Perspectives for static and dynamic high-pressure experiments at the High Energy Density Science (HED) instrument at European XFEL

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Abstract

With unique properties, like pulse length, coherence and brilliance, free-electron laser facilities offer new perspectives for the study of matter at extreme conditions. The extremely high brilliance offers the possibility to achieve single shot structural and spectroscopic data of short-lived states. At the upcoming facility of the high energy density science instrument (HED) at the European X-ray Free Electron Laser in Schenefeld, Germany, hard X-rays with energies between 5 and 25 keV, a photon flux of about 10E+12 photons/pulse at 12 keV photon energy, pulse durations from 2 - 100 fs will be available from the SASE2 undulator [1]. Relative bandwidths vary between 10E-3 in FEL mode, or ˜10E-4 in monochromatic or seeded mode.
At HED with important contributions by the international user consortium *Helmholtz International Beamline for Extreme Fields* (HIBEF) [2,3], it will be possible to study materials at temperatures of up to several 1000 K and up to 1 TPa by shock and ramp compression with an optical long pulse laser (DIPOLE100X). The short-lived states can be investigated with several X-ray techniques, such as XRD, XANES and Thomson scattering. In addition, phase contrast imaging will allow visualizing the response of the material by imaging snapshots at the fs timescale. In addition to high-pressure studies using an optical laser, the high photon energies will enable for the first time to use diamond anvil cells at an FEL. Besides a set-up for conventional DACs, which is optimized for XRD, it is planned to build a set-up for dynamic DACs as well as a pulsed-laser heated system.

HED will be an open user instrument with beam distribution based of peer-reviewed scientific proposals [4]. User experiments are planned to start end of 2018.

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