Development of an advanced dynamic-diamond anvil cell and its application to deriving equation of state of molecular liquids

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We have developed a dynamic compression system with optical probes, which enables simultaneous measurements of pressure, volume, optical image and molecular vibration of a sample under high pressure. For quantitative measurements of dynamic responses, laser interferometer, high speed cameras and Raman spectroscopes are assembled with a dynamic-diamond anvil cell which is driven by piezoelectric actuators. Hereafter, we call the developed system as advanced dynamic-diamond anvil cell (d-DAC).

Different with conventional static compression, smooth and deep supercompression above the equilibrium melting pressure can be obtained with the dynamic compression. In addition, movement of diamond anvil is recorded based on Michelson interferometer with resolution of a few tens of nanometers. Dynamic responses of sample can be measured with spatial and temporal resolution of a micron and sub-miliseconds, respectively.

In present study, we have applied this system to trace pressure and volume of molecular liquids during dynamic compression. Liquid samples such as water, heavy water and alcohol are loaded in the diamond anvil cell and compressed dynamically. Pressure versus volume data of the samples are plotted in stable and metastable states and compared with literature data.

In case of the water, pressure versus volume data measured from the advanced d-DAC are consistent with the reference equation of state of water [1] and also cover metastable water regime ranging from 0.96 GPa to 2.1 GPa at ambient temperature (Figure 1). This implies that the advanced d-DAC makes possible to allow quantitative measurements on dynamic responses of a sample and also to supply thermodynamic analyses for the measured data.

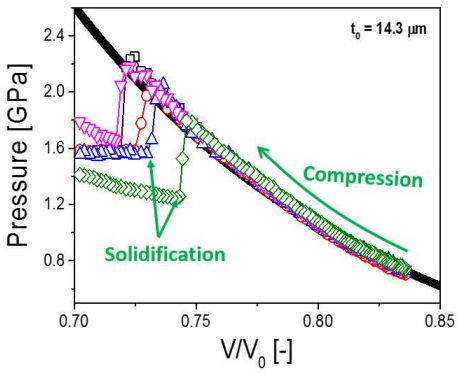

Figure 1. Comparison of equation of state measured for liquid water with the reference curve [1] marked as solid circle.

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