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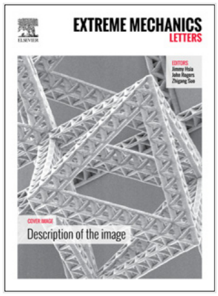

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Deposition of ordered two-phase materials using microfluidic print nozzles with acoustic focusing

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Abstract

The deposition of multiphase materials with microstructural control would enable new fabrication modalities, such as spatial variation in composition and the integration of microstructure and structural features. In this work, acoustically-excited microfluidic print nozzles were used to tailor the microstructure of printed composite filaments consisting of SiC fibers, solid $BaTiO_3$ spheres, or hollow SiO_2 spheres in an epoxy matrix . The results demonstrate that acoustic focusing is a promising technique to control microparticles and deposit two-phase ordered structures using a single nozzle. In addition to tuning the microstructure within a single print line, the overall concentration of particles can be increased by focusing the particle stream in a branched geometry, enabling the deposition of material with higher particle volume fractions than the initial ink composition. We show that even modest volume fractions of acoustically-focused and concentrated SiC fibers can produce printed composite filaments with unprecedented control over microstructural ordering that exhibit strengths rivaling polymer-matrix composites with higher volume fractions of stiffer fibers.

Keywords: additive manufacturing, 3D printing, microfluidics, acoustic waves

1. Introduction

There is significant motivation to develop direct deposition techniques for composites, particularly those capable of producing ordered phases. Such techniques would unleash the true power of additive manufacturing, in that the printing process could directly couple spatial variations in composition (including both volume fraction and phase orientation) with structural features of components. Notable examples include functionally graded soft robots[1], monolithic[2, 3] and lattice composite materials with strong, stiff reinforcements aligned with cell walls[4],