Neutron diffraction is a powerful tool of high pressure research and in many ways can be considered to be complementary to X-rays for crystallographic experiments. The special features of neutron diffraction include its sensitivity to hydrogen (deuterium) and other common light atoms, its contrast for atoms having similar atomic weights, and its sensitivity to magnetic order. However, despite these advantages, neutron diffraction has been much less used than X-ray scattering for high pressure studies because until recently, large sample volumes were required and the maximal attainable pressures were limited to ~2 GPa. These limitations were overcome in 1992 with the advent of the Paris-Edinburgh cell which allows structural studies by neutron diffraction at pressure up to 30 GPa. In this talk, I will give an introduction to high pressure neutron diffraction techniques with a strong emphasis on recent developments, in particular the new design of a cell assembly with internal heating which enables neutron diffraction to be performed at simultaneous high temperatures and pressures (8 GPa, 2000 K). A novel non-invasive neutron radiographic method to measure the temperature of the sample in the high-P/HT cell will be also presented. I will illustrate the potential of these methods for fundamental Solid State Physics, Planetology and Earth Sciences by presenting some structural studies on a variety of materials under pressure. Finally, future developments and improvements will be reviewed.

Keywords: NEUTRON DIFFRACTION HIGH PRESSURE HIGH TEMPERATURE

The last decade has seen the development of very bright third generation X-ray synchrotron sources that have significantly improved X-ray diffraction experiments at high-pressure and high-temperature. In the same time, focusing optics as well as detectors have been improved in such a way that X-ray diffraction experiments can be routinely carried out on samples in laser-heated diamond anvil-cell, i.e. under extreme static pressure and temperature conditions. It is now possible to obtain from a laser heated (LH) sample in a diamond anvil cell (DAC) very high quality powder patterns, needed for accurate in situ phase boundary and PVT equation of state determinations, as well as for structural refinements. The set-up for in situ X-ray investigation at simultaneous high pressure and temperature is complex, since perfect alignment of X-ray path, infrared-laser hot spot, and optical temperature measurement is required. It provides, however, the most accurate information on the structural behavior with step by step increases of pressure and temperature. In addition, a range of experiments can also be realized at room-temperature after laser-annealing of DAC samples, which has been shown very efficient in releasing stresses build on compression, and/or overcoming phase transitions kinetic barriers.

Keywords: PRESSURE TEMPERATURE DIFFRACTION

Elastic properties of iron and magnesiowustite at high pressures are very important for geophysical science, however, they are not easily accessible in high-pressure experiments.

We will explain in detail how nuclear resonant inelastic X-ray scattering can provide experimental information regarding phonon density of states and elastic properties at pressures close to the Earth's outer core conditions. Specifically, experimental data for Fe to 153 GPa, Fe-Ni(7.5at%) to 110 GPa, and FeO-FeMgO to 120 GPa will be presented.

This work was done in collaboration with H. K. Mao and R. J. Hemley (Geophysical Laboratory, Washington, DC), W. Sturhahn and E. Alp (Advanced Photon Source, Argonne, IL), W. Mao (University of Chicago), E. Huang (Institute of Earth Sciences, Taiwan), and G. Shen (GSECARS and University of Chicago, Argonne, IL).

Keywords: NUCLEAR INELASTIC PRESSURE