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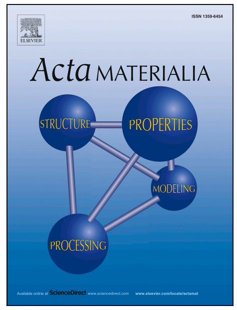

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Anisotropic Sintering Behavior of Freeze-Cast Ceramics by Optical Dilatometry and Discrete-Element Simulations

Aaron Lichtner[a], Denis Roussel[b], Daniel Röhrens[c], David Jauffres[b], Julie Villanova[d], Christophe L. Martin[b], Rajendra K. Bordia[e]

[a] *Dept. of Mat. Sci. and Eng., University of Washington, Seattle, Washington, USA*
[b] *Universite de Grenoble Alpes, CNRS, SIMaP, F-38000 Grenoble, France*
[c] *Forshunzentrum, Institutfr Energie und Klimaforschung, D-52425 Jülich, Germany*
[d] *ESRF, The European Synchrotron CS 40220 38043 Grenoble Cedex 9, France*
[e] *Dept. of Mat. Sci. and Eng., Clemson University, Clemson, South Carolina, USA*

Abstract

Directional freeze-casting of ceramic slurries followed by freeze drying and partial sintering results in materials with highly anisotropic properties parallel and transverse to the freezing direction. Physical measurements and optical dilatometry confirm that, during sintering, freeze-cast structures experience more strain along their freezing direction than transverse to it. Discrete Element (DEM) simulations of equivalent freeze-cast structures confirm this behavior. These simulations indicate that not only is sintering anisotropic on the macroscopic scale but within the walls and macropores themselves. It was determined that the anisotropic particle contact network that resulted from the aligned macropores led to anisotropic shrinkage during sintering.

Keywords: Freeze-Cast, Anisotropic Pores, Optical Dilatometer, Sintering, Discrete Element Simulations

1. Introduction

Freeze-casting is a materials processing technique that can be used to create a variety of anisotropic porous microstructures for use in fields such as materials for energy conversion devices [1], dentistry [2], bioengineering [3], and even food science [4]. This technique is attractive because of the high level of control and wide range of properties one can achieve with relatively simple equipment and primarily "green" methods. A significant number of researchers have reported