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A new hydrothermal moissanite cell apparatus for optical in-situ observations at high pressure and high temperature, with applications to bubble nucleation in silicate melts

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Abstract

We present a new hydrothermal moissanite cell for in situ experiments at pressures up to 1000 bar and temperature to 850 °C. The original moissanite cell presented by Schiavi et al. (2010) was redesigned to allow precise control of fluid pressure. The new device consists of a cylindrical sample chamber drilled into a bulk piece of NIMONIC 105 super alloy, which is connected through a capillary to an external pressure control system. Sealing is provided by two gold gasket rings between the moissanite windows and the sample chamber. The new technique allows the direct observation of various phenomena, such as bubble nucleation, bubble growth, crystal growth, and crystal dissolution in silicate melts, at accurately controlled rates of heating, cooling, and compression or decompression.

Several pilot experiments on bubble nucleation and growth at temperature of 715 °C and under variable pressure regimes (pressure oscillations between 500 and 1000 bar and decompression from 800 to 200 bar at variable decompression rates) were conducted using a haplogranitic glass as starting material. Bubble nucleation occurs in a short single event upon heating of the melt above the glass transition temperature and upon decompression, but only during the first 100 bar of decompression. New bubbles nucleate only at a distance from existing bubbles larger than the mean diffusive path of water in the melt. Bubbles expand and shrink instantaneously in response to any pressure change. The bubble-bubble contact induced during pressure cycling and decompression does not favor bubble coalescence, which is never observed at contact times shorter than 60 s. However, repeated pressure changes favor the diffusive coarsening of larger bubbles at the expense of the smaller ones (Ostwald ripening). Experiments with the haplogranite show that, under the most favorable conditions of volatile supersaturation (as imposed by the experiment), highly viscous melts are likely to maintain the packing of bubbles for longer time before fragmentation. In-situ observations with the new hydrothermal moissanite cell allow to carefully assess the conditions of bubble nucleation, eliminating the uncertainty given by the post mortem observation of samples run using conventional experimental techniques.

Keywords: Moissanite cell, in-situ observation, bubble nucleation, bubble coalescence, degassing, decompression, Ostwald ripening