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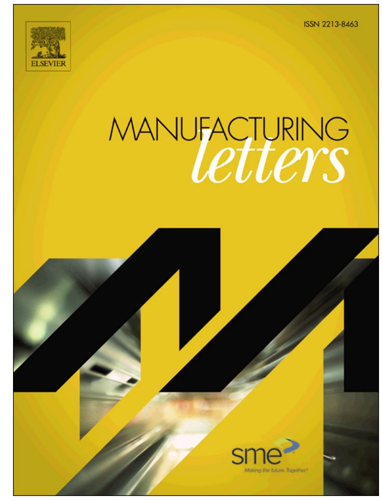

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Projected UV-Resin Curing for Self-Supported 3D Printing

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Abstract

This research introduces a new additive manufacturing process for support-free printing. This process uses an array of ultra-violet laser diodes to cure the jetted photopolymer at the laser intersection for rapid solidification. A prototype system using 405 nm laser is designed and built, and a process model is modified from conventional vat photopolymerization to find a proper range of printing speed. Using a speed of 1 mm/s for a flow rate about 0.5 mm^3/s, a 60-degree overhanging structure can be repeatedly printed with commercial photopolymers. The study also discusses the challenges associated with fluid behaviors in such a dynamic condition.

Keywords: Additive manufacturing; 3D printing; support structure; self-support printing; photopolymer

1. Introduction

Current polymeric additive manufacturing (AM) techniques, including Fused Filament Fabrication (FFF), Stereolithography (SLA), Selective Laser Sintering (SLS), and material jetting heavily rely on the use of soluble support materials or breakable support structures to create three-dimensional (3D) objects that have overhanging structures. In the practical view of AM system design, uses of support material or breakable structure introduce numerous complexities in the process, such as controls design, limited material combinations, path planning, cross-contamination between materials, or parts detachment from the supports. Digital geometry processing approaches, such as separation of models and optimization of printing orientation, have been proposed to address these issues [1], but they cannot eliminate the use of support. Several extrusion-based support-free methods have been recently reported with photopolymer [2] [3] or six-degree-of-freedom FFF [4]. However, the material deposition depends on fluid rheology, which in turn limit the feature size and printing orientation. Also, extrusion-based methods often have issues with material dragging due to the contact between the nozzle and deposited material.

In this study, a new printing approach for self-supported printing is presented. The printing head jets ultra-violet (UV) curable polymer (photopolymer) and cures the projected photopolymer immediately by an array of UV laser diodes. Also, instead of building the 3D object with the conventional layer-by-layer fashion, the proposed printing method draws the toolpath in 3D space using a multi-axis motion stage without contacting printing objects.

The objective of this study is to test the feasibility of this concept and investigate a potential modeling approach to optimize the process. To this end, this paper outlines the design concept, material