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Design of model experiments for melt flow and solidification in a square container under time-dependent magnetic fields

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Abstract

This paper describes novel equipment for model experiments designed for detailed studies on electromagnetically driven flows as well as solidification and melting processes with low-melting metals in a square-based container. Such model experiments are relevant for a validation of numerical flow simulation, in particular in the field of directional solidification of multi-crystalline photovoltaic silicon ingots. The equipment includes two square-shaped electromagnetic coils and a melt container with a base of 220x220 mm^2 and thermostat-controlled heat exchangers at top and bottom. A system for dual-plane, spatial- and time-resolved flow measurements as well as for in-situ tracking of the solid-liquid interface is developed on the basis of the ultrasound Doppler velocimetry. The parameters of the model experiment are chosen to meet the scaling laws for a transfer of experimental results to real silicon growth processes. The eutectic GaInSn alloy and elemental gallium with melting points of 10.5°C and 29.8°C, respectively, are used as model substances. Results of experiments for testing the equipment are presented and discussed.

Keywords: A1. Directional solidification, A1. Fluid flows, A1. Magnetic fields, A1. Computer simulation, A1. Stirring

1. Introduction

Lab-scale model experiments with low-melting-point metals are of increasing importance in the field of bulk crystal growth from the melt, especially to analyse the influence of magnetic fields. The main advantage is that the melt flow and related phenomena can be systematically investigated at moderate temperatures, i.e., below 100°C in many cases. The results of model

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