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Numerical model of turbulent CZ melt flow in the presence of AC and CUSP magnetic fields and its verification in a laboratory facility

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Abstract

The paper describes a numerical simulation tool for heat and mass transfer processes in large diameter CZ crucibles under the influence of several non-rotating AC and CUSP magnetic fields. Such fields are expected to provide an additional means to influence the melt behaviour, particularly in the industrial growth of large diameter silicon crystals. The simulation tool is based on axisymmetric 2D models for the AC and CUSP magnetic fields in the whole CZ facility and turbulent hydrodynamics, temperature and mass transport in the melt under the influence of the electromagnetic fields. The simulation tool is verified by comparisons to experimental results from a laboratory CZ setup with eutectics InGaSn model melt. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

The increase of crystal diameters up to 300 mm and crucible diameters up to 36″ in silicon CZ crystal growth during recent years has led to several problems that cannot be solved with the conventional pulling technology [1]. The use of CUSP- and especially AC-electromagnetic (EM) fields to influence hydrodynamics promises to facilitate the necessary control of the growth process [2]. However, the development of magnet systems and corresponding growth experiments in industrial scale CZ pullers is very expensive. As numerical modeling of the melt behavior has grown to become a powerful tool, it can shorten design cycles, reduce development costs, and demonstrate how to use the installed magnet systems [3].

Several authors have indicated that the highly complex mechanisms in turbulent CZ- melt flows are characterized by three-dimensional time dependent flow and temperature distributions, e.g. [4]. However, a fully 3D transient simulation of

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