Dynamic compression-induced anomalous crystal growth at near-equilibrium melting pressure

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We have developed an advanced dynamic-diamond anvil cell (d-DAC) which combines d-DAC with high speed camera and micro Raman spectroscope to measure dynamic response of a sample with sub-ms time resolution.

This dynamic pressurization technique has been applied to grow an ice VI crystal surrounded by liquid water at its equilibrium melting pressure [1], [2]. By increasing compression strain rate from 10^{-4} to 1.0 /s, we have observed a distinct transition of crystal growth morphology above a critical strain rate. Different with three-dimensional facet growth with slow compression, a series of morphological changes such as local faceting, corners protrusion, concaving on crystal edges and surface, and then fast two-dimensional crystal growth from the crystal edges is recorded with fast compression [2]. In addition, growth speed of the crystal increases by an order of magnitude under fast compression.

During the dynamic compression, pressure inside of the d-DAC is also monitored. As expected, tiny overpressure is formed and kept constant during the 3D facet growth. However, slight overpressure in the range of few tens of megapascals is accumulated with fast compression and partially released due to the anomalous 2D crystal growth (Figure 1).

This phenomenon distinctly different from the dendrite growth is explained with fast crystal growth under large driving force localized at the crystal edges and its rapid release with a lower dimensional growth in a small scale [2]. This anomalous fast growth can be accelerated with interface ordering of a specific crystal plane under large overpressure. This scenario on improvement of interface kinetics under large driving force is also supported by simulation works.

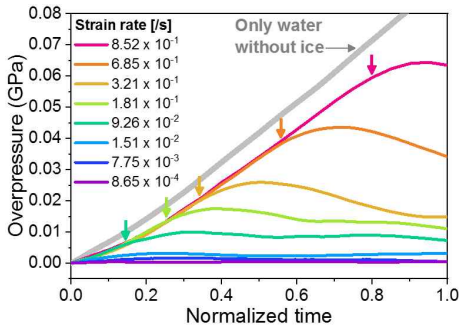

Figure 1. Overpressure formation under fast compression

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