DS 1: Thin Film Properties: Structure, Morphology and Composition (XRD, TEM, XPS, SIMS, RBS, AFM, ...) 1

Time: Monday 9:30–10:45 Location: H14

DS 1.1 Mon 9:30 H14

Low-energy ion channeling in nanocubes — •Shiva Choupanian[1], Wolfhard Möller[2], Martin Seyring[1], and Carsten Ronning[1] — [1]Institute of Solid State Physics, Friedrich Schiller University Jena — [2]Helmholtz-Zentrum Dresden-Rossendorf

Focused ion beam (FIB) processing with low-energy ions has become a standard technique for the manipulation of nanostructures. Many underlying ion beam effects that deviate from conventional high-energy ion irradiation of bulk systems are considered today; however, ion channeling with its consequence of significant deeper penetration depth has been only theoretically investigated in this regime. We present here an experimental approach to determine the channeling of low-energy ions in crystalline nanoparticles by measuring the sputter yield derived from SEM images taken after irradiation under various incident ion angles. Channeling maps of 30 and 20 keV Ga+ ions in Ag nanocubes have been identified and fit well with the theory. Indeed, channeling has a significant impact on the transport of energetic ions in crystals due to the large critical angle at low ion energies, thus being relevant for any FIB-application. Consequently, the obtained sputter yield clearly differs from amorphous materials; therefore, it is recommended not to rely only on, e.g., ion distribution depths predicted by standard Monte-Carlo (MC) algorithms for amorphous materials.

DS 1.2 Mon 9:45 H14

Tuning the properties of thin films via disorder — •Alessandro Troglia[1], Jorik van de Groep[2], Anne de Visser[2], and Roland Bliem[1,2] — [1]Advanced Research Center for Nanolithography (ARCNL), Science Park 106, 1098 XG Amsterdam, The Netherlands (NL) — [2]Van der Waals-Zeeman Institute, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, The Netherlands (NL)

Structural disorder in thin films is often considered detrimental compared to the well-defined nature of epitaxial layers. However, some examples of amorphous thin films show superior properties such as better corrosion resistance, mechanical strength and catalytic performance. Here we investigate amorphous and crystalline CuZr thin films of identical composition. Grazing-incidence x-ray diffraction (GI-XRD) demonstrate that amorphous and crystalline CuZr thin films were achieved by varying the substrate temperature during deposition with pulsed laser deposition (PLD). The effect of disorder is clearly visible in the optical, transport and corrosion properties. The amorphous films are optically transparent in the visible, while polycrystalline films are dark and reflective. The temperature-dependent electronic transport changes its mode from a bad metal to a charge-hopping conductor with an increase in structural disorder. Moreover, we observe a higher oxidation resistance of amorphous CuZr thin films due to the absence of grain boundaries. These results pave the way to the synthesis of metallic thin films with superior and tunable properties via disorder for customizing materials properties to their technological applications.

DS 1.3 Mon 10:00 H14

Faster and lower dose X-ray reflectivity measurements enabled by physics-informed modelling and artificial intelligence co-refinement — •David Marecek[1], Julian Oberreiter[1], Andrew Nelson[2], and Stefan Kowarik[1] — [1]Physikalische und Theoretische Chemie, Universität Graz, Graz, 8010, Austria — [2]ANSTO, Locked Bag 2001, Kirrawee DC, NSW, 2232, Australia

We present an approach for analysis of real-time X-ray reflectivity (XRR) process data not just as a function of the reciprocal space vector q as is commonly done, but as a function of both q and time. We restrict the real-space structures extracted from the XRR curves to be solutions of a physics-informed growth model, and use state-of-the-art convolutional neural networks (CNNs) and differential evolution fitting to co-refine multiple time-dependent XRR curves $R(q,t)$ of a thin film growth experiment. Thereby it becomes possible to correctly analyze XRR data with a fidelity corresponding to standard fits of individual XRR curves even if they are sparsely sampled with a 7-fold reduction of XRR datapoints, or if the data is noisy due to a 200-fold reduction in counting times. Our approach of using a CNN analysis and of including prior information through a kinetic model is not limited to growth studies, but can be easily extended to other kinetic X-ray or neutron reflectivity data to enable faster measurements with lower beam damage.

DS 1.4 Mon 10:15 H14

Scattergram analysis and filtering of differential phase contrast STEM images — •Julius Bürger[1,2], Maja Groll[1,2], Thomas Riedl[1,2], and Jörg K. N. Lindner[1,2] — [1]Nanostructuring, Nanoanalysis and Photonic Materials Group, Dept. of Physics, Paderborn University, Paderborn, Germany — [2]Center for Optoelectronics and Photonics Paderborn (CeOPP), Paderborn, Germany

Differential phase contrast (DPC) in scanning transmission electron microscopy allows the imaging and quantification of electric fields in solid specimen by measuring the transferred (first) momentum perpendicular to the optical axis imposed on the beam by the specimen's electrostatic potentials. Owing to the high-resolution capability of modern Cs-corrected transmission electron microscopes, electric fields and charge densities can be revealed with sub-atomic resolution. However, the requirements are very high, since the field distributions being measured by a position sensitive detector are drastically influenced by numerous factors, such as the lens aberrations, dynamic diffraction effects, noises, and the detector response function. We demonstrate how these influences can be readily detected in a DPC image using the so-called scattergram, which is a two-dimensional histogram of all transferred momenta, and particularly focus on the effect of noise and detector rotation by comparing DPC measurements and simulations for Si [110] performed with a segmented annular quadrant detector. In this regard, we introduce a novel method, the scattergram filtering, revealing the position of characteristic features in DPC images.

DS 1.5 Mon 10:30 H14

Contrast modes in transmission experiments using broad and focussed keV ion beams — •Svenja Lohmann[1,2], Gregor Hlawacek[1], Radek Holeňák[2], Nico Klingner[1], Daniel Primetzhofer[2], and Eduardo Serralta[1,3] — [1]Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — [2]Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden — [3]Technische Universität Dresden, Germany

The helium ion microscope (HIM) is an instrument for high-resolution imaging, composition analysis, and materials modification at the nanoscale. Ion transmission experiments could further improve the analytical capabilities of this technique, and multiple contrast modes are possible. We explore the latter at keV ion energies using a HIM in a scanning transmission approach as well as a broad beam in combination with a time-of-flight (ToF) set-up. Both systems employ position-sensitive detectors allowing for analysis of angular distributions.

In the ToF-system, we find a strong trajectory-dependence of the measured specific energy loss attributed to charge-exchange events in close collisions [Phys. Rev. Lett. 124 (2020), 096601]. Channelling and blocking of transmitted ions allows for mapping of intensity as well as different energy loss moments [Ultramicroscopy 217 (2020), 113051]. In the HIM we demonstrate different contrasts, e.g., due to orientation of nanocrystals, channelling in single-crystalline membranes and material contrast for layered films [Beilstein J. Nanotechnol. 11 (2020), 1854].