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Extrusion-based additive manufacturing of high resolution ceramic lattice structures

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Abstract

Extrusion-based additive manufacturing (AM) technologies offer the ability to fabricate functional complex 3D structures from variety of inks/pastes with different materials and resolutions. Minimum feature size printed from ceramic colloidal inks is limited to circa 100-200µm as these inks either have problem of nozzle jamming (or clogging) due to agglomeration of powders, or need a very high pressure to extrude the ceramic ink to flow through a fine nozzle. The objective of this research is to investigate the parameters affecting the extrusion resolution, including ceramic paste formulation, extrudate velocity, as well as nozzle geometry, in order to increase the resolution of ceramic extrusion freeforming. In this report, an extrusion-based AM system was designed and set up and series of experiments were conducted to analyze the effects of solvent content in the paste, extrudate velocity and die design on extrusion pressure using the Benbow's model. In addition, factorial design of experiment (DOE) was served for statistical analysis of contribution of each control factor on the extrusion pressure and the results were considered as a guide for 3D direct printing of high resolution ceramic lattice structures. Ceramic scaffolds with struts diameter as fine as 30µm could be manufactured by optimizing the process parameters.