P61B LVP: The Large Volume Press station for in-situ X-ray diffraction and imaging on materials at HPHT

Robert FARLA (Deutsches Elektronen-Synchrotron DESY, Germany)
Shrikant BHAT (Deutsches Elektronen-Synchrotron DESY, Germany)
Kristina SPEKTOR (Deutsches Elektronen-Synchrotron DESY, Germany)
Xiaokang FENG (Deutsches Elektronen-Synchrotron DESY, Germany)
Adrien NÉRI (Université de Lille, France)
Lianjie MAN (ETH Zurich, Switzerland)
Artem CHANYSHEV (Bayerisches Geoinstitut, University of Bayreuth, Germany)
Christian LATHE (GFZ Potsdam, Germany)
Stefan SONNTAG (Deutsches Elektronen-Synchrotron DESY, Germany)
Ulrich HAEUSSERMANN (Stockholm University, Sweden)
Tomo KATSURA (Bayerisches Geoinstitut, University of Bayreuth, Germany)

Abstract

The 'Aster-15' LVP at the Wiggler beamline station P61B1 can routinely generate high pressure (ca. 30 GPa) and temperature (ca. 3000 K) HPHT environments on samples. Investigations using energy-dispersive X-ray diffraction (ED-XRD) and absorption-contrast imaging in the high-energy range 30 – 160 KeV reveal in-situ processes in near-real time. The type of experiments possible at P61B are summarized in Figure 1. The station provides two highly positional Ge-detectors for XRD acquisition at user-defined pre-calibrated diffraction angles (3° < 2θ < 10°), including vertical positioning (3° < 2θ < 20°) for cubic compression. These geometries are useful for e.g. tracking solid-state phase transformations and unit cell volume measurements for equations of state. For controlled sample deformation (< 15 GPa) using X-ray transmissive cBN/sintered-diamond anvils, stresses from lattice strains can be estimated with both detectors at the same 2θ (≥ 5°) and at 0° and 90° azimuthal positions. A beamstop is used to reduce background scattering and nearly eliminate Pb fluorescence (from detector shielding) in the diffraction patterns. Furthermore, we offer additional in-situ techniques, such as 1) acoustic emissions detection with 6 sensors (one on each anvil) combined with high-P deformation to study the physics of rock failure and earthquakes, 2) ultrasonic wave speed measurements using a $LiNbO_3$ transducer and a signal amplification system to study the elastic properties of materials and seismic structure of the Earth (to 38 GPa), and 3) electrical conductivity experiments on solid-state and partially molten systems to interpret magnetotelluric measurements e.g. of subduction zones. Imaging experiments, such as falling sphere viscosimetry, are enhanced with an extremely bright scintillator GAGG:Ce, for high-frame rate (150 fps) acquisitions. The in-situ LVP experiments are supported by an in-house suite of data processing software found on the beamline website. To apply for access, proposals can be submitted to P61B during regular calls for beam time, and we offer rolling access for LVP proposals (e.g. synthesis runs) that do not require X-rays. Details on the current status and development of a monochromator for angle-dispersive XRD will be presented, as well as information about the future in-situ LVP beamline at PETRA IV.

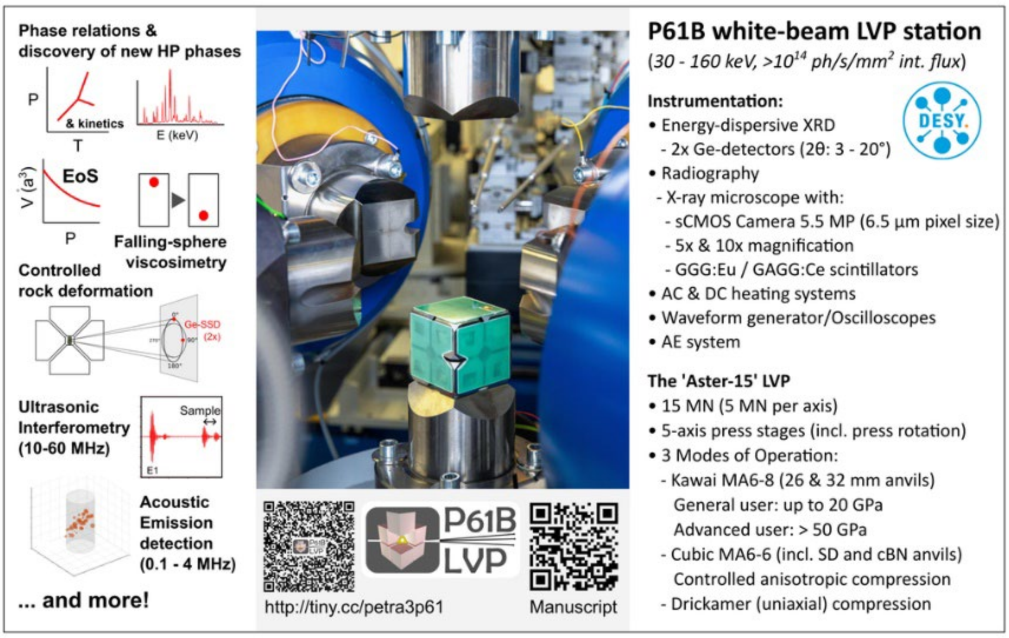

Figure 1. Overview of the capabilities of the P61B LVP beamline station.

References
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