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Authors: J. Tarabeux, V. Pateloup, P. Michaud, T. Chartier

PII: S0955-2219(18)30198-5
DOI: https://doi.org/10.1016/j.jeurceramsoc.2018.03.052
Reference: JECS 11809

To appear in: *Journal of the European Ceramic Society*

Received date: 22-1-2018
Revised date: 28-3-2018
Accepted date: 30-3-2018

Please cite this article as: Tarabeux J, Pateloup V, Michaud P, Chartier T, Development of a numerical simulation model for predicting the curing of ceramic systems in the stereolithography process, *Journal of the European Ceramic Society* (2010), https://doi.org/10.1016/j.jeurceramsoc.2018.03.052

Development of a numerical simulation model for predicting the curing of ceramic systems in the stereolithography process

J.Tarabeux, V.Pateloup, P.Michaud, T.Chartier

IRCER, Univ. Limoges, UMR 7315, 12 Rue Atlantis, F-87000 Limoges, France

Abstract: The control of ceramic green parts dimensions produced by stereolithography is a central concern of the ceramic additive manufacturing industry. The presence of ceramic particles within the photopolymerizable system induces UV-laser beam scattering phenomenon, disrupting the polymerization process. This study focuses on the development of a numerical simulation model of the curing process, considering the scattering phenomenon. This paper presents each stages of the development of the numerical simulation model, supported and finally validated by experimentation on a commercial photopolymerizable alumina paste. Firstly, the numerical simulation model is presented. Then, a Greco-Latin square design of experiments is conducted to reduce the number of experiments. Subsequently, material-dependent parameters are identified through simulations and experimental measurements, and a scattering law is proposed. Finally, the simulation model enables to simulate easily and with accuracy the cure widths and the cure depth. It also provides visualization of the exposure distribution and the scattering phenomenon.

Keywords: Additive manufacturing; Stereolithography; Curing; Scattering; Simulation model

1. Introduction

Stereolithography is an additive manufacturing process using a layer-by-layer fabrication procedure in which the selective curing of a polymer resin by a computer-controlled UV laser beam enables the fabrication of a three-dimensional part [1]–[10]. Initially used in the plastics industry, stereolithography has expanded in the field of ceramics only from the mid-1990s with the development of photopolymerizable ceramic pastes/suspensions [1], [5], [6], [9], [10]. These