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Journal of Crystal Growth 230 (2001) 48–56

JOURNAL OF CRYSTAL GROWTH

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Numerical 3D study of FZ growth: dependence on growth parameters and melt instability☆

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Abstract

Three-dimensional modelling of the floating zone (needle-eye) crystal growth process is carried out to analyse numerically the stability of the melt flow and the influence of the crystal rotation rate and inductor slit width on the 3D flow field and on the grown crystal resistivity. The unsteadiness of the melt is simulated and it is found that for the considered growth parameters a steady-state flow can be a reasonable approximation to the unsteady melt motion. The parametric studies have shown that increasing the rotation rate essentially changes the flow pattern and weakens the rotational striations, while the inductor slit width has a more local influence on these characteristics.

Keywords: A1. Computer simulation; A1. Fluid flows; A1. Mass transfer; A2. Floating zone technique; B2. Semiconducting silicon

1. Introduction

For the floating zone (FZ) growth of large-diameter (⩾100 mm) silicon rods, the needle-eye technique and a high frequency electromagnetic field (≈3 MHz) are used. Two-dimensional (i.e. axisymmetric) models and the calculation methods of the processes during FZ growth have been considered in numerous studies, e.g. Refs. [1–8]. In fact, the pancake inductor has only one turn and current suppliers with a slit between them (see the sketch of one half of the system in Fig. 1), therefore the EM field and the distribution of heat sources are only roughly axisymmetric even if the rest of the system arrangement can be assumed as axisymmetric. The non-symmetry together with crystal rotation generates the small-scale inhomogeneities of resistivity in the grown crystal rod that are called rotational striations. Some three-dimensional (3D) aspects of non-industrial FZ processes with small crystal diameters have been considered in Ref. [9]. Also 3D calculations of an industrial FZ process have been carried out [10–12]. In Ref. [11], the influence of the 3D electromagnetic, Marangoni and buoyancy forces is studied, while in Ref. [12] the rotational striations are analysed

☆This paper presents results obtained within the frame of a cooperation project sponsored by VW foundation, Hanover, Germany. Cooperation partners of this project: Institute for Electroheat, University of Hanover, Germany and Department of Physics, University of Latvia, Latvia.

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PII: S0022-0248(01)01318-5