Paper ID: 45902
student

IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Fluid and Materials Sciences (2)

Author: Dr. Tina Sorgenfrei
University of Freiburg, Germany

Ms. Nadine Pfändler
University of Freiburg, Germany
Dr. Katharina Gimbel
University of Freiburg, Germany

IN-SITU OBSERVATION OF FOREIGN PHASE PARTICLES IN FLUIDS AND THEIR INTERACTION WITH A SOLIDIFICATION FRONT

Abstract

The incorporation of foreign phases during the solidification of materials is a difficulty occurring in different material systems and techniques. One prominent example for a lowered yield due to incorporated foreign phases is VGF solar silicon. The main impurities here are Si3N4 and SiC forming within the melt by oversaturation of carbon and nitrogen. The particles show sizes in the range of several micrometers to millimeters, have an increased hardness compared to silicon and partly lower resistivity, and therefore lead to a considerable material loss due to sawing damage and/or shunts.

Because of the requirements on the PV-industries to reduce the costs of module production, the avoidance of the particle formation, which originates from the crystal growth setup, is not possible. The only chance to increase the yield is to control the incorporation of the present particles. Motivated by the question of the PV-industries, it is important to investigate and understand more in detail the behavior of such particles inside the melt and especially their interaction with the solidification front. Therefore, different particle materials, sizes, and morphologies are chosen as relevant particle species and were inserted into a transparent melt. This ensures the determination of the influence of different density ratios, wetting behavior, thermal capacities and conduction, and interaction areas between particle and phase boundary.

To determine the behavior of the particles at the solidification front, a high-speed camera system is installed on a double-ellipsoid-mirror-furnace to record in-situ the current state in melt. This system is built up in that way to be implemented later in a sounding rocket for additional experiments under reduced gravity.

First observations show that a flat solidification front can be reached and the different particle materials can be tracked within the melt and at the phase boundary. A critical value (vcr) for the particle velocity was found. Independent on the particle size, below this vcr particles stay within the present convection roles and do not touch the phase boundary while those particles with higher movement velocities penetrate an observed, 800 μm thick boundary layer between solidification front and residual melt body and are then engulfed and incorporated.

Additionally, by inserting small-sized particles it is possible to calculate the velocity and depth of activity of the Marangoni as well as the buoyancy convection what gives information about material specific characteristic numbers. This is important for the data implementation in numerical models.