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Toward the modeling of Freeze Casting

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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.

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