## 7. High Pressure Science

### 7-1. *In Situ* X-Ray Diffraction Experiments using Laser-Heated DAC

The X-ray diffraction system under high pressure and temperature originally installed at BL-13B2 was moved to the BL-13A hutch (Fig. 1) during the summer shutdown period of 2000 [1]. The new optics realized both higher resolution and intensity of the powder X-ray diffraction profile at the sample position. The large uncertainty of temperature measurements and chemical differentiation due to a long time exposure time [2] were drastically improved in BL-13A. Accordingly, several new users start their experiments in BL-13A.

Quasi-hydrostatic compression experiments using helium as a pressure-transmitting medium have been performed to utilize the high brilliance of BL-13A. Uniaxial stress is one of the serious problems in high-pressure experiments. In order to improve the sample environment under pressure, it is desirable to use soft and inert material as a pressure medium. Helium is the best material for the pressure medium that we know so far. However, the sample room under pressure becomes very small because of the highly compressible nature of helium. Therefore, ultra-high pressure data using helium is very limited and using a small beam as a probe is indispensable. In their experiments, the unit-cell volume of silicate, pressure maker (Au, MgO etc.) and pure elements under pressure up to about 200 GPa at maximum have been investigated with 20 - 30 μm collimator. These experiments will allow great progress in studies on the high-pressure behaviors of materials.

For heating experiments, stability fields of high-pressure and high-temperature phase in some oxides and the reaction boundary of the iron-water system have been studied using a high-power multimode Nd:YAG laser. The post-stishovite phase of $SiO_2$, which has a $CaCl_2$ structure and is known to be an elastically anisotropic phase, was observed up to 80 GPa and about 2000 K, indicating that most of the free silica in the lower mantle is not the stishovite phase, but a $CaCl_2$-structured phase.

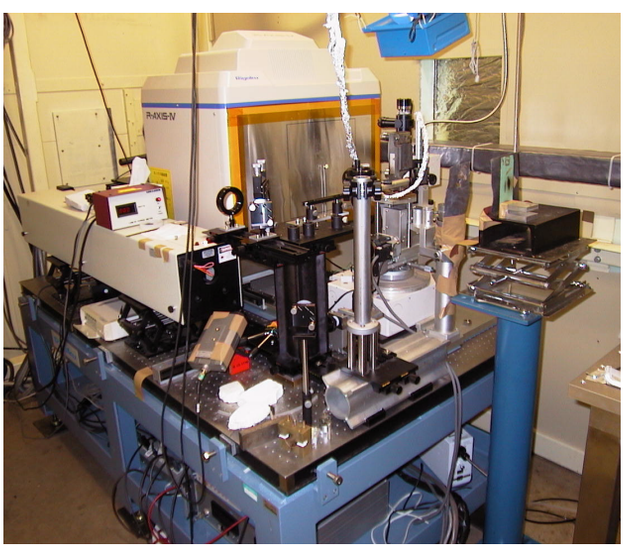

Figure 1.
*In situ* X-ray diffraction system using laser-heated diamond anvil cell with an imaging-plate detector installed at BL-13A.

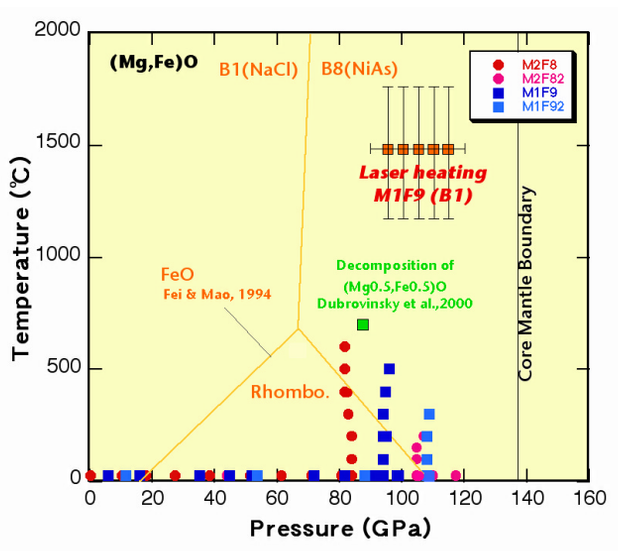


Figure 2.
Phase diagram of (Mg,Fe)O. M1F9 and M2F8 indicate $(Mg_{0.1},Fe_{0.9})O$ and $(Mg_{0.2},Fe_{0.8})O$, respectively. All data below 1000˚C were heated by an external heating method. The high-pressure, high-temperature phase of $(Mg_{0.1},Fe_{0.9})O$ was confirmed to have a rock-salt structure.

(Mg,Fe)O is also one of the most important minerals in the deep mantle. Both MgO and FeO have a rock-salt structure, and can make a complete solid solution under ambient condition. Wüstite, FeO, however shows a transition from rhombohedoral to the B8 phase at 90 GPa and 600K, and no transition has been observed in MgO over 200 GPa in static and shock experiments. In our recent experiments, $(Fe_{0.9}, Mg_{0.1})O$ transformed from the rhombohedoral phase to the B1 phase up to 110 GPa and about 1500 K. It has been clarified that the existence of 10% MgO resulted in a great change in the stability field of the NiAs phase in FeO (Fig. 2).

The reactions between iron and light elements are important to understand the density profile of the earth's core. In experiments concerning the iron-water reaction, we studied the possibility of the incorporated water into the core during the early history of the earth. No reaction was observed up to 600˚C and 35 GPa using an external heating method. However, they reacted easily by laser heating and generated wüstite and iron hydride ($FeH_x$). The run products below about 10 GPa showed a quite different reaction during the laser heating, suggesting that a different transportation mechanism occurred at different depths of the proto earth.

These studies are important for understanding the internal structure and evolution of the earth, and are also expected to provide new information about material under high pressure and high temperature.

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References

[1] See p. 72 of this volume.
[2] T. Yagi et al., Rev. Sci. Instrum., 72 (2001) 1293.