Simulation of Float-Zone Silicon Single Crystal Growth

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Abstract

Single crystal silicon is the basic building material for nearly all semiconductor electronics and is therefore an important raw material for the electronics industry. Single crystalline silicon rods of very high purity can be manufactured by the Float Zone technique, in which a polycrystalline rod is molten locally using a radio frequency electromagnetic field induced by a narrow coil surrounding the rod. The molten silicon solidifies into a single crystal, which is sliced into thin wafers.

We employ mathematical modelling as a tool for investigating the Float Zone process. Of special interest is the dynamics of the molten zone, crusial for the stability of the process and the quality of the produced crystal. The computational work includes solving the Navier-Stokes equations for the molten silicon with a free surface moving boundary and with boundaries at which melting and solidification occur. The shape of the melt free surface is influenced by the AC electromagnetic field calculated from Maxwell's equations. Heat transfer from the free surface into the silicon melt is included together with buoyancy, gravitational, electromagnetic and surface tension forces. We present a two-dimensional finite element model, with which the main features of the Float Zone process are illustrated by numerical simulations.