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Numerical investigation of the influence of EM-fields on fluid motion and resistivity distribution during floating-zone growth of large silicon single crystals

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Abstract

The floating-zone-process with needle-eye inductor is a complex process with many coupled parameters that have nonlinear influence on the process stability and resistivity distribution in the silicon single crystal. To fulfill the requirements of semiconductor industry for tighter specification of resistivity distribution, additional means like magnetic fields can be used to reach a more homogeneous resistivity distribution without disturbing process stability. The current paper analyses the influence of static and alternating fields on the fluid motion and macroscopic and microscopic resistivity profile by means of numerical calculations. It is found that with a lower frequency of the HF-inductor current and with an additional AC-field the radial resistivity profile can be made more homogeneous. Rotating magnetic fields give only a slightly more homogeneous resistivity profile. DC-fields do not change the radial resistivity distribution qualitatively, but suppress all flow oscillations and therefore axial microscopic resistivity variations.

Keywords: A1. Computer simulation; A1. Convection; A1. Magnetic fields; A2. Floating zone technique; B2. Semiconducting silicon

1. Introduction

The modern component industry needs tighter specifications of semiconductor material while higher crystal diameters are difficult to grow due to more complex processes. Nowadays, usually crystals with diameters of 4″ to 6″ are grown with the floating-zone (FZ) method, but soon it will be necessary to grow 8″ crystals. An important quality issue for FZ-Silicon is to control the resistivity distribution, which is determined by the mass flow in the molten zone. In most cases for FZ, gas doping at the free surface of the molten zone is performed to get the desired dopant concentration within the crystal. Finally, to control the quality of FZ-material, it is necessary to control the melt flow. Because of the high electrical conductivity of semiconductor melts, magnetic fields are powerful tools to influence convection [1–3].

Numerical modeling of crystal growth processes has established itself as a means to support process development. At the Institute for Electroheat, University of Hannover, a chain of 2D-models have been developed to calculate the interface shape, temperature field, flow motion, dopant

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