



HAL
open science

Toward the modeling of Freeze Casting

Martin Genet, Eduardo Saiz, Antoni Tomsia

► **To cite this version:**

Martin Genet, Eduardo Saiz, Antoni Tomsia. Toward the modeling of Freeze Casting. 8th International Workshop on Interfaces, Jun 2011, Saint-Jacques de Compostelle, Spain. <hal-01274883>

HAL Id: hal-01274883

<https://hal.science/hal-01274883v1>

Submitted on 18 Feb 2016

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

Toward the modeling of Freeze Casting

Martin Genet^{1†}, Eduardo Saiz^{2‡}, Antoni Tomsia^{1†}

¹*Lawrence Berkeley National Laboratory, One Cyclotron Road MS 62, Berkeley, CA 94720, USA*

²*Imperial College London, Exhibition Road, London SW7 2AZ, UK*

Abstract

Freeze casting –*i.e.* directional freezing of ceramic suspensions[1, 2]– is nowadays considered one of the top candidates to process highly structured porous ceramics for several application domains including precision filters and bone regeneration implants. Here, we present our early studies toward the first tridimensional simulation of the freeze casting process. The goal is not only to provide fundamental understanding of the solidification process, but also to derive theoretical tools to quantitatively master the effect of each of its parameters. The finite element method[3] is used to compute the heat diffusion within the matter. The evolving interface between solid and fluid plays a major role and is tracked using the level set method[4, 5] combined with mesh adaptivity techniques. These developments, adapted from existing research on metal casting, allow to characterize the influence of the cooling rate on the shape of the ice crystals, and then of the ceramic walls. In the future, fluid convection as well as particles motion will be introduced in the simulation to complete the analysis. We will then be in possession of a powerful numerical tool for the quantitative optimization of the freeze casting process, leading to tougher and stronger scaffolds, *e.g.*, for the repair of load-bearing bone defects.

References

- [1] Sylvain Deville, Eduardo Saiz, Ravi K. Nalla, and Antoni P. Tomsia. Freezing as a path to build complex composites. *Science*, 311(5760):515–8, January 2006.
- [2] Etienne Munch, Maximilien E Launey, D. H. Alsem, Eduardo Saiz, Antoni P. Tomsia, and Robert O Ritchie. Tough, bio-inspired hybrid materials. *Science*, 322(5907):1516–20, December 2008.
- [3] W. Bangerth, R. Hartmann, and G. Kanschat. deal.II—A general-purpose object-oriented finite element library. *ACM Transactions on Mathematical Software*, 33(4):24/1–24/27, August 2007.
- [4] Stanley Osher and James A. Sethian. Fronts propagating with curvature-dependent speed: Algorithms based on Hamilton-Jacobi formulations. *Journal of Computational Physics*, 79(1):12–49, November 1988.
- [5] Timothy J. Barth and James A. Sethian. Numerical Schemes for the Hamilton–Jacobi and Level Set Equations on Triangulated Domains. *Journal of Computational Physics*, 145(1):1–40, September 1998.

[†]mgenet@lbl.gov

[‡]e.saiz@imperial.ac.uk (Chair in Structural Ceramics)

[†]aptomsia@lbl.gov