Special Issue 1: Thermophysical Property Measurements and Processing of High-Temperature Melts Using Magnetic Fields
(Review)

Reduction of Marangoni Convection by Magnetic Fields

P. DOLD[1]* and A. CRÖLL[2]

Abstract

Systems with free melt surfaces are frequently affected by gravity independent, capillary flows due to the temperature and/or concentration dependence of the surface tension. For low Prandtl number liquids like metal or semiconductor melts, small temperature differences are already sufficient to cause a time-dependent flow regime, which induces fluctuation of the temperature and the velocity field of the melt. The high electrical conductivity of the low Prandtl number substances makes the use of magnetic fields the first choice for flow control and the elimination of undesirable flow structures. Static magnetic fields or dynamic ones are in use.

In radiation-heated float zones, the time-dependent natural convection results in irregular temperature fluctuations in the melt, which reach peak-to-peak values of 1 K; their frequency range is between 0.05 and 0.2 Hz. Numerical simulations reveal flow velocities in the range of 15 cm/s. Static axial magnetic fields result in crystals free of (detectable) microsegregation. The radial dopant distribution is distorted by the magnetic field due to the establishment of stationary flow cells. Static magnetic fields can induce thermoelectromagnetic flows ahead of the solid-liquid interface, which cause strong compositional irregularities in the μm to mm range. Applying rotating magnetic fields, the convectively induced temperature fluctuations can be reduced by more than one order of magnitude. The microsegregation is nearly eliminated and the radial dopant distribution is improved.