MEMS-stencil lithography for mechanically-tunable infrared metasurfaces on 3D-DLW printed scaffolds*

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We have developed methods for the precise patterning of soft polymer scaffolds utilizing a microelectromechanical systems (MEMS) atomic calligraphy based method. By combining MEMS devices with two-photon direct laser writing, we are able to apply metallic patterns to the surface of a polymer microstructure with high levels of accuracy. Polymer microstructures are generally incompatible with typical lithographic processes involving exposure to electron beam, ultraviolet light, or harsh solvents. Utilizing MEMS-based focused-ion-beam-milled stencils we are capable of patterning polymer scaffolds without the need for intermediate process steps.

In this presentation, we describe our technique and demonstrate its utility in the fabrication of mechanically-tunable infrared metasurfaces, like that in Figure 1. The resonant frequency of the metasurface can be tuned by controlling the separation metallic meta-atom elements patterned on the surface of the polymer scaffold. By appropriately designing the polymer scaffold, the deformation of the meta-atoms, and thus the metasurface frequency shift, can be enhanced with respect to the use of a ‘bulk’ stretchable substrate.

Beyond frequency tunable metasurfaces, we explore the applicability of these methods to the fabrication of 3D metamaterials. Furthermore, the integration of such structures with MEMS actuators for the fabrication of dynamically controllable devices is considered.

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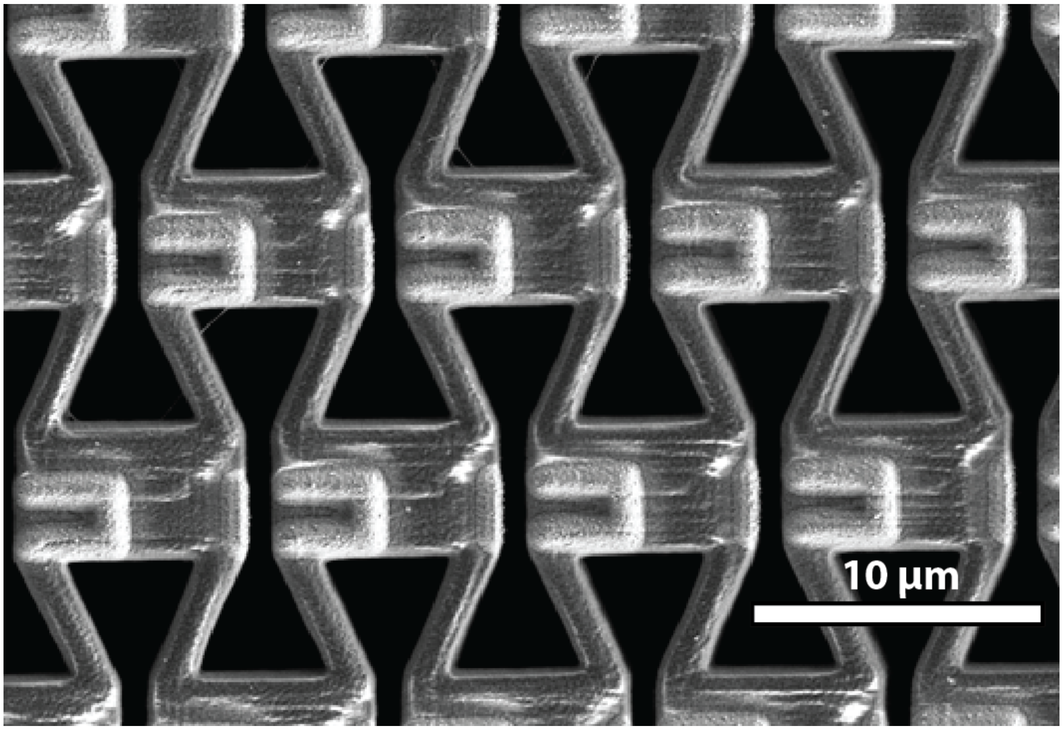

Figure 1. SEM micrograph of an infrared metasurface fabricated on a soft polymer scaffold. A two-photon-polymerization direct-laser-write polymer scaffold patterned with aluminum split-ring resonators coupled to bars. When strained the gap between the bar and the split-ring is changed, shifting the resonance frequency of the metasurface.