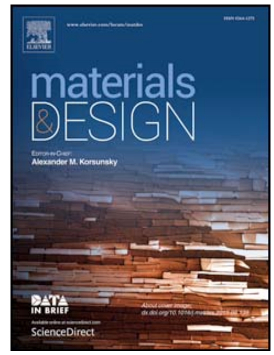
Accepted Manuscript



Advanced ceramic components with embedded sapphire optical fiber sensors for high temperature applications

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PII: S0264-1275(16)31248-5
DOI: doi: 10.1016/j.matdes.2016.09.074
Reference: JMADE 2324

To appear in:

Received date: 25 July 2016
Revised date: 19 September 2016
Accepted date: 20 September 2016

Advanced ceramic components with embedded sapphire optical fiber sensors for high temperature applications

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Abstract

This paper describes an extrusion-based additive manufacturing process that has been developed to enable embedment of sapphire optical fiber sensors in ceramic components during the part fabrication. In this process, an aqueous paste of ceramic particles is extruded through a moving nozzle to build the part layer-by-layer. In the case of sensor embedment, the fabrication process is halted after a certain number of layers have been deposited; the sensors are placed in their predetermined locations, and the remaining layers are deposited until the part fabrication is completed. Because the sensors are embedded during the fabrication process, they are fully integrated with the part and the problems of traditional sensor embedment can be eliminated. Scanning electron microscopy was used to observe the embedded sensors and to detect any possible flaws in the part or embedded sensor. Attenuation of the sensors was measured in near-infrared region (1500-1600 nm wavelength). Standard test methods were employed to examine the effect of embedded fibers on the strength and hardness of the parts. The results indicated that the sapphire fiber sensors with diameters smaller than 250 micrometers were able to endure the freeform extrusion fabrication process and the post-processing without compromising the part properties.

Keywords: ceramic on demand extrusion; extrusion freeforming; additive manufacturing; smart material; smart structure; alumina.

1. Introduction

Embedded sensors have been widely used in structural health monitoring and proven very effective in civil and structural engineering [1,2]. However, there are currently no viable techniques for in-situ monitoring of the health status of the critical components in energy production systems. In addition, the existing techniques for process monitoring are inadequate to operate reliably in the extremely harsh environments over a long time [3]. The sensing capabilities can be incorporated in the design phase of various energy systems by embedding sensors into the critical components, enabling a new paradigm in harsh-environment sensing. The embedded sensors not only provide the real-time information on the health status of the component, but also reduce the complexity in sensor installation and increase the robustness of the sensors for reliable measurements of various parameters that are important for system control and optimization.

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