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IN SITU OBSERVATION OF GROWTH DYNAMICS IN DECLIC DIRECTIONAL SOLIDIFICATION INSERT ONBOARD ISS: DSI-R FLIGHT CAMPAIGN

Abstract

The study of solidification microstructure formation is of utmost importance for materials design and processing, as solid-liquid interface patterns largely govern mechanical and physical properties. Pattern selection occurs under dynamic conditions of growth in which the initial morphological instability evolves non-linearly and undergoes a reorganization process. This dynamic and nonlinear nature renders in situ observation of the interface an invaluable tool to gain knowledge on the time-evolution of the interface pattern. Transparent organic analogs, which solidify like metallic alloys, allow direct visualization of interface dynamics. Extensive ground-based studies of both metallic and organic bulk samples have established the presence of significant convection during solidification processes that alters the formation of interfacial microstructures. A reduced-gravity environment is therefore mandatory for fluid flow elimination in bulk samples.

In the framework of the CNES project MISOL3D (MIcrostrutures de SOLidification 3D) and the NASA projects DSIP (Dynamical Selection of 3D Interface Patterns) and SPADES (SPAtiotemporal Evolution of three-dimensional DEndritic array Structures, we participated in the development of the Directional Solidification Insert (DSI) of the DEvice for the study of Critical Liquids and Crystallization (DECLIC). The DECLIC-DSI is dedicated to in situ and real-time characterization of solid-liquid interface patterns during directional solidification of transparent alloys in diffusive transport regime. Between April 2010 and March 2011, the first campaign (DSI) explored the entire range of microstructures resulting in unprecedented observations. A second campaign (DSI-R), performed between October 2017 and December 2018, in which the insert contained an alloy of higher solute concentration, allowed to complete the benchmark database in the diffusive regime. The increase of solute concentration resulted in well-developed dendritic patterns at lower velocities (lower interface curvature and larger tip radius). The microstructure resulting from dendritic growth has large consequences for material properties in metallurgy. To that end, the main aims of this experimental campaign are to understand: the mechanisms of the cell to

dendrite transition; the fundamental mechanisms of sidebranching formation; the dependence of dendrite tip shapes on growth conditions; and the interaction of primary array and secondary sidebranches. Preparation, analysis and interpretation of the experiments performed onboard ISS are considerably enhanced by experiments performed on ground using thin-samples (Pr. Trivedi's group) and phase-field simulations (Pr. Karma's group).

In this summary, we will present an initial assessment of the results obtained during the DSI-R campaign.