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Microtruss structures with enhanced elasticity fabricated through visible light photocuring

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KEYWORDS

Polymers, self-trapping, microstructures, cellular solids

ABSTRACT

We report on the fabrication of an open cellular solid structure using visible light photocuring in combination with light-induced self-writing. A visible light sensitive photopolymer is irradiated with multiple arrays of microscale optical beams, which are generated from LEDs. These beams undergo self-trapping and elicit the inscription of microscale, solid struts into the medium. This process creates a structure consisting of multiple, intersecting struts that form a microtruss structure. Such structures retain their elasticity at higher temperatures as compared to a bulk film of the same thickness. This is the first demonstrating of visible light photocuring of photopolymers into a microtruss structure, as well as investigation into their elastic properties under tension.

INTRODUCTION

Cellular solids are attractive for their enhanced mechanical properties combined with their low density and high porosity.[1] Examples of cellular solids include foams, hexagonal structures, as well as exotic lattices.[1] One example of a cellular solid that has gained significant interested is the microtruss structure, which consists of microscale cylindrical struts that connect to other struts to form an interconnected structure, often in the form of a lattice. Such structures are commonly produced with direct laser writing.[2] Another approach to the fabrication of microtruss structures is through light self-trapping in photopolymer resins. The technique entails the transmission through the medium of a microscale optical beam with a wavelength that can initiate free-radical polymerization. The initial polymer cures into the shape of a microscale lens, which induces a self-focusing effect on the beam that counters its natural divergence.[3] The dynamic balance between self-focusing and natural divergence induces a microscale, cylindrical solid strut to grow.[4] The fiber-optic like properties self-traps and channels the optical energy along its geometry towards its furthest tip, thereby continuously initiating and sustaining its growth, as it "propagates" over the depth of the photopolymer. This process has been term light-induced self-writing[4] as well as propagating polymer waveguide (PPW) prototyping.[5] 3D structures are fabricated by generating and transmitting multiple arrays of beams from several light sources through a photopolymer, each of which self-write their own array of struts. Aligning the arrays such that beams intersect results in an intersecting structure, namely the microtruss structure. These self-written structures have been shown to have enhanced compression resistance,[5-8] as well as open opportunities for other functionalities.[9]

While microtruss structures have been produced with UV light sources, there have been no reports on their synthesis with visible, incoherent light. 2D and 3D waveguide lattice microstructures that were