JOURNAL OF CRYSTAL GROWTH

Journal of Crystal Growth 230 (2001) 92–99

www.elsevier.com/locate/jcrysgro

Numerical investigation of silicon melt flow in large diameter CZ-crystal growth under the influence of steady and dynamic magnetic fields

J. Virbulis[a,*], Th. Wetzel[b], A. Muiznieks[b], B. Hanna[a], E. Dornberger[a], E. Tomzig[a], A. Mühlbauer[b], W.v. Ammon[a]

[a] *Wacker Siltronic AG, P.O. Box 1140, Burghausen, D-84479, Germany*

[b] *Institute for Electroheat, University of Hannover, Wilhelm-Busch str.4, D-30167, Hannover, Germany*

Abstract

Turbulent silicon melt flows are studied in large diameter Czochralski crucibles under the influence of alternating, steady and combined magnetic fields. The investigations are based on the experimentally verified two-dimensional axisymmetric mathematical models. The influence of steady, alternating and combined magnetic fields on the flow pattern and temperature field is investigated. Global heat transfer and melt flow calculations are coupled and the influence of melt convection on the interface shape is studied and compared with experimental data. © 2001 Elsevier Science B.V. All rights reserved.

PACS: 47.27.i; 47.65.+a

Keywords: A1. Fluid flows; A1. Heat transfer; A1. Magnetic fields; A2. Czochralski method; B2. Semiconducting silicon

1. Introduction

The conversion to large silicon (Si) single crystals of 300 mm diameter requires larger batch sizes which generates turbulent melt convection with Grashof number up to 10^{10}. Several efforts of the crystal growth industry are dedicated to control the melt flow and the temperature distribution. In particular, its focus is on the correct prediction of the interface shape and the related point defect distribution in the crystal, of the oxygen transport, of the crucible overheating and of the dislocation free growth. Besides conventional means, electromagnetic steady (DC) and dynamic (AC) fields offer new possibilities to meet the continuously increasing demands for crystal quality, yield improvement and cost reduction. A numerical simulation helps in investigating the wide field of possible process conditions, to save a lot of experimental costs for large diameter crystal growth and to reduce the time to market.

Global heat transfer calculations [1–3] provide good agreement with temperature measurements in crystal and insulation [4] and are established as a standard tool for Czochralski (CZ) process development.

*Corresponding author. Tel.: +49-8677-83-4227; fax: +49-8677-83-7303.

E-mail address: janis.virbulis@wacker.com (J. Virbulis).

0022-0248/01/$ - see front matter © 2001 Elsevier Science B.V. All rights reserved.

PII: S0022-0248(01)01321-5