Simulation-aided design and interpretation of results of microgravity-based solidification experiments

V. Riabov [1,] A. G. Ostrogorsky[1], M.P. Volz[2] and A. Croell[3]
[1]Illinois Institute of Technology, Chicago, IL 60616, AOstrogo@IIT.edu
[2]NASA Marshall Space Flight Center, Huntsville, AL35899
[3]University of Alabama in Huntsville, Huntsville, AL35812

The preparation and interpretation of microgravity experiments conducted on the International Space Station (ISS) can be challenging because of the remote location of the equipment. Although a "ground unit" is typically available on Earth, it is not located in the laboratory of the principal investigator. Furthermore, test experiments in the ground unit cannot fully duplicate heat transfer conditions of the weightless environment, and thus be a reliable reference for experiment design. Under such conditions, numerical simulations are a valuable tool both for preparing the experiments and interpreting the results obtained under terrestrial and micro-gravity conditions. In this work, we developed a detailed 3D model of the "SUBSA" furnace located at the ISS, and demonstrate its use in our present investigation which includes melt growth and vapor growth of InI crystals on the ISS.

In 2002, the SUBSA furnace was designed and built for the growth of InSb crystals in the Microgravity Science Glovebox (MSG) at the ISS. The SUBSA furnace features a transparent section without heating elements, where the axial temperature gradient is high. In our present investigation, we have used the same furnace to grow four InI crystals from the melt, and two InI crystals from the vapor phase (2018-2021). InI crystals have ~20 times lower thermal conductivity than InSb crystals. As a result, during melt growth, the InI crystals were exposed to extremely high temperature gradients. To reduce the axial temperature gradient, we added external jackets made from high thermal conductivity material to the growth ampoules. The SUBSA furnace could not be modeled as asymmetric because of its rectangular shape and right-angled transparent section, which contains a convoluted geometry. The rectangular shape of the transparent section further complicates modelling of radiative heat transfer, which dominates in the zone. At present, numerical simulations are being conducted to resolve an apparent discrepancy between the readings of the 5 thermocouples located in the SUBSA furnace, and the observed position of the solid and molten material.

The 3D simulation will be presented, along with the calibration and growth experiment results conducted in microgravity and in the SUBSA ground unit. The developed model should be useful for upcoming microgravity investigations planned to be conducted in the SUBSA facility.