Multi-focus two-photon polymerization with real time calculated holograms

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Two-photon polymerization enables the fabrication of micron sized structures with submicron resolution by a tightly focused femtosecond laser beam. Spatial light modulators (SLM) are generally used to holographically split the original beam into multiple ones, thus generating multiple polymerizing foci in the photoresist. Scanning these foci along a predefined three-dimensional path - usually by a piezo-electric stage– results in multiple identical microstructures.

Here we present a method where the three-dimensional scanning is done holographically by continuously updating the phase modulation pattern (hologram) on the SLM, in such a way that each new hologram generates foci in a new position. In this manner a single microstructure can be fabricated in parallel by multiple foci. During the fabrication optimized holograms are calculated real-time on an NVidia Cuda GPU, and displayed on an electrically addressed SLM. Each hologram is optimized against optical aberrations present in the system. We designed a demonstrational structure, that is built up from a set of dodecahedron frames of decreasing size nested one into the other (Figure 1.). Such single microstructures were fabricated in parallel by 5 holographic foci. A scanning electron microscope was used to qualify the fabricated microstructures (Figure 2.).

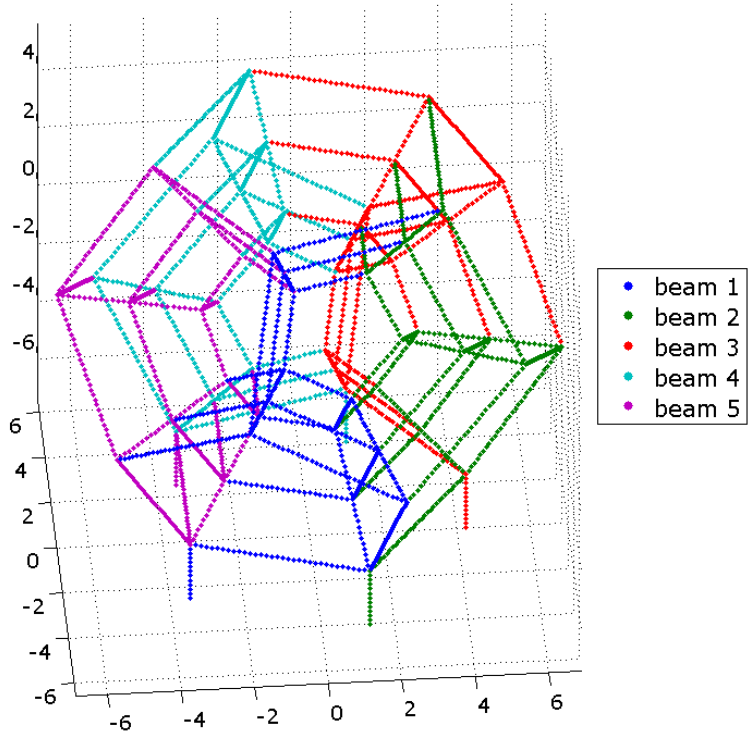

Figure 1: test-structure of the method. Fabricating foci were formed by 5 holographically generated beams. Different colors highlight parts of the structure fabricated by different beams. Axis units are in microns.

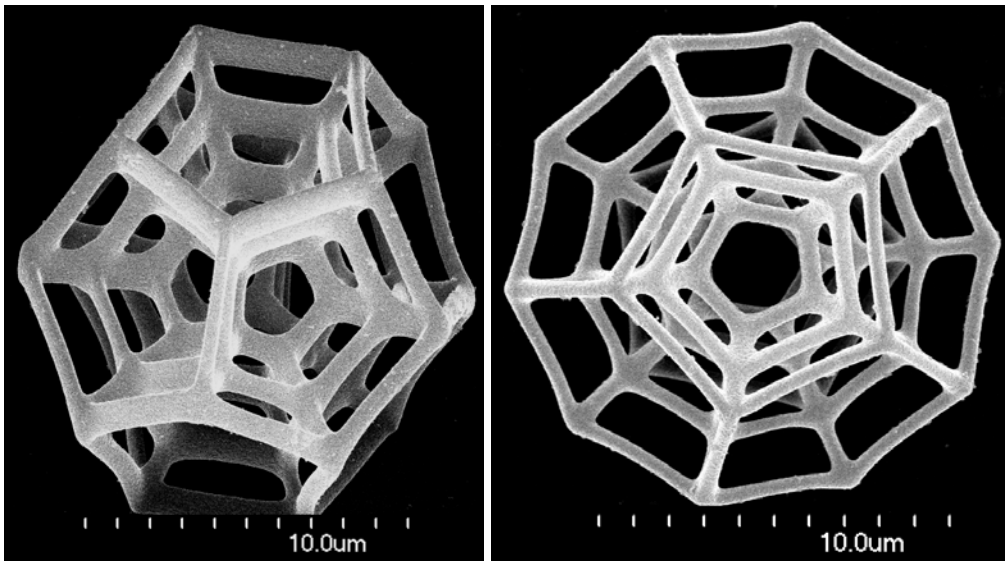

Figure 2: scanning electron micrographs of the fabricated structure.