MI 6: X-ray imaging, holography and tomography

Chair: H. S. Leipner

Time: Wednesday 12:30–14:30 Location: TA 201

MI 6.1 Wed 12:30 TA 201

Confocal STXM - a novel approach to 3D X-ray microscopy — •Andreas Späth[1], Jörg Raabe[2], Christian Riess[3], Simon Schöll[3], Joachim Hornegger[3], and Rainer H. Fink[1] — [1]Friedrich-Alexander Universität Erlangen-Nürnberg, Physical Chemistry II, Erlangen, Germany — [2]Swiss Light Source (SLS), Paul Scherrer Institut, Villigen Switzerland — [3]Friedrich-Alexander Universität Erlangen-Nürnberg, Computer Science 5, Erlangen, Germany

Common approaches to 3D microscopy with soft X-rays (e.g. tomography, holography, etc.) are often disadvantaged by a high experimental or computational effort. We will present a novel procedure to obtain 3D images of nanostructured soft matter based on the PolLux scanning transmission X-ray microspectroscope installed at a bending magnet beamline of the Swiss Light Source [1]. Using latest zone-plate technonology, imaging is not only achieved with very high lateral resolution (limit 12 nm) [2], but also with a depth of focus of better than 550 nm. Image stacks from the variation of the sample position along the X-ray propagation axis offers the opportunity to confocal imaging. Thus, we are able to image nanoscopic inhomogeneities of the sample (e.g. nanoparticles) within each confocal plane and recheive 3-dimensional reconstructions by determining the focus plane of these features. The required analysis tools are provided by computational sciences and comfortable in application and computing time. We will discuss the opportunities and limitations in conventional STXM imaging.

1. J. Raabe, et al., Rev. Sci. Instrum. 79, 2008, 113704.
2. J. Vila-Comamala, et al., Ultramicroscopy 109, 2009, 1360.

MI 6.2 Wed 12:45 TA 201

Hard x-ray scanning microscope with chemical, elemental and structural contrast — •Jens Patommel[1], Christian G. Schroer[1], Manfred Burghammer[2], and Gerald Falkenberg[3] — [1]Institute of Structural Physics, Technische Universität Dresden, D-01062 Dresden, Germany — [2]European Synchrotron Radiation Facility ESRF, B. P. 220, F-38043 Grenoble Cedex, France — [3]HASYLAB at DESY, Notkestr. 85, D-22607, Hamburg, Germany

We designed, built and are now operating a scanning microscope for hard x rays at the synchrotron radiation facility PETRA III at DESY. The instrument uses nanofocusing refractive lenses (NFLs) to generate an intense x-ray nanobeam with a size of between 50 nm and 100 nm. The nanoprobe supports a variety of contrast mechanisms like x-ray absorption spectroscopy, fluorescence spectroscopy, small/wide angle x-ray scattering, and coherent diffraction contrast, retrieving chemical, elemental and structural information from inside the specimen. Although the spatial resolution in direct measurement is limited by the beam size, a much better resolution is achieved with ptychography, combining coherent x-ray diffraction imaging with scanning techniques. All these contrast mechanisms can be performed in tomography mode to retrieve the three-dimensional contrast distribution.

In my talk I will address theoretical considerations of hard x-ray scanning microscopy as well as instrumental aspects of the nanoprobe at PETRA III. I will also present examples for each of the contrast mechanisms.

MI 6.3 Wed 13:00 TA 201

Investigation of biological specimens with a 30 nm resolution table top X-ray microscope based on a high repetition laser plasma source — •Christian Seim[1], Christoph Redlich[1], Jonas Baumann[1], Gernot Blobel[2], Herbert Legall[2], Bernhard Hesse[3], Holger Stiel[2,4], and Birgit Kanngiesser[1,4] — [1]TU Berlin, Germany — [2]Max-Born-Institute, Germany — [3]Chartité Berlin, Germany — [4]Berlin Laboratory for innovative X-ray Technologies (BLiX), Germany

This talk describes a table top X-ray microscope based on a high repetition rate laser plasma source which enables investigations of biological specimens at 30 nm resolution. The laboratory soft X-ray microscope works at the nitrogen Ly_α at 2.478 nm in the so called water window, to gain a high contrast when investigating biological samples with thickness up to 10 μm. A detailed description of the instrument is given and the feasibility of X-ray tomography of aqueous samples will be discussed. First images of reference biological samples, diatoms, with structures in the 30 nm region will be shown. It is planned to apply the instrument for investigations of the BRONJ disease. BRONJ is a rare disease, in which the patient's jaw bone suffers osteonecrosis, induced by bisphosphonates (Salvatore L. Ruggiero et al., 2009). One theory is that the canaliculi system that connects and supplies the osteocytes (bone cells) becomes clogged. The canaliculi diameter is approximately 300 nm. The feasibility of capturing a 3D image of the canaliculi network using X-ray tomography will be discussed.

MI 6.4 Wed 13:15 TA 201

Ptychographie: Rastermikroskopie mit kohärentem Röntgenbeugungskontrast — •Robert Hoppe[1], Manfred Burghammer[2], Gerald Falkenberg[3] und Christian G. Schroer[1] — [1]TU Dresden, Dresden, Deutschland — [2]ESRF, Grenoble, Fankreich — [3]DESY, Hamburg, Deutschland

Ptychographie kann zur ortsaufgelösten Bestimmung der Absorption und des Phasenschubs einer Probe verwendet werden. Die bisher erreichte laterale Auflösung ist dabei besser als 10 nm [1]. Ptychographische Röntgenrastermikroskopie nutzt den Fernfeldbeugungskontrast zur Abbildung. Parallel zum Objekt werden die Amplitude und die Phase der Beleuchtung mit rekonstruiert. Diese Trennung der Beleuchtung vom Objekt erlaubt einzigartige Einblicke in die Intensitätsverteilung und Phasenlage verschiedener Teilbereiche des fokussierten Röntgenstrahls. Das bedeutet, dass über den Röntgenstrahl die vollständigen Informationen vorliegen. Diese einzigartigen Information werden unter anderem zur Weiterentwicklung von Röntgenoptiken wie zum Beispiel von Nanofokussierenden Linsen (NFLs) [2] verwendet. Mit NFLs wurde der Röntgenstrahl bisher bis auf eine Größe von $46 \times 63\,\mathrm{nm}^2$ (FWHM) fokussiert [3]. Der fokussierte Strahl erlaubt es, simultan zur ptychographischen Bildgebung die Elementverteilung mittels Fluoreszenzanalyse im Objekt ortsaufgelöst zu untersuchen. [1] A. Schropp et. al., Appl. Phys. Lett. 96, 091102(2010) [2] C. G. Schroer et.al., Appl. Phys. Lett. 87, 124103(2005) [3] C. G. Schroer et. al. AIP Conference Proceedings, P227-230,(2011)

MI 6.5 Wed 13:30 TA 201

Pink Beam Ptychography — •Björn Enders, Pierre Thibault, Martin Dierolf, Andreas Fehringer, Marco Stockmar, Irene Zanette, and Franz Pfeiffer — Department of Physics (E17) and Institute of Medical Engineering (IMETUM)

In the field of X-ray Coherent Diffraction Imaging we use a scanning technique called ptychography to image 2D and 3D specimen at the nanoscale. From the ptychographically reconstructed sample projections we use computed tomography to obtain fully quantitative 3d electron density maps of bone or other material science specimen. We report on latest results in ptychographic tomography on bone and on its applications to less coherent synchrotron x-ray sources of wider spectral bandwidth (pink beam sources). Providing higher flux, those sources promise a significant speed increase that would facilitate the usage of ptychography tomography for a broader application spectrum.

MI 6.6 Wed 13:45 TA 201

Progress in X-Ray Inline Holography Phase Retrieval — •Marco Stockmar[1], Pierre Thibault[1], Martin Dierolf[1], Björn Enders[1], Andreas Fehringer[1], Julia Herzen[1], Irene Zanette[1], Peter Cloetens[2], and Franz Pfeiffer[1] — [1]Department of Physics (E17) and Institute of Medical Engineering (IMETUM), Technische Universität München, Germany — [2]European Synchrotron Radiation Facility (ESRF), Grenoble, France

We present first numerical and experimental results obtained at a Synchrotron light source of an advanced X-ray inline holography phase retrieval method for high resolution nondestructive 2D and 3D imaging. Unlike existing methods, which are based on limiting constraints such as weak phase or absorption, our new method retrieves the full complex-valued transmission function of any object while eliminating reconstruction artefacts from imperfect wavefronts. This allows for imaging of a wide range of challenging samples inaccessible by existing methods.

MI 6.7 Wed 14:00 TA 201

Soft X-ray tomoholography — •Erik Guehrs[1,2], Andreas M. Stadler[2], Sam Flewett[1], Stefanie Frömmel[1], Jan Geilhufe[3],

Bastian Pfau[1], Torbjörn Rander[1], Stefan Schaffert[1], Georg Büldt[2,4], and Stefan Eisebitt[1,3] — [1]Institut für Optik und Atomare Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin — [2]Institute of Complex Systems, Forschungszentrum Jülich, 52428 Jülich — [3]Helmholtz-Zentrum Berlin für Materialien und Energie, Hahn-Meitner-Platz 1, 14109 Berlin — [4]Research-Educational Centre Bionanophysics, Moscow Institute of Physics and Technology, 141700 Dolgoprudniy, Russia

Fourier transform holography (FTH) is a well established imaging method in the soft X-ray regime. In common mask-based FTH the reference wave is produced by a small pinhole which is physically connected to the sample. Due to the high aspect ratio (1:10) of the pinhole it is not possible to record a tomographic dataset as the required rotation of the sample blocks the transmission through the pinhole at small angles. Therefore, only 2D projections have been imaged until now using soft X-ray FTH. However, the determination of the three-dimensional structure of samples is of high interest in many scientific areas. We demonstrate an X-ray imaging method which combines Fourier transform holography with tomography ("tomoholography") for 3D microscopic imaging. A 3D image of a diatom shell with a spatial resolution of 140 nm is presented. The experiment is realized by using a small gold sphere as reference wave source for holographic imaging.

MI 6.8 Wed 14:15 TA 201

Three-dimensional X-ray Fourier transform holography — •Jan Geilhufe[1], Carsten Tieg[1], Christian Günther[2], Erik Gührs[2], Bastian Pfau[2], Stefan Schaffert[2], and Stefan Eisebitt[1,2] — [1]Helmholtz-Zentrum für Materialien und Energie GmbH — [2]Institut für Optik und Atomare Physik, Technische Universität Berlin

Three-dimensional topography information is successfully extracted from a single soft X-ray Fourier transform hologram. The feature height is retrieved by propagating the focal plane through the object reconstruction. An artificial test specimen with features sizes down to 20 nm and maximum height differences of 10 μm was prepared by focused ion beam assisted deposition of platinum. In order to acquire a small depth of focus, the hologram was recorded with a large numerical aperture. The small depth of field is exploited to acquire depth information with 500 nm resolution to model a two-dimensional height map with a lateral resolution of 50 nm.