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ABSORPTION- AND PHASE-CONTRAST MICROTOMOGRAPHY AT HASYLAB / DESY

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Microtomography using synchrotron radiation has become a valuable tool for the 3-d investigation of samples in the fields of e.g. Medicine, biology and material science. At HASYLAB at DESY absorption-contrast microtomography is applied in user mode at three different beamlines BW2, W2 and BW5 covering the energy range from 4 keV to 150 keV. Furthermore intererometric phase-contrast microtomography was developed and applied using 12, 20, 24 and 70 keV. Furthermore different scanning techniques were developed and applied to larger samples up to 24 mm in diameter and 40 mm in height. The experimental setup originally developed at the University of Dortmund, Germany and the improvements made at Hasylab to provide for a user experiment for absorption-contrast microtomography will be described. Several examples will demonstrate the practical application of the current system as a user experiment for performing continuous tomographical scans.

Keywords: SYNCHROTRON RADIATION

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HIGH-RESOLUTION HARD X-RAY PHASE-CONTRAST MICROSCOPE FOR OBSERVING TRANSPARENT BIOLOGICAL SPECIMENS

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A hard X-ray imaging transmission microscope has been in development using an X-ray beam from an undulator in SPring-8 (1,2). It uses a Fresnel phase zone plate made of tantalum as its X-ray lens. The diameter and the outermost zone width of the latest phase zone plate are 1 mm and 50 nm, respectively. The microscope has achieved the high spatial resolution capable of imaging as fine as 100 nm line-and-space patterns at the photon energy of 10 keV (3). The Zernike's phase-contrast method has been implemented to the microscope with phase plates made of gold. The photon energy was tuned to 12 keV near the L3 absorption edge of gold (11.9 keV) in order to increase the phase contrast. To demonstrate its capability, small polystyrene ($[CH(C_6H_6)CH_2]_n$, ρ=1.1 g/cm^3) particles of 7 μm in diameter were imaged clearly in the opposite contrast (positive and negative contrast) with phase plates to shift the phase of the central order of the Fourier spectra in the back focal plane of the objective by one-quarter and three-quarters of a period, while the conventional absorption imaging showed little contrast. Further, diatoms and conidia were also imaged with good contrast even in water. The phase-contrast microscope may open a way to observe thick biological specimens in their natural living state.

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PHASE-SENSITIVE X-RAY IMAGING AT THE SYRMEP BEAMLINE OF ELETTRA

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Taking advantage of the high intensity and high spatial coherence of synchrotron radiation, it is possible to investigate the use of phase-sensitive imaging techniques in the hard X-rays region. Actually, in the energy range 15*25 keV, the phase shift is up to 1000 times more sensitive to variation of the structure and composition of soft biological tissues if compared with absorption. Therefore it is possible to reveal phase effects even if the absorption is negligible.
At Elettra a research program dedicated to medical imaging is carried out at the SYRMEP beamline where the use of the PHase Contrast radiology (PHC) and the Diffraction Enhanced Imaging (DEI) techniques, in various contexts of diagnostic radiology, are studied. Recently the same approaches have been applied also to other fields of investigation, in material science and in the imaging of biomaterials.
On account of SYRMEP is a bending magnet beamline, with a source dimension of approximately 140 µm x 1100 µm, nevertheless the obtained results show the efficacy of the phase-sensitive imaging with respect of conventional absorption radiography. Regarding the applications to diagnostic radiology, the PHC and DEI techniques bring a significant improvement in the contrast resolution and in the visibility of details with no increase of the delivered dose.

Keywords: PHASE IMAGING, PHASE CONTRAST RADIOLOGY, DIFFRACTION ENHANCED IMAGING

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DEVELOPMENT OF X-RAY DARK FIELD IMAGING

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We would like to report an X ray optics capable of dark field imaging 'Owl' comprising a Bragg case asymmetric monochromator and a monolithic X-ray optics housing a collimator C and an analyzer A that can select only the refracted light by 4,4,0 diffraction and the crystals C and A with 1.08 mm thickness. Their angular width of diffraction was 0.3 mrad at X-ray energy of 35keV. It has been proven that one can obtain a forward diffracted beam which corresponds to the dark field imaging and the other a diffracted one corresponding to the bright field or vice versa depending on the specified thickness of the analyzer. Images due to refraction contrast in the dark field imaging are clearly shown. In this talk successful design and test of this X-ray optics and its preliminary applications are described in details. Also I would like to talk about another X-ray optics 'Trinity' capable of viewing three kinds of contrast, refraction, phase interference and absorption, which has been successfully in operation.

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