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Advanced Upgrade of Diamond Anvil Cell Program at GSECARS

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The Advanced Photon Source is undergoing a complex upgrade replacing its original electron storage ring with a new multi-bend achromat lattice to provide extremely enhanced coherent flux and increased hard X-ray brightness by a hundred times. To take full advantage of these improved capabilities we have started the process of comprehensive technical improvements and developments of multi-probe techniques across a suite of beamline stations at GSECARS.

The laser-heated diamond anvil cell technique combined with high energy tightly focused X-ray beam and fast detectors for spectroscopic measurements is the workhorse method for exploration of deep Earth mineral physics and chemistry. To provide new constraints on models for planetary evolution and origin, essential properties (melting, structure, phase relation, chemical reactions and kinetics, transport, elastic, electronic and optical properties) of a wide range of minerals must be studied in-situ at extreme conditions of pressure and temperature. However existing data sets are often inconsistent or too poorly constrained to provide unique answers. This underscores the need for unique beamline capabilities: high-energy high-flux sub-micron X-ray beam to probe ultra-small samples (micron-sized) in megabar pressure range, high resolution large area fast X-ray and optical detectors for time-domain experiments, sample emissivity and absorption measurements to improve radiative temperature metrology etc. To accomplish that we will construct a vibration-free granite-table system at 13-ID-D station, install a pre-shaped sub-micron X-ray focusing system (300 nm) coupled with high precision sample positioners including an air-bearing rotary stage, replace our optical spectrometer and acquire a new Eiger2 CdTe 9M X-ray detector. We plan to upgrade the X-ray and laser optics (Raman, Brillouin, fluorescence, absorption) at 13-IDD-D, 13-BM-C and 13-BM-D stations to accommodate higher X-ray energies in a tighter focused beam, which grants a significant boost in the reciprocal space explored at high temperatures with increased spatial resolution.

Recent results and details of future developments of the cutting-edge synchrotron and optical techniques for comprehensive characterization of materials in-situ at extreme conditions will be discussed.