China Semiconductor Technology International Conference (ISTC/CSTIC 2009)
Shanghai, March 19-20 2009, China

INVITED PAPER

Global Simulation of the Growth of Large Diameter Silicon Crystals: from Dynamic Modelling to Crystal Quality Optimization

F. Dupret[1,2], R. Rolinski[2], L. Wu[2], F. Loix[2], A. de Potter[2]

[1]*CESAME Research Center, Université catholique de Louvain, Bâtiment EULER, 4 av. Georges Lemaître, B-1348 Louvain-la-Neuve, Belgium*
[2]*FEMAGSoft S.A. Company, 7 Rue André Dumont, Axis Parc, B-1435 Mont-Saint-Guibert, Belgium*

Corresponding author (e-mail): francois.dupret@uclouvain.be

When Silicon ingots are grown by the CZ technique for IC applications, the crystal diameter has to conform to current market requirements while the crystal defects and composition have to be perfectly controlled. However, a high crystal diameter results in a complex melt flow regime and an enhanced system dynamics (which also could result from a high pull rate). Therefore, designing the furnace hot zone requires appropriate heat shields while obtaining a satisfactory melt flow pattern necessitates the use of transverse or configured magnetic fields. Accordingly, the selection of optimal process parameters often becomes difficult, especially during the critical process stages. Similar constraints govern the growth of Silicon crystals for PV applications. This paper is devoted to illustrate CZ Silicon growth optimization by use of the FEMAG-CZ.2 software, as co-developed by FEMAG*Soft* SA Company and the CESAME center of the Université de Louvain.

The model is global and dynamic. All important phenomena are considered, and FEMAG-CZ.2 automatically simulates the entire growth process while coupling the calculations with accurate melt and gas flow predictions. The model also predicts the evolution of point- and micro-defects in the crystal, by an extension of the lumped model of Voronkov and Kulkarni (to calculate the micro-void concentration and size distribution anywhere in the crystal). Another objective is to predict the concentration of Oxygen, dopants and impurities in the melt and the crystal. The role of the “off-line control” technique is to determine the heater power and pull rate histories required to obtain a crystal of constant diameter and optimal quality. Additional command parameters such as crystal and crucible rotation rates, magnetic field intensity, etc., can be optimized as well. Crystal quality is measured by the simulated defect density above the crystal-melt interface, or the deflection of this interface, etc. Examples will illustrate this procedure.