[JJ] Evening Poster | S (Solid Earth Sciences) | S-MP Mineralogy & Petrology

[S-MP38]Physics and Chemistry of Minerals

convener:Hiroaki Ohfuji(Geodynamics Research Center, Ehime University), Seiji Kamada(Frontier Research Institute for Interdisciplinary Sciences, Tohoku University)
Thu. May 24, 2018 5:15 PM - 6:30 PM Poster Hall (International Exhibition Hall7, Makuhari Messe)
In this session, we will discuss the physics and chemistry of the Earth and planetary materials (including amorphous and melts) based on the results obtained from various experimental methods such as X-ray diffraction, FT-IR, Raman spectroscopy, electron microscopy and computer simulations.

[SMP38-P06]Observation of lattice dynamics under laser-induced shock compression using nano-second time-resolved XRD

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Keywords:Laser-induced shock, Time-resolved XRD, Crystal structure dynamics

1. Introduction
Shock wave is ubiquitous event in the history of solar system. Some minerals in meteorites have evidence of shock compression at high pressures and temperatures during collisions between the asteroids. Traditionally, velocimetry technique, measuring shock wave velocity and particle velocity, has been used in shock wave experiments. This method, however, does not allow us to observe information of the crystal structure and their phase transition of specimen under shock compression condition. To understand the response of the minerals to shock wave, the observation at crystal structure level is needed. Time-resolved X-ray diffraction (TR-XRD) is the powerful tool to observe the in situ crystal structure under shock loading. We developed the TR-XRD system combined with laser-driven shock in order to observe the phase transition of the mineral under shock-loaded condition. We also set up the VISAR system, which allow us to measure the particle velocity in the specimen under shock loading.

2. Methods
We performed the experiments at NW14A beamline at PF-AR (Photon Factory Advanced Ring), High Energy Accelerator Research Organization (KEK), Japan. Nd:glass laser with the wavelength of 1064 nm, pulse energy of 16 J, pulse width of 12 ns was used for shock-driving source. The laser beam was focused by optical lens to the size of 500 μm × 500 μm on the sample surface.
For TR-XRD experiments, the synchrotron X-ray pulse of PF-AR was used as a probe source. The energy, the pulse width, and the size on the sample were 15.68 keV, about 100 ps, and 450 μm (H) × 250 μm (W), respectively. The irradiation timing between laser pulse and X-ray pulse on the sample surface were controlled by delay generator at ns time scale.
The CW laser with the wavelength of 532 nm was used for the probe source of VISAR system. The fringe shift recorded on the streak camera gave us information of the particle velocity under shock loading. We estimated shock pressure-time history from the VISAR data.
The targets consisted of an ablator, PET film with Al coated on the surface, and either the samples of polycrystalline aluminum foil and polycrystalline iron foil.

3. Results
TR-XRD patterns of aluminum exhibited continuous lattice response during the shock loading. The peak pressure estimated from the compression of (111) lattice plane was reached at least 20 GPa. This

pressure exceeds the reported HEL of the aluminum [1], suggesting the compression condition transited from elastic response to plastic relaxation. No phase transition was observed during the compression. The VISAR data also showed the shock wave with the peak pressure of more than 20 GPa arose in the aluminum sample, then the pressure attenuated in tens of ns.
For iron, the (101) peak of the high-pressure phase (ε-phase) was observed during compression condition, which disappeared after decompression. This α (bcc)-ε (hcp) phase transition is known to occur at 13 GPa [2]. We succeed to directly observe the martensitic transformation of iron during the shock wave propagated in the sample. In this presentation, we will discuss the details of structural dynamics under shock loading analyzed by XRD patterns and shock wave profiles.

[1] E. B. Zaretsky and G. I. Kanel: *J. of Appl. Phys.*, **112**, 073504 (2012).
[2] D. Bancroft, E. L. Peterson, and S. Minshall: *J. Appl. Phys.*, **27**, 291 (1956).