Two-photon polymerization of 3D structures for open-air microfluidics and untethered microrobotic systems

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Additive manufacturing using 2-photon polymerization (2PP) provides unique capabilities in creating arbitrary shaped 3D structures with submicron fidelity. By taking advantage of the flexibility in creating intricate 3D elements offered by 2PP, we implemented and explored several types of model systems with an over-arching goal of demonstrating new promising concepts in open-air microfluidics and soft microrobotics. Of our particular attention are fabrication sequences that combine 2PP additive manufacturing with bulk silicon micromachining and thin film processing.

The first part of this presentation will focus on chip-level microfluidic platforms that provide controlled transport of liquid and solid objects using principles of aerodynamic levitation. In order to achieve desired flow patterns and aerodynamic force fields, we created chips with a two-tier hierarchy of through pores. After forming the first tier of larger pores using conventional deep reactive ion etching of silicon, the second tier of smaller slanted pores was added using 2PP. Our experimental designs were guided and validated using computational fluid dynamics modeling in COMSOL.

In the second part we will describe our recent efforts in realizing acoustically powered microscale walkers. Starting with biologically inspired spider-like shapes and elastic elements, we designed and fabricated microscale mechanical resonators that could be actuated in presence of acoustic fields or vibrations applied through the substrate. The experimentally observed resonances in the substrate supported structures were found to be in a good agreement with results of our finite element analysis performed in COMSOL. Subsequently, we were able to release micro-walkers from the substrate, harvest them and observe their movement under acoustic excitation.

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