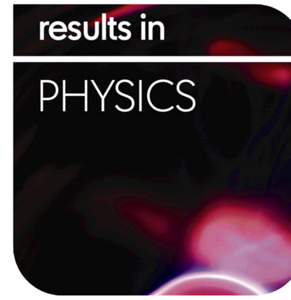

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PII: S2211-3797(18)30769-1
DOI: https://doi.org/10.1016/j.rinp.2018.05.014
Reference: RINP 1457

To appear in: *Results in Physics*

Received Date: 30 March 2018
Revised Date: 4 May 2018
Accepted Date: 6 May 2018

Please cite this article as: Manière, C., Chan, S., Lee, G., McKittrick, J., Olevsky, E.A., Sintering dilatometry based grain growth assessment, *Results in Physics* (2018), doi: https://doi.org/10.1016/j.rinp.2018.05.014

SINTERING DILATOMETRY BASED GRAIN GROWTH ASSESSMENT

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Microarticle format

A B S T R A C T
Volume shrinkage, grain growth, and their interaction are major events occurring during free sintering of ceramics. A high temperature sintering dilatometry curve is influenced by these both phenomena. It is shown that the continuum theory of sintering can be utilized in the format enabling the extraction of the maximum amount of information on the densification and grain growth kinetics based on a simple dilatometry test. We present here the capability of such a fast approach (Dilatometry based Grain growth Assessment DGA) utilized for the modeling of sintering and grain growth of zirconia.

Keywords: sintering; grain growth; dilatometry; densification kinetics; regression method

I. Introduction

During free sintering of ceramics the grain growth usually occurs at the final stage of processing when relative density is close to 90 %. When grain growth starts, it affects the densification kinetics because the grain size has a direct influence on the length of the diffusional path and on the capillary forces that govern sintering. In consequence, the grain growth slows down the densification of the powder specimen at the final stage of sintering. Conversely, the sintering has also an influence on the grain growth kinetics given that the porosity or the segregation of impurities may reduce the grain growth rate [1,2]. Previously it was shown that taking into account the grain growth improves the final density predictions by a sintering model describing spark plasma sintering experiments [3,4]. Accurate assessment of the grain growth, highly active at the end of sintering, is of great importance because grain growth favors residual porosity and may reduce the mechanical properties of the processed material. In other advanced sintering approaches, controlling the grain growth/densification behavior (also called sintering trajectory) is the key issue. These approaches include the two-step sintering method which prescribes the optimized processing thermal history to reduce the final grain size, the pressure and/or field assisted sintering, such as spark plasma sintering, which highly improves the retention of the small grain size microstructures [5,6]. The modeling of both densification and grain growth is therefore of high interest for these techniques. In the present study, the full extraction of the densification and grain growth constitutive parameters is conducted based on a simple free sintering dilatometry curve for zirconia. Such an analysis is made possible due to the developed specific formulation based on the continuum theory of sintering [7] adopted for the description of the material constitutive behavior at the intermediate and final stages of sintering.

II. Theory and method

Free sintering can be modelled analytically via the following equation of the continuum theory of sintering [7]:

$$P_l = \frac{-A(T)\psi\dot{\theta}}{(1-\theta)} = \frac{3\alpha(1-\theta)^2}{r} \qquad (1)$$