FULL FIELD IMAGING TECHNIQUES AT THE P05 BEAMLINE

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Summary: The Imaging Beamline IBL / P05 at the DESY storage ring PETRA III is operated by the Helmholtz-Zentrum Geesthacht and has two dedicated endstations; One optimized for micro tomography and one dedicated to nano tomography experiments [3-5]. A variety of full field imaging techniques are currently available to users and a range of sample environments are presented along with experimental highlights and future upgrades.

1. INTRODUCTION

Tomography has become a vital tool for studying the structure and function of materials, allowing to study the inner structure, the material porosity or crack propagation, thus understanding failure mechanisms and leading ideally to an optimization of the production process. Apart from engineering and materials sciences this technique is also widely spread in disciplines like medicine, biology, archaeology and geology where the technique has become a standard method [1-4]. This development has of course also benefited form the much-improved performance of modern bench top CT machines having made a big step forward in spatial resolution and flux [2].

Synchrotron based imaging however has still several advantages compared to lab sources, e.g. the high achievable density resolution can only be realised using monochromatic radiation at sufficient flux. In particular for in situ measurements and time resolved studies the synchrotron based imaging techniques are a very important tool thanks to the high photon flux. Furthermore the high coherence of a 3rd generation synchrotron opens up a range of techniques, which are not accessible with a bench top machine. Here we present the current status of the imaging beamline IBL / P05 at the PETRA III storage ring at DESY [4, 5]. The micro tomography station is dedicated to materials science with an emphasis on high density resolution and a range of advanced sample environments is provided to users. The nano tomography station is currently equipped with an X-ray microscopy setup using Fresnel zone plates (FZPs), though the high flexibility of the setup allows using other imaging modes e.g. cone beam experiments.

2. BEAMLINE SETUP

Dedicated to materials science the imaging beamline IBL / P05 allows visualizing structural properties in the range of several micrometers down to the nanometer regime [3-6]. With a total length of 90 m, the beamline has two experimental stations: A micro – and a nano tomography station (figure 1). In the optics hutch of the IBL beamline two monochromators are installed: A Double Chrystal Monochromator (DCM) and a Double Multilayer Monochromator (DMM), covering an energy range of 5 – 50 keV each. The energy bandwidth of the DCM is $\Delta E/E \sim 10^{-4}$ while the DMM, being currently under commissioning, allows for higher flux at an energy bandwidth of $\Delta E/E \sim 10^{-2}$ with multilayer coatings produced inhouse by HZG [7].
The design of the setup is optimized to house extended sample environments, like e.g. an in situ oven or differential phase contrast (DPC) setup. Samples of several millimetres in diameter can be investigated at the setup since the sample–to–source distance allows for a sufficient field of view (FOV). Next to standard attenuation based tomography, phase contrast methods like in line phase contrast and grating based phase contrast experiments (one and two gratings) are in user operation.

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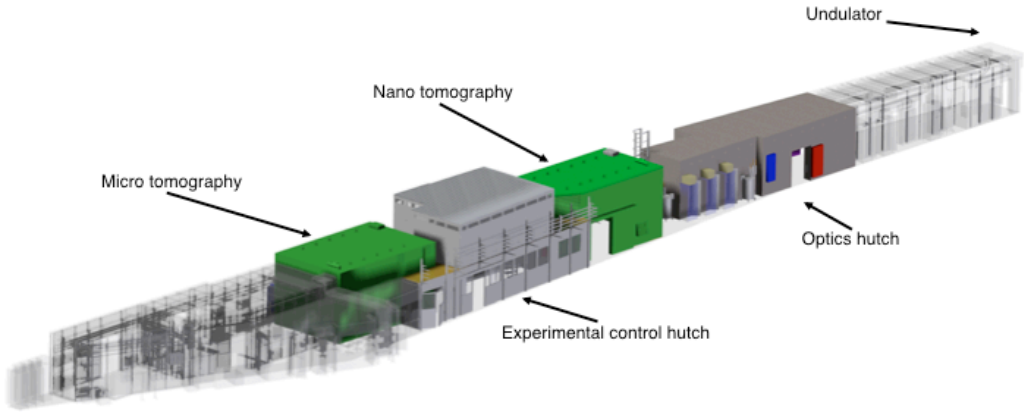

Figure 1: Schematic view of the imaging beamline IBL / P05. The beamline is sharing the sector with the P06 beamline (transparent hutches on the very left side (experimental hutches) and right side (optics hutch)).

Allowing for resolutions well below 1 μm the nano tomography setup is closing the gap between micro-tomography and Focussed Ion Beam (FIB) tomography [2]. Being situated at a distance of 62 – 72 m from the source the highly flexible nano tomography setup accommodates a 6.8 m long granite substructure with four air - bearing granite sliders. Each of these four sliders can move independently along the substructure. For precise alignment of the objective and condenser optics, six-axis kinematics are installed on two of the four sliders. The high precision rotation stage is mounted on a granite slider in between the two optics stages. A kinematics mounted in the aperture of this rotation stage allows precise aligning of the sample in the centre of rotation. The last slider houses the detector system, currently a PCO.edge 4.2 with a pixel size of 6.5 μm. This highly flexible setup can operate in X-ray microscopy mode [3, 6] as well as in cone beam geometry.

3. CONCLUSION AND OUTLOOK

The imaging beamline P05/IBL at PETRA III, dedicated to full field imaging techniques is offering attenuation based tomography in the micrometer down to the nanometer range at high density resolution. In addition several phase contrast methods and complex sample environments are optimized for user operation. Together with the available energies ranging from 5 up to 50 keV the beamline therefore covers a broad range of research fields from biological or biomedical all the way to engineering materials samples.

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