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Abstract

Si_3N_4 Parts Fabricated by Robocasting: Proof of Concept †

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Additive manufacturing (AM) techniques in the category 'material extrusion', such as robocasting, can produce ceramic pieces from high-solid concentrated pastes. It uses lower amounts of organic additives than fused filament fabrication (FFF) or stereolithography/digital light processing (SLA/DLP), avoiding long burnout steps and preventing high shrinkage, which may result in better structural quality (density, mechanical properties) of the final pieces. Robocasting is thus a promising technique to produce dense ceramic parts from Si_3N_4-based materials. Considering that more and more ceramic components based on this material are being used in the aerospace, biomedicine, cutting tools, and automobile industries, it is a great challenge to fabricate components without microstructural defects, with high reliability, and with the required geometric complexity at acceptable costs. A few works documented the use of robocasting to fabricate silicon nitride-based materials, emphasizing the challenge and motivation for the present study.

The objective of this work is the optimization of concentrated Si_3N_4 aqueous suspensions, in order to achieve a properly viscoelastic ceramic paste as a feedstock for robocasting AM technology. For such a purpose, aqueous-based Si_3N_4 compositions containing yttria (Y_2O_3) and alumina (Al_2O_3) as sintering additives, in a total amount of solids from 40 vol.% to 45 vol.% were developed. Small amounts of Dolapix A88 as dispersant, carboxymethyl cellulose (CMC), and polyethyleneimine (PEI) were used as organic additives. The suspension rheological behavior was investigated to optimize the paste viscoelasticity to be extrudable, while keeping the shape. Circular samples (diameter 20 mm and height 5 mm) were made for preliminary characterization tests.

The shrinkage and relative density of the additive manufactured parts were measured after sintering at 1750 °C, under a N_2 atmosphere in a powder bed of similar composition. The mechanical characterization was performed by micro-hardness and flexural strength.

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