The High-Energy Density instrument at European XFEL: Current status and latest research applications

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The High-Energy Density instrument at European XFEL (HED) is an instrument dedicated to study short lived extreme states of matter with hard X-ray FEL radiation [1,2]. HED is located at the SASE2 hard X-ray undulator that is designed to provide photon energies in the range of 3 to 25 keV and allows probing with fs short X-ray pulses with repetition rates of up to 4.5 MHz. After a long construction period, SASE2 delivered first X-ray radiation in May 2018. Subsequently, major parts of the X-ray beamline were commissioned and first FEL radiation entered the optics hutch right ahead of the FEL shut down at beginning of December. In early 2019, the optics hutch and interaction area 1 will be completed for first user experiments. Commissioning of the X-ray components will resume after the FEL restart in mid-February to prepare the first three user experiments that will be taking place from May 15th.

While the first set of experiments are either advanced commissioning experiments of the X-ray performance or use the FEL beam directly as a driver, work on the optical drive lasers is being performed in parallel: the Amplitude 10 Hz short pulse laser system was delivered to HED in May 2018 and is currently in its commissioning phase. The 10 Hz long pulse Dipole laser D100X is currently being tested at The Centre for Advanced Laser Technology and Applications (CALTA) at the Central Laser Facility, UK and recently demonstrated lasing at 100 J. The delivery to European XFEL is expected for 2019. In addition, there is an update project for a kJ laser. The generic pump-probe laser developed by the European XFEL laser group [3] demonstrated the ability to work at up to 4.5 MHz. The respective laser system for HED will be installed from 2019.

In addition to information on latest beamline performance and optical laser status, this contribution will present one research application of the HED science group in the field of shock physics. In a recent experiment at MEC at LCLS, we were able to compress SiO_2 (fused silica and quartz) along its Hugoniot to pressures of up to 140 GPa, reaching temperatures corresponding to the SiO_2-liquidus regime. With optical laser pump-X-ray diffraction probe experiments at different time delays, we were able to study the dynamic behavior and structural properties of SiO_2 crystals and melts during shock loading and release [4]. The results help resolving the nature of the mixed phase region of SiO_2 and extend the studies on SiO_2 glasses at ambient temperatures to in-situ conditions in the Earth's interior.

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