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IMPACT OF SOLUTOCAPILLARY CONVECTION IN GERMANIUM-SILICON GROWTH WITH FREE LIQUID SURFACES

Abstract

In crystal growth, free liquid surfaces are encountered in a variety of important melt growth techniques, including Czochralski, Float-Zone, or Vertical Gradient Freeze (VGF) method. Different driving forces are responsible for mass transport phenomena which influence directly the composition and the quality of the growing material. Such fluctuations in chemical composition and/or structural quality change locally the physical properties of the crystalline material what may decrease the yield of the produced crystal for the suggested technological application. There are various possibilities to manipulate and control fluidal movements by external forces like static or different moving magnetic fields, vibrations, and physical rotation, but to apply them purposefully a profound understanding of the real flow patterns, the interplay of the different acting forces, and their impact on the chosen system and setup is mandatory.

Germanium-silicon (GeSi) is a technological important material system in the field of energy conversion, high-frequency technology, and fast digital technics and is mainly crystallized by melt growth technics. The surface tension of liquid Si is about 30% higher than that of Ge, the density on the other hand is only half as large. Together with the strong segregation in this system, in which Si is preferentially incorporated into the crystal hence Ge accumulates in front of the phase boundary, this leads to strong solutocapillary convection and strong solutal buoyancy convection. Because it is not possible to separate the influences of buoyancy and surface tension driven convection on the segregation on earth, microgravity (μg) conditions were utilized. In parabolic flight experiments, which provide 22 seconds of microgravity per parabola, the magnitude of solutocapillary convection is determined in dependence of the ratio of mixture (3-30 at% Si).

The here presented results of different parabolic flight campaigns will help to understand the overall convection during the growth of GeSi, to improve the predictions of numerical simulations, and to adjust parameters of external forces to optimize the growth processes to achieve high-quality crystalline material.