236
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X-ray Microscopy Opportunities at ID 15B Beamline at the ESRF.

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New ultimate parameters of the beam provided by the diffraction-limited sources – new synchrotrons with the reduced horizontal emittance will open up unique opportunities to build up a new concept for the beam transport and conditioning systems based on in-line refractive optics [1]. In addition to traditional micro-focusing applications, the refractive optics can provide the various beam conditioning functions: condensers, micro-radian collimators, low-band pass filters [2], high harmonics rejecters [3], beam-shaping elements [4]. Taking an advantage of reduced horizontal source size, the refractive optics integrated into the front-end can transfer the photon beam almost without losses from the source directly to the end-stations. In this regard, development of diamond refractive optics is crucial [5-7]. The implementation of the lens-based beam transport concept will significantly simplify the layout of majority of new beamlines [8-9], opening novel opportunities for the material science research under extreme conditions [10-11].

The versatile beam conditioning properties of refractive optics enable to develop and implement new X-ray coherence-related techniques including Fourier optics [12-13], coherent diffraction [14-16], phase contrast imaging [16-19], and interferometry [21-24].

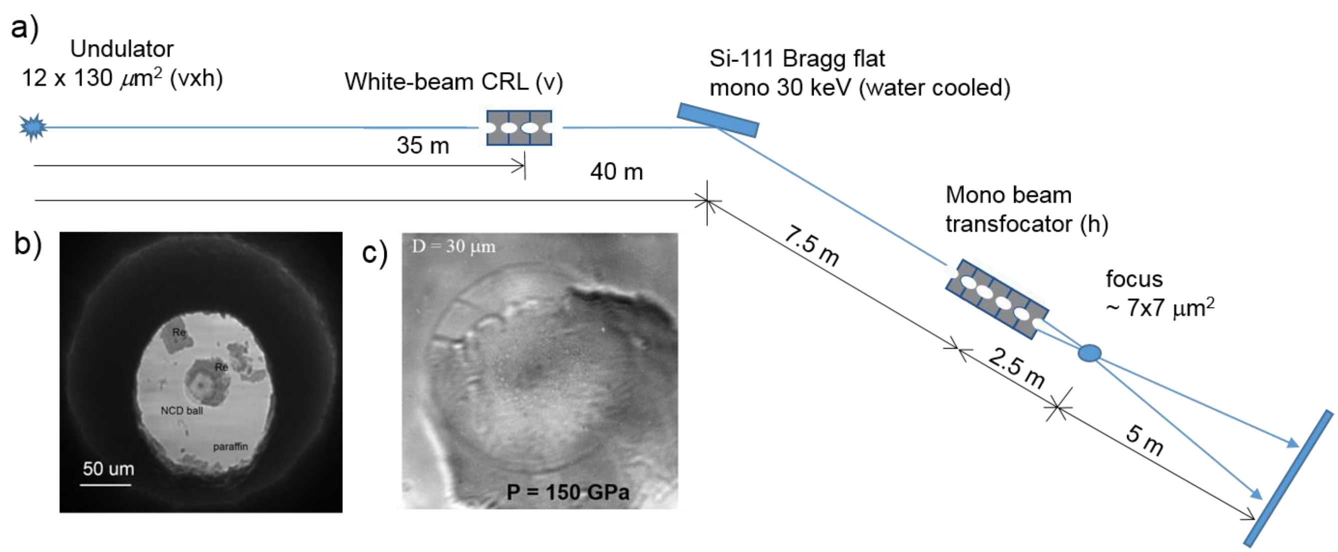

Figure. 1. ID 15B beamline setup (a). X-ray phase contrast image of micro-sample inside the diamond anvil cell (b) and X-ray microscopy magnified image of the 30 μm diamond ball inside the cell (c).

The new upgraded ID15B beamline was constructed based on in-line refractive optics. A sketch of its optical layout is presented in Fig. 1(a). Two transfocators, which are very stable and easily aligned, are used for X-ray focusing on the sample inside the Diamond Anvil Cell (DAC). The focal spot of 7x7 μm was experimentally measured. Taking the advantages of the new ID15B optical scheme, we suggest to implement the X-ray phase contrast imaging techniques in addition to traditional diffraction studies for high-pressure research. X-ray microscopy allows to look inside the diamond anvil cell, monitor the position and size of the sample. Preserving the high coherence of the X-ray beam, the refractive lenses allow observing the low absorbing micro-objects due to the phase contrast just adding the high resolution CCD camera. Phase contrast image of the micro sample inside the DAC including diamond nanoball, Re foil and paraffin is shown in Fig. 1(b). The introduction of an additional X-ray objective lens gives unique opportunities for realization of X-ray High Resolution Microscopy (HRTM) with a high spatial resolution which is in the order of 100 nm [15].

The development of XRTM using compound refractive lenses at ID06 and ID15B opened up new perspectives for studies in DACs. We demonstrated, particularly, that with XRTM it is possible to get an image with the sub-micron resolution, which is hardly possible with conventional optics in the visual light. XRTM images of nano crystalline diamond (NCD) ball in a pressure chamber of a DAC were taken at different pressures. Image of NCD ball at pressure of 150 GPa is shown in Fig. 1(c). Moreover, if we would rotate DAC during heating at each fixed temperature and collect a series of images under different angle, we may be able to perform a kind of tomography of the sample [24].

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