

Advanced synchrotron and optical techniques for mineral characterization and synthesis

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Understanding the complex nature of the deep interiors of the Earth and giant planets requires knowledge of physical and chemical properties of their constituting elements and compounds at relevant extreme pressure-temperature conditions. To provide new constraints on models for planetary evolution and origin, essential properties (melting, structure, phase relation, chemical reactions, and kinetics, transport, elastic, electronic properties, etc) of a wide range of minerals must be studied *in-situ* at ultra-extreme conditions of pressure, temperature up to 1TPa and 10,000K. These formidable experiments can only be conducted at dedicated synchrotron beamlines, like GSECARS (Sector 13, Advanced Photon Source), where state-of-the-art high-pressure synchrotron techniques are combined with advanced optical methods. Recent progress in continuous and pulse laser heating technique, including application of fiber lasers and flat top laser beam shaping optics, result in significant improvement of the quality of x-ray data collected *in-situ* at high pressures and high temperatures in the diamond anvil cell. Optical and vibrational spectroscopy greatly complementing X-ray diffraction and spectroscopy techniques, become crucial when dealing with light elements. The advanced high-resolution user-friendly integrated optical system was recently built at GSECARS where we have implemented Raman spectroscopy with five excitation wavelengths (266, 473, 532, 660, 946 nm), confocal imaging, double sided IR laser heating combined with high temperature Raman (including coherent anti-Stokes Raman scattering) and transient (based on a bright supercontinuum light source) spectroscopies in a wide spectral range (200-1600 nm).

Details and future developments of cutting-edge techniques at GSECARS for comprehensive characterization of materials *in-situ* at extreme conditions in a view of planned APS diffraction limited storage ring upgrade will be discussed.