11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

ENHANCED GROWTH OF SINGLE- AND MULTI-CRYSTALLINE SEMICONDUCTORS USING PULSED TRAVELLING MAGNETIC FIELDS

N. Dropka, Ch.Frank-Rotsch

Leibniz-Institute for Crystal Growth (IKZ), Max-Born-Str. 2, 12489 Berlin, Germany,
natascha.dropka@ikz-berlin.de, www.ikz-berlin.de

Key Words: *MHD, crystal growth, pulsed magnetic fields, silicon, GaAs.*

Challenge that crystal growth technology is facing nowadays lies in obtaining of higher yields at lower process costs. They can be achieved by e.g. up scaling of ingot sizes and/or by an increase of a crystallization growth rate. However, the bottleneck of these approaches is a lot of generated latent heat and consequently a concave bending of the s-l interface that enable formation of defects in growing crystal. A feasible method to overcome these drawbacks is forced convection by Lorentz forces, particularly if generated by KRIST*MAG*® internal heater–magnet module (HMM) [1], as recently reported in the literature for various materials and growth techniques. KRIST*MAG*® multi-coil heater positioned around the crucible is supplied with a combination of DC and out-of-phase AC that enables simultaneous generation of a heat and Travelling Magnetic Field (TMF). In contrast to other heater designs, a wide range of magnetic parameters is at disposal.

Recently, new advanced concepts of pulsed stirring by bottom TMF and side Rotating Magnetic Fields (RMF) were proposed for isothermal metals and metallic alloys, to prevent flow-induced macrosegregation and harmful segregation freckles [2-5].

In this study, we were interested to further extend the application of pulsed TMF stirring to various semi-conducting materials grown by various techniques. Particularly, we performed a systematic numerical investigation of transport phenomena taking place during growth of VGF-GaAs and Cz-silicon single crystals as well as DS-silicon multi crystalline materials.

The numerical models described three industrial-size furnaces provided with either top, side or bottom KRIST*MAG*® HMM with at least two heating coils positioned concentrically or upon each other. Lorentz forces of various direction, magnitude and spatial distribution were induced by the variation of AC/DC ratio, frequency and phase shift among the coils (Figure 1). Additional heat was supplied by common resistance heaters. By modulating AC magnitude in a sinusoidal way, pulsed TMF was generated.

For 3D CFD simulations, we applied the commercial finite-volume code ANSYS CFX 14.0. Magnetic 3D simulations were performed using finite elements commercial code ANSYS Emag.

Our results derived guidelines for optimization of pulsed TMF stirring technique with respect to the design of heater magnets and identification of operational electro-magnetic parameters.

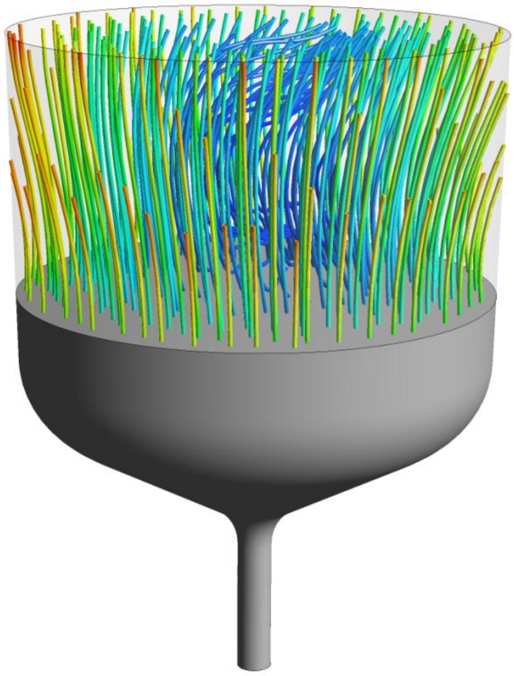

Figure 1. Lorentz force density streamlines in GaAs melt exposed to TMF.

REFERENCES

[1] P. Rudolph, *J. Crystal Growth,* Vol. **310**, pp. 1298-1306, 2008.

[2] X. Wang, Y.Fautrelle, J. Etay and R. Moreau, *Metallurgical Transactions,* Vol. **B40 B**, pp. 82–90, 2009.

[3] X. Wang, R. Moreau, J. Etay and Y. Fautrelle, *Metallurgical Transactions*, Vol. **B40 B**, pp.104–113, 2009.

[4] D. Räbiger, S. Eckert, G. Gerbeth, S. Franke and J. Czarske, *Magnetohydrodynamics,* Vol. **48**, pp. 213–220, 2012.

[5] S. Eckert, P.A. Nikrityuk, D. Raebiger, K. Eckert and G. Gerbeth, *Metallurgical and Materials Transactions*, Vol. **38B**, pp. 977–988, 2007.