Crystallization of silicate melt droplets under non-contact conditions: Understanding chondrule formation in early solar system

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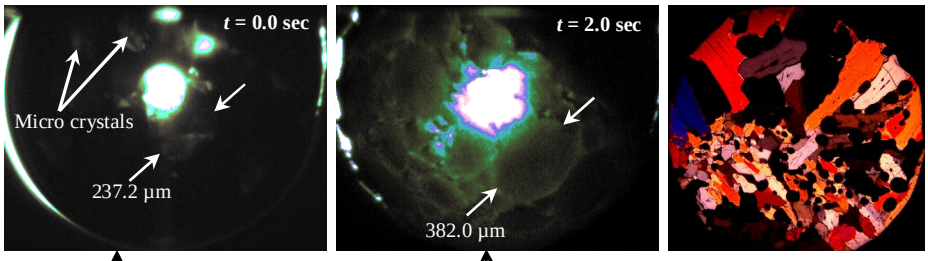
Formation conditions of chondrules remain an open issue. In order to understand the textures of natural chondrules and interpret their formation conditions, considerable efforts have been made by various researchers to experimentally reproduce chondrule-like textures through dynamic crystallization experiments. However in these studies, the authors completely excluded the possibility of rapid crystallization for chondrule formation. Moreover, the crystallization experiments reported in the literature were not performed in container-less conditions but in a sample holder. The sample holder acts as the site for heterogeneous nucleation and hence this arrangement inadequately reproduces the actual mechanism. In view of these constraints, these studies are inadequate in closely simulating the experimental conditions of chondrule crystallization.

The present talk would cover the primary findings of our experiments on chondrule crystallization conducted using a levitation crystallization system (for achieving container-less conditions) and space-based experiments that lead to a conclusion that chondrule melts crystallized quite rapidly in a few seconds under the conditions that are far below equilibrium. One of the representative results on reproduction of porphyritic textures and in-situ visualization of the crystallization process is presented in the figure below (Srivastava *et al.*, JAP, 2010):



Our experiments also reveal that the phenomenon of Recalescence (release of latent heat of crystallization) plays an important role in deciding the chondrule textures. Such a rapid crystallization mechanism, as proposed, opens a pathway for a complete new theory of chondrule formation and is capable of explaining the dependence of different chondrule textures on 3-D temperature distribution inside and around the silicate melt volume and also explain phenomena like little isotopic fractionation, as observed in natural meteorites.