildikó Cora, Dániel Zámbó, Zsolt Endre Horváth, Miklós Serényi, and Béla Pécz — Institute for Technical Physics and Materials Science, HUN-REN Centre for Energy Research, H-1121 Budapest, Hungary

Ga2O3, as an ultrawide bandgap semiconductor has numerous potential applications in the field of optoelectronics and high-power electronics. Gallium oxide thin films can be grown by a variety of methods, among which radio frequency sputtering is a commonly used technique. In most cases, a ceramic Ga2O3 target is used for the sputter deposition of Ga2O3. In our work, we present an alternative method, i.e. reactive sputtering of a liquid Ga target. We have shown that by using this technique, layers close to the ideal stoichiometry can be deposited with higher deposition rates than by using a Ga2O3 target. The optical properties (e.g. refractive index) were studied as a function of the oxygen concentration in the films. Post-deposition annealing experiments were also performed on the amorphous as-deposited layers to study the annealing-induced structural and optical changes. It was found that as a first step of crystallization γ-Ga2O3 phase was formed and the thermodynamically stable β-Ga2O3 appeared only at higher temperatures. The photoluminescence emission and the optical bandgap were also measured at different annealing temperatures and the results were correlated with the structural properties.

DS 6.5 Tue 11:00 REC/C213

Depth Profiling of Oxygen Migration in Ta/HfO_2 Stacks During Ionic Liquid Gating — •Martin Wortmann[1,2], Beatrice Bednarz[3], Olga Kuschel[3,4], Fabian Kammerbauer[3], Mathias Kläui[3], Andreas Hütten[1], Joachim Wollschläger[4], Gerhard Jakob[3], and Timo Kuschel[1,3] — [1]Bielefeld University, Bielefeld, Germany — [2]Bielefeld University of Applied Sciences and Arts, Bielefeld, Germany — [3]Johannes Gutenberg University Mainz, Mainz, Germany — [4]Osnabrück University, Osnabrück, Germany

Ionic-liquid gating enables electric-field-driven ion transport at thin-film interfaces to manipulate structural, electronic, optical, and magnetic properties [1]. Oxygen is driven from a donor oxide layer into an underlying acceptor metal layer, but the resulting spatial distribution and voltage dependence of oxygen migration remain poorly understood. Here, we investigate the formation of Ta_2O_5 at the interface between the HfO_2 donor and Ta acceptor layers as a function of gate voltage, time, and HfO_2 thickness using oxidation-state depth profiling by combining X-ray reflectivity measurments with multi-line angular-resolved X-ray photoelectron spectroscopy [2,3]. The results elucidate both the quantitative oxygen distribution as well as the underlying mechanism [4].

[1] Bednarz et al., Appl. Phys. Lett. 124, 232403 (2024)
[2] Wortmann et al., Small Methods 8, 2300944 (2023)
[3] Wortmann et al., Appl. Surf. Sci. 713, 164356 (2025)
[4] Bednarz et al., arxiv: 2509.05748 (2025)

Invited Talk DS 6.6 Tue 11:15 REC/C213

Charge transfer at interfaces of free-standing oxide membranes and heterostructures — Kapil Nayak[1], Lee-Kang Huang[1], Anton Kaus[1], Marcus Wohlgemuth[1], Alexandros Sarantopoulos[1], Christoph Baeumer[2], Regina Dittmann[1], and •Felix Gunkel[1,2] — [1]PGI-7, FZ Jülich — [2]MESA+, UTwente

Free-standing oxides, based on the delamination of atomically defined epitaxial thin films, provide new opportunities to combine functional complex oxides with semiconductor electronics and other typically incompatible technology environments. The nanoscale confinement of these transferable membranes enables unique structures and functionalities, applicable in hybrid electronics as well as energy applications. Here, we discuss the synthesis of transferable perovskite oxide membranes and heterostructures via the all-perovskite sacrificial-layer

route. We present control strategies to achieve singly-terminated membranes, using chemical treatments as well as direct growth mode control. These yield atomically smooth membrane-based substrates, serving as ideal template for heterostructure growth on Si. We use typical charge-transfer oxide heterostructures, such as LaAlO3/SrTiO3, to probe the interfacial charge-transfer across the heterostructure interface. To disentangle growth-induced redox response and thermodynamic ion-exchange, we employ in-situ x-ray spectroscopy and correlate the interplay of confinement-phenomena, redox-chemistry & growth kinetics. Finally, we will provide an outlook on membrane-based oxide heterostructures used in electrochemical water splitting, offering new opportunities for analysis and integration.