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Authors: J. Diatta, G. Antou, N. Pradeilles, A. Maître

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Numerical modeling of spark plasma sintering - discussion on densification mechanism identification and generated porosity gradients

J. Diatta, G. Antou*, N. Pradeilles, A. Maître

Univ. Limoges, CNRS, ENSCI, SPCTS, UMR 7315, F-87000 Limoges, France

Abstract.

A multi-physical numerical model of the SPS process has been developed in order to evaluate electrical, thermal and mechanical fields undergone by the powder during sintering. The reliability of this numerical model has been validated by comparison with experimental data carried out on a submicrometric alpha alumina powder. This numerical approach is applied to achieve a critical analysis of the main methodologies used in the literature for the identification of the densification parameters, and the possible misinterpretations of involved deformation mechanisms. Moreover, as shown during sintering of alumina pellets of larger diameter (50 mm in diameter), the induced porosity gradient seems to be mainly correlated to the existence of thermal gradient within the powder, and in a lesser level to stress gradient. Consequently, the temperature gradient seems to be a crucial point to be controlled during SPS process of large size samples in order to obtain fine and homogeneous microstructure.

Keywords: Ceramics; Spark Plasma Sintering; Finite-element modeling (FEM); Creep; Densification.

I. Introduction

Spark Plasma Sintering (SPS), also known as Field Assisted Sintering Technique (FAST) or Pulsed Electric Current Sintering (PECS), belongs to a class of sintering techniques that couples a mechanical uniaxial pressure and an electric pulsed current to make sintering easier. This technique demonstrates numerous benefits compared to other conventional techniques (*i.e.* hot pressing or hot isostatic pressing) such as high heating rate and short holding time, which