HL 29: Microscopy, Tomography and Spectroscopy with X-ray Photons, Electrons, Ions and Positrons (joint session KFM/HL)

Chair: Enrico Langer (Technische Universität Dresden)

Time: Wednesday 9:30–12:10 Location: H47

HL 29.1 Wed 9:30 H47

Phase Retrieval in X-Ray Near-Field Holography on Strong Objects — •Johannes Hagemann — DESY, Notkestraße 85, 22607 Hamburg

Lensless imaging techniques in the hard x-ray regime have become popular over the last two decades since no image forming optic is needed. Instead, the image is formed a posteriori numerically by reconstruction algorithms, which solve the ill-posed phase problem inherent to the measured data. Lensless techniques are demanding in terms of the radiation's properties used for illumination i.e. coherence, monochromaticity and fluence. The image reconstruction is often carried out under idealized assumptions of the probing illumination. The effects of failing these assumptions on the result of the reconstruction have been studied earlier in greater detail [1, 2]. For this work we study the effects of the object under reconstruction in the setting of x-ray near-field holography in greater detail. By numerical modelling and experiment we investigate the aspects of (i) the contrast of a hologram as a function of Fresnel number and phase shift, and (ii) the influence of strong objects on the image reconstruction process by phase retrieval. Our results indicate a maximum of contrast at Fresnel number $10^{-5} - 10^{-4}$.

[1] J. Hagemann and T. Salditt, "The fluence-resolution relationship in holographic and coherent diffractive imaging", J. Appl. Crystallogr., 50 (2017)

[2] J. Hagemann and T. Salditt, "The Coherence-resolution relationship in holographic and coherent diffractive imaging", Opt. Express, 26 (2017)

HL 29.2 Wed 9:50 H47

X-ray phase-contrast micro-CT of biological tissues at a rotating anode source — •Jasper Frohn and Tim Salditt — Institut für Röntgenphysik, Göttingen

X-ray phase-contrast offers the possibility of enhancing the image contrast for low absorbing materials such as biological soft tissues. Applied in a tomographic setup, the phase-contrast can be utilized to investigate the structure of such samples in 3d in a non-invasive way. One method to realize phase contrast images is "propagation-based imaging (PBI)", which is based on the free space propagation from the sample to the detector. To perform PBI tomography inhouse, x-ray sources are required with a certain degree of coherence. We were able to establish a high resolving propagation-based phase-contrast tomographic setup at a microfocus x-ray source with a rotating copper anode in our laboratory. The 3d resolution is in the range of few micrometers, achieved with a high resolving detector in inverse geometry. Results will be presented and compared with the synchrotron tomography endstation "GINIX" (P10 at PETRA III/DESY).

HL 29.3 Wed 10:10 H47

Atomic Resolution Differential Phase Contrast STEM investigations of electric fields in ZnO nanostructures — •Julius Bürger, Julia Weiss, Dennis Meinderink, Katja Engelkemeier, Wolfgang Bremser, Guido Grundmeier, Mirko Schaper, and Jörg K. N. Lindner — Paderborn University, Paderborn, Germany

Differential phase contrast (DPC) is one of the most promising techniques for future research with scanning transmission electron microscopy (STEM) giving rise to a new range of measurable material properties. By detecting phase gradients, i.e. by quantifying the electron beam deflection on a specimen site with a segmented detector, electric and magnetic field components can be detected. With an installed C_s-corrector the projected charge carrier distribution and electric fields can be estimated with a resolution much smaller than typical atomic distances. Zinc oxide (ZnO) is a piezoelectric material with excellent optical and semiconductor properties. Hence ZnO is promising for green energy harvesting converting mechanical stress into electric energy. For optimization of ZnO-based piezoelectric devices the operating principles and charge carrier displacements resulting from mechanical stress have to be understood down to the sub-nanoscale. In this presentation, the electric fields and charge carrier distributions of bent ZnO nanobelts, ZnO nanorods, nanowall network hollow body microspheres and ZnO-functionalized carbon fibers are revealed for the first time by DPC-STEM both at a macroscopic scale and with atomic resolution.

HL 29.4 Wed 10:30 H47

Investigation of superlattice defects in magnetite mesocrystals via (S)TEM tomography — •Sebastian Sturm[1], Daniel Wolf[1], Julian Brunner[2], Elena Sturm[2], Axel Lubk[1], and Bernd Büchner[1] — [1]IFW Dresden, Deutschland — [2]FB Chemie, Universität Konstanz, Deutschland

Mesocrystals are a special sub class of colloidal crystals fulfilling the definition of a crystal on two different hierarchical levels, exhibiting single crystal like diffraction pattern in small angles as well as single or texture like pattern in wide angles. They are thus formed by assembly of single crystalline building blocks in a long range ordered superlattice with reoccurring specific crystallographic orientation of the crystalline building blocks. In order to characterize the growth mechanism and investigate the defect structure of 3D iron oxide self-assembled mesocrystaline materials, we employed electron tomography on specifically picked areas. This allows to resolve structural defects generated within the superlattice during the self-assembly process inside the crystal in three dimensions. In case of a mesocrystal with fcc superlattice, grown by dislocation driven crystal growth mechanism, the disintegration of a (111) plane intersecting screw dislocation defect structure, in two Shockley-partials has been resolved, very similar to traditional fcc crystals. The aim is to study the structure of these partials and relate it to the elastic properties of the mesocrystal.

HL 29.5 Wed 10:50 H47

Thickness Determination on Molecular Thick Carbon Nanomembranes by HIM, XPS and EFTEM — •Daniel Emmrich[1], Annalena Wolff[2], Nikolaus Meyerbröker[3], Jörg K. N. Lindner[4], André Beyer[1], and Armin Gölzhäuser[1] — [1]Bielefeld University, Germany — [2]Queensland University of Technology, Australia — [3]CNM Technologies GmbH, 33607 Bielefeld, Germany — [4]Paderborn University, Germany

The Helium Ion Microscope (HIM) offers a lateral imaging resolution of 0.3 nm and is known for its excellent sub 10 nm milling capabilities [1]. While imaging with secondary electrons (SE) is well established for this microscope, the ion transmission signal attracts growing attention. Imaging in transmission offers additional information on membranes [2] and core shell nanoparticles [3]. Monolayer thin membranes have not been studied so far. Our systems are molecular thick Carbon Nanomembranes which are made of self-assembled monolayers that are cross-linked by low energy electrons [4]. We are able to measure dark field transmission of the same sample area at different acceptance angles using a SE conversion holder. The image contrast at different acceptance angles is compared to simulations and the membrane thickness is determined. We demonstrate our concept for different energies and thicknesses. We compare our results to standard techniques, e.g., XPS and EFTEM. [1] G. Hlawacek, A. Gölzhäuser (Eds.), Springer Intl., Switzerland 2016. [2] A. R. Hall, Microsc Microanal 2013, 19, 740. [3] T. J. Woehl et al., Microsc Anal, 2016, 22, 544. [4] A. Turchanin, A. Gölzhäuser, Adv. Mater 2016, 28, 6075.

Break 20 min

HL 29.6 Wed 11:30 H47

Positron Annihilation Studies using a Superconducting Electron LINAC — •Maik Butterling[1], Andreas Wagner[1], Maciej Oskar Liedke[1], Eric Hirschmann[1,2], Ahmed G. Attallah Elsherif[1], Reinhard Krause-Rehberg[2], and Kay Potzger[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf, Bautzner Landstr. 400, 01328 Dresden, Germany — [2]Martin-Luther-Universität Halle, Institut für Physik, 06099 Halle, Germany

The Helmholtz-Center at Dresden-Rossendorf operates several user beamlines for materials research using different techniques for positron annihilation spectroscopy. Two of them are being operated at a superconducting electron linear accelerator producing positrons via pair production from electron-bremsstrahlung. While one of the sources uses bremsstrahlung to directly generate positrons inside the sample of interest, in the second source (MePS), monoenergetic positrons with energies ranging from 500 eV to 25 keV are used for thin-film studies of porosity and defect distributions. The MePS beam line is currently complemented by a new in-situ end station (AIDA-2), where defect studies can be performed in a wide temperature range during thin film growth and ion irradiation. Developments as well as examples of recent experimental results at all facilities will be presented. The MePS facility has partly been funded by the Federal Ministry of Education and Research (BMBF) with the grant PosiAnalyse (05K2013). The AIDA facility was funded by the Impulse- und Networking fund of the Helmholtz-Association (FKZ VH-VI-442 Memriox) and through the Helmholtz Energy Materials Characterization Platform.

HL 29.7 Wed 11:50 H47

The influence of trace element additions to Al-1.7 at.% Cu alloys: preservation of quenched-in vacancies and atomistic mechanisms supporting θ'-formation — •Torsten E.M. Staab[1], Frank Lotter[1], Uwe Mühle[2], Mohamed Elsayed[3], Danny Petschke[1], Thomas Schubert[4], Reinhard Krause-Rehberg[3], and Bernd Kieback[2,4] — [1]University Wuerzburg, Dep. of Chemistry, LCTM, Roentgenring 11, D-97070 Wuerzburg — [2]TU Dresden, Institute of Materials Science; Helmholtzstr. 7, D-01069 Dresden — [3]Martin-Luther-University Halle-Wittenberg; Faculty of Natural Science II; von-Danckelmann-Platz 3; D-06120 Halle — [4]Fraunhofer IFAM, Winterbergstrasse 28, D-01277 Dresden

Aluminium-copper alloys of the 2xxx type receive their strength during hardening at room or elevated temperature by the formation of copper-rich precipitates. They are responsible for the final mechanical properties of these alloys. Alloying small amounts of Cd, In or Sn influences the precipitation behavior as well as the final strength of Al-Cu alloys. Obviously, quenched-in vacancies are bound to trace element atoms in the aluminium matrix. Thus, the diffusion behavior of the copper atoms is influenced and the main type of the formed precipitates changes. For high-purity ternary alloys we investigate the interaction of copper atoms and trace elements (In, Sn, and Pb) with quenched-in vacancies. By employing Differential Scanning Calorimetry (DSC), Small Angle X-Ray Scattering (SAXS), Positron Annihilation Lifetime Spectroscopy (PALS) as well as Transmission Electron Microscopy (TEM) we obtain a comprehensive picture.