The Extreme Conditions Beamline (P02.2) at PETRA III (DESY): Recent advances and Outlook

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3^{rd} generation light sources continue to be an essential tool for conducting X-ray diffraction/scattering experiments at high-pressures and simultaneous high and low temperatures. While laboratory X-ray sources can provide some information at lower pressures because of lack of the flux and micrometer beam size, only the use of very brilliant hard X-ray sources enable multi-megabar expreriments at temperatures from the single didgits to several thousands of Kelvin. Here we present the capabilities, recent advances and an outlook on future upgrades plans for the Extreme Conditions Beamline (ECB, P02.2) at the synchrotron PETRA III, DESY, Hamburg.

In order to offer standart sample enviroments for extreme conditions research, the ECB was designed with two spatially separated setups: the general purpose (GP) experiment to support resistive heated (up to 2000 K) and cryogenically cooled (up to 5 K) experiments and laser heating (LH) experiment with permanent installations of near-infrared YAG and CO_2 lasers and optics for temperature measurements. The two experimental setups possess identical X-ray focusing capabilities: Compound Refractive Lenses (CRLs) and Kirkpatrick-Baez (KB) mirror systems providing a miminum spot size of 8 (h) $\times$ 2 (v) μm^2 and 2 $\times$ 2 μm^2, respectively. Taken together with opportunity to operate at three different energies (25.6 keV, 42.7 keV and 60.0 keV), ECB is optimized for wide range of X-ray diffraction studies at extreme conditions of high pressure and simultaneous high and low temperatures: powder and single crystal diffraction at static pressure, dynamic powder diffraction, total scattering and PDF studies on powders and non-crystalline materials.

Several recent advances make the ECB an attractive high-pressure beamline. The fast compression in dynamically driven DACs in conjunction with powder diffraction attracted much attention over the last decade as a powerful technique to explore phase transition kinetics as function of compression rates. Combination of the fast and sensitive GaAs-based Lambda detector and high flux provided by the beamline have made it possible to collect diffraction data during fast compression up to rates of the 100s of TPa/s acquiring diffraction images at kHz repetition. Another recent featured setup is a two-circle diffractometer with rotating laser heads to conducte in situ SCXRD experiments at simultaneously high temperatures and high pressures. The overcoming of the long-lasting limitation of SCXRD technique enables tracking of structural changes of geomaterials at real conditions of planetary bodies' interior conditions. In addition, the recent development of the CRL setup allowed to reach submicron X-ray focusing (*i.e.* 1.02 (h) $\times$ 0.64 (v) μm^2) enabling XRD studies at multi megabar pressures.

Future upgrade plans focus on strengthening of the existing capabilities in order to continue to serve the high-pressure community to perform cutting edge experiments at extreme conditons.