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Gripping mechanisms for micro-scale optical fiber holders

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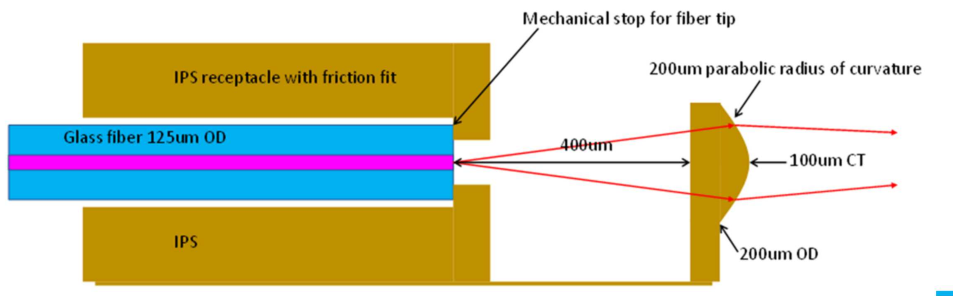
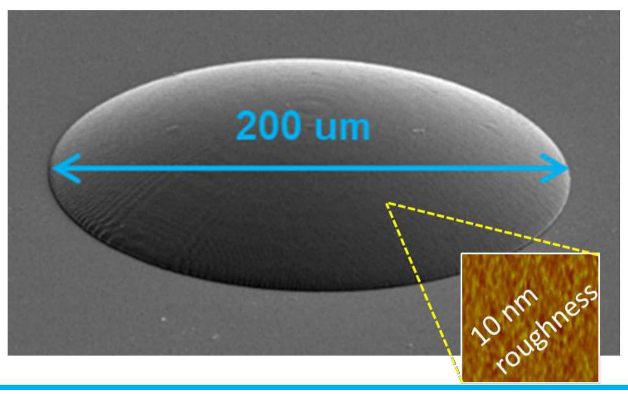
Problem:

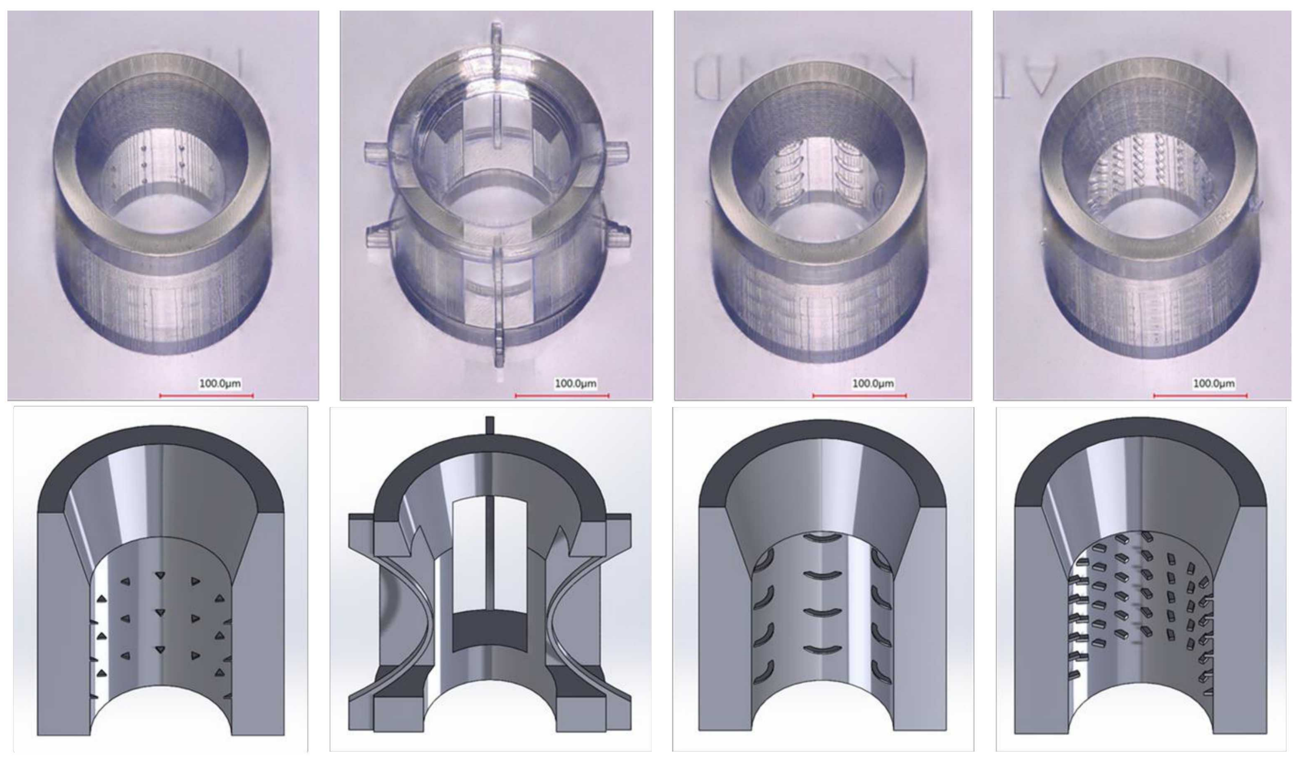
Design and optimization of optical components using 3D fabrication processes enables rapid prototyping and pre-alignment. This micro-optic component integrates a 200-micron diameter collimating lens with a pre-aligned fiber optic holder to accommodate a 125 micron wide fiber. Following initial studies to position the fiber in the holder, it became apparent that a mechanical gripping mechanism was needed to accurately position and hold the fiber in place.



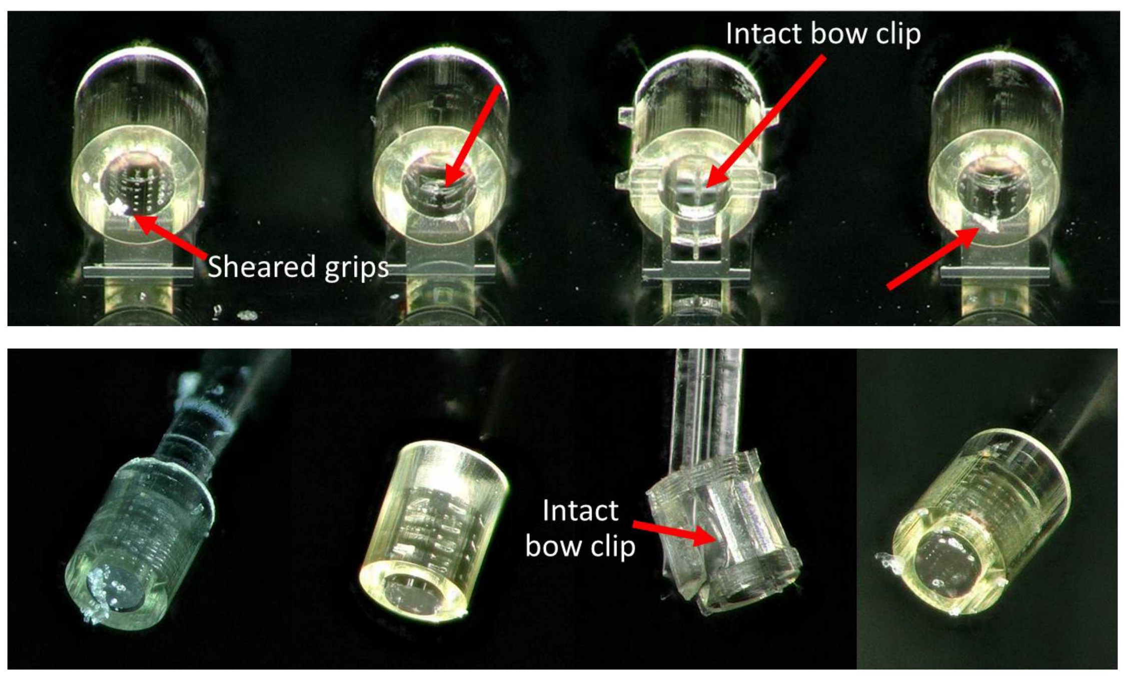
Approach:

Multiphoton lithography (MPL) is one of few printing techniques that can achieve microscale (<1 µm) feature size while maintaining optical surface quality. All samples were printed using IP-s negative-tone photoresist on ITO covered glass slides that were surface treated with O2 plasma to increase wettability.

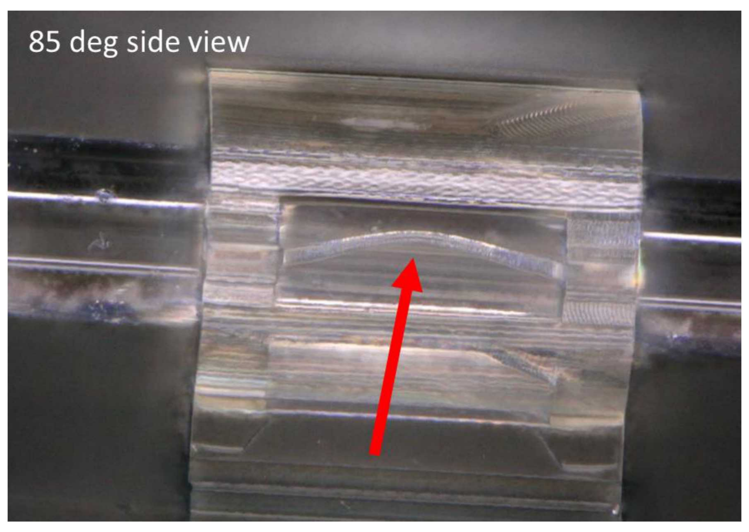




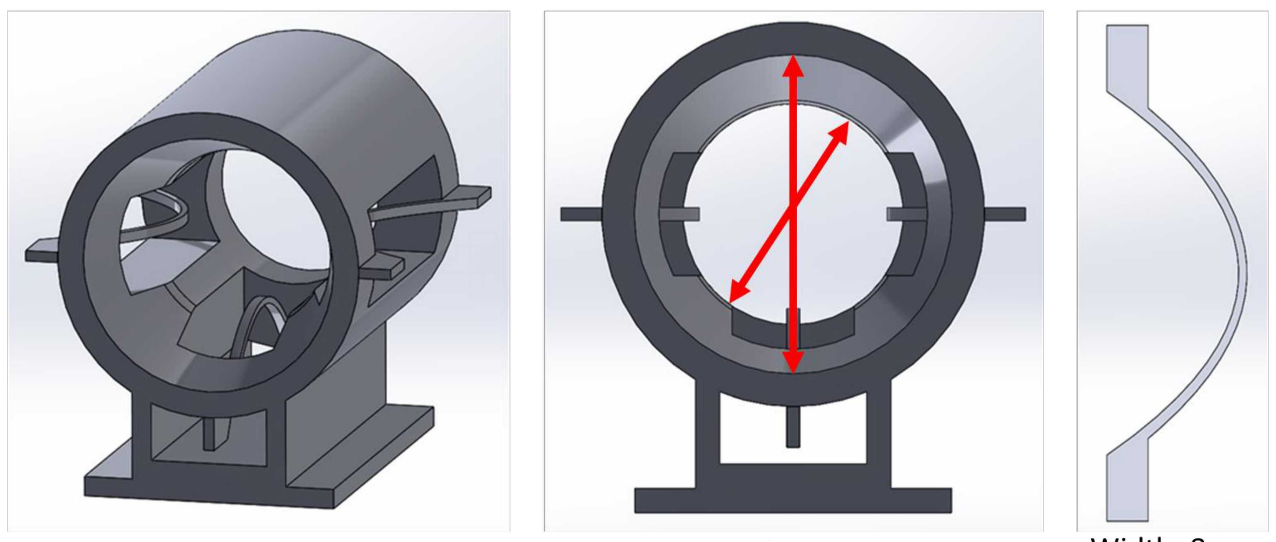
Results:



Initial tests revealed that the flexible bow clip showed good strength and repeatability and all other mechanical grips sheared off during insertion of the fiber. Although the fiber holder itself ruptured, the flexible bow clip remained intact therefore we converged on this design and focused on optimizing it.



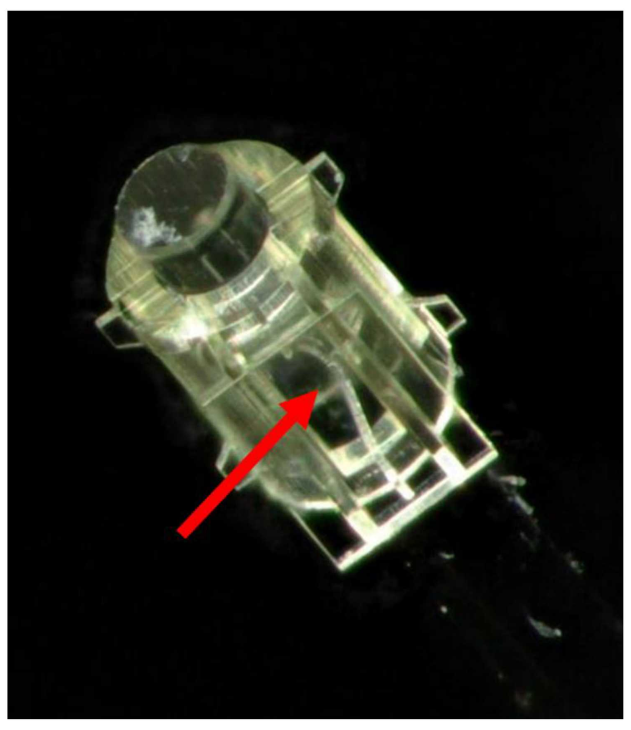
During inspection, it was observed that the bow clip was being pushed up on its side by the fiber and was not following through its expected dampening motion. To avoid this occurrence, the width, thickness and protrusion of the clip were varied and tested.



300 x 285 x 300 µm

Funnel ID: 195um
Base ID: 135um

Width: 8um
Thickness: 5 um
Extrusion: 10um



Application of Castigliano's Theorem

Deflection produced by force:

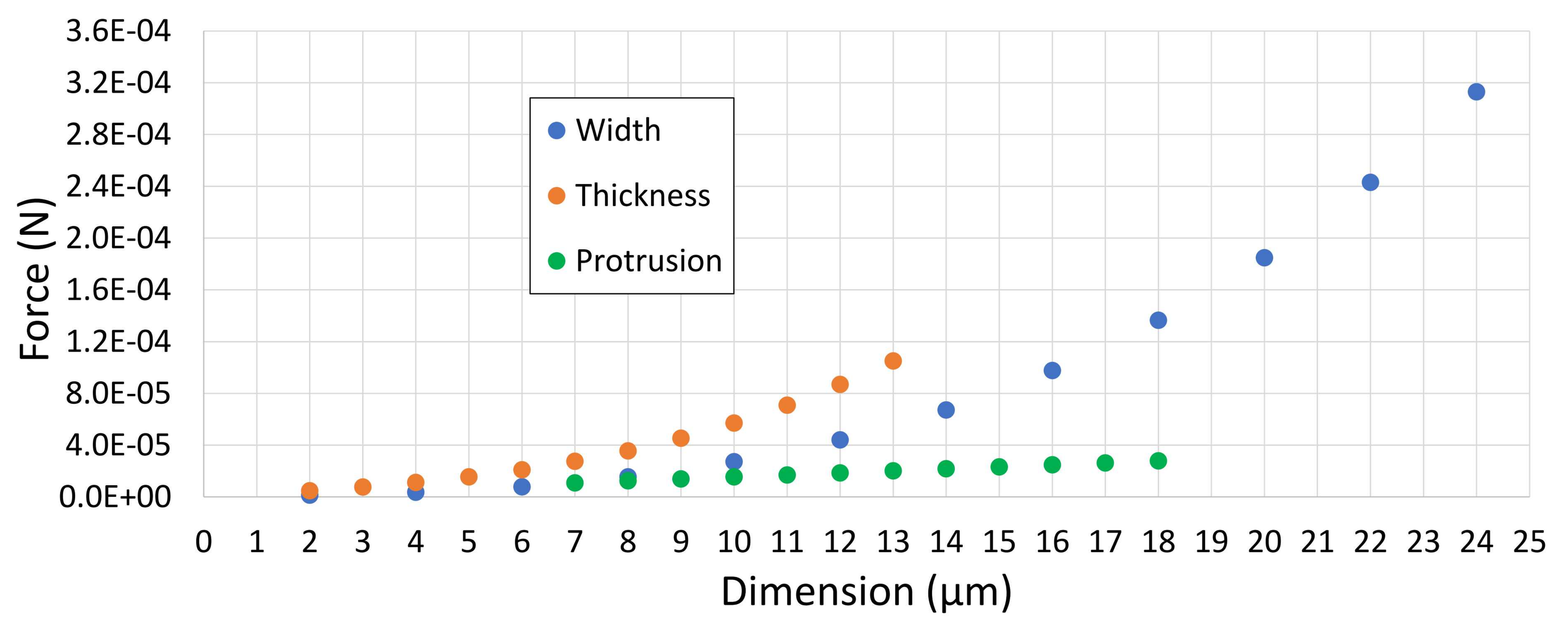
$$\delta \doteq \frac{\pi F R^3}{2EI}$$

R = 82.5um
E = 4.6 Gpa

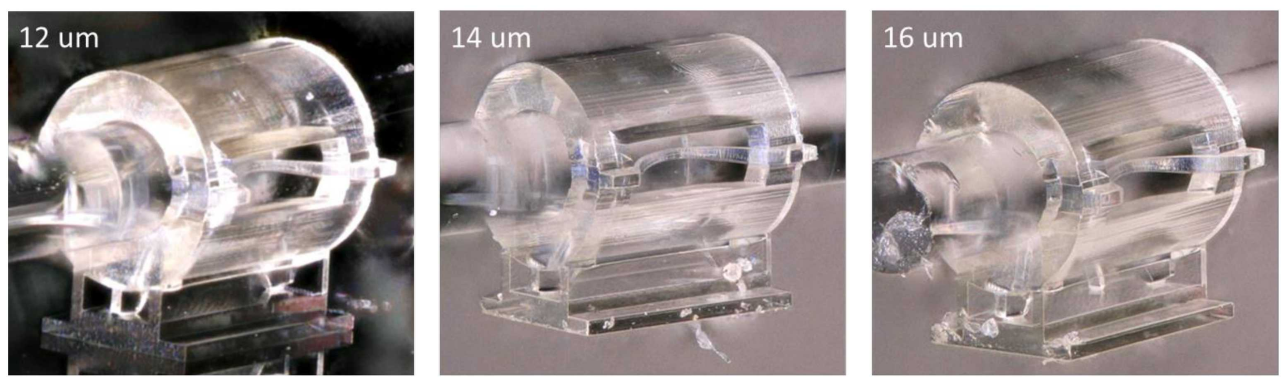
$$I = \frac{ab}{12} * (a^2 + b^2)$$

a = thickness
b = width
δ = extrusion

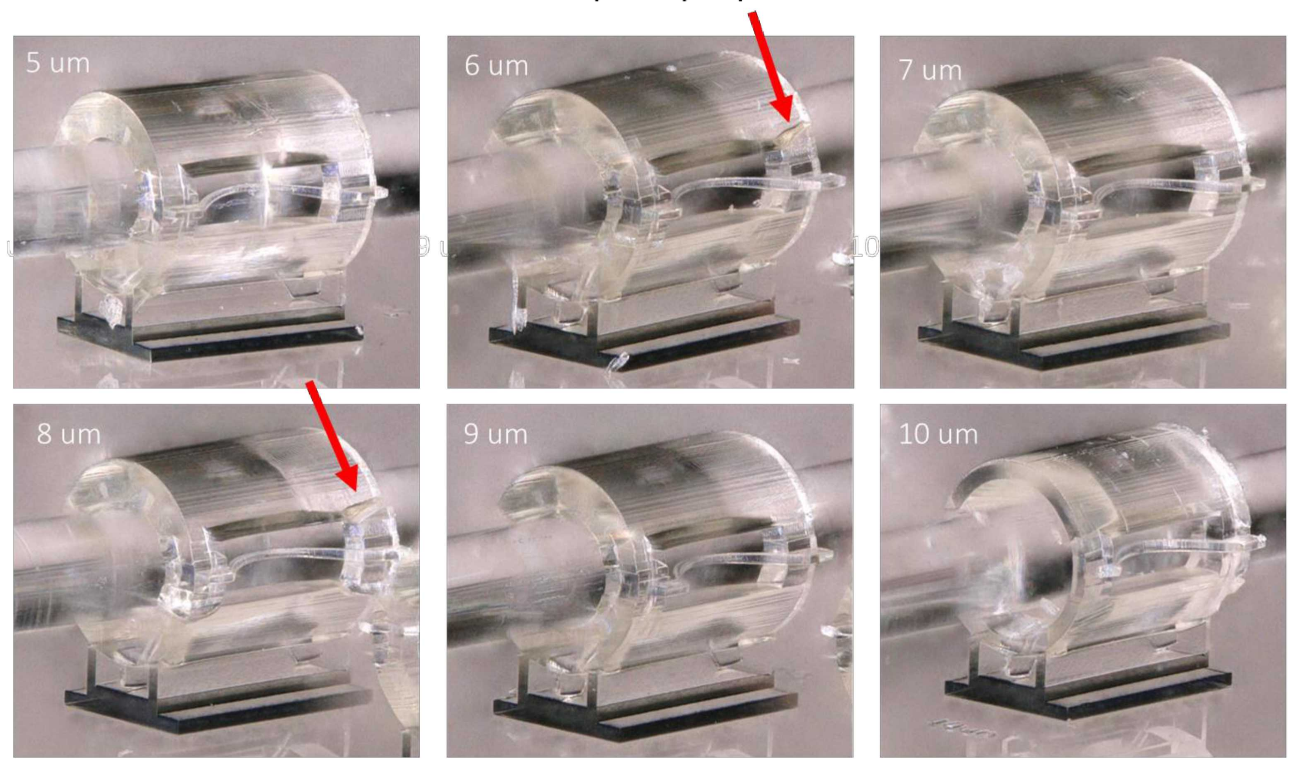
Assuming complete deflection of the clip, as all three variables increased in dimension, the amount of force the bow clip could withstand increased. The goal is to optimize the life of the bow clip under cyclic loading of the largest possible force.



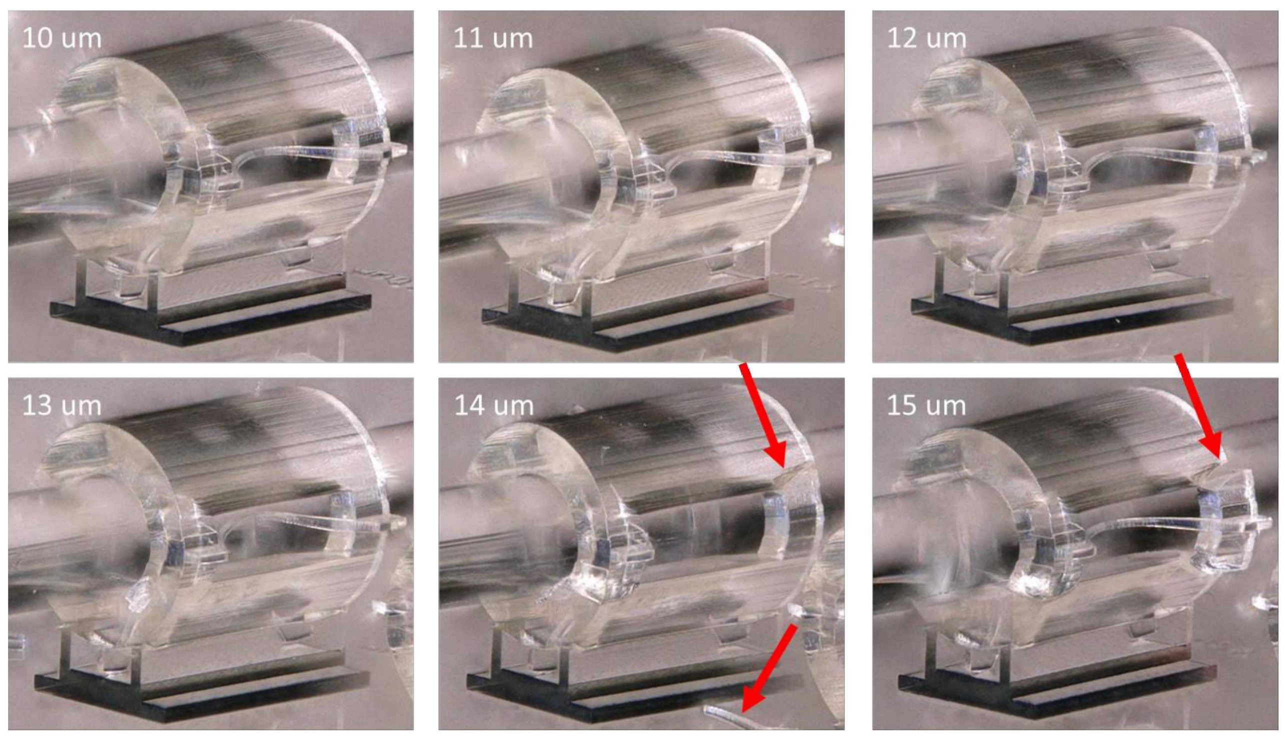
Varied Width
8-18 µm by 2 µm



Varied Thickness
5-10 µm by 1 µm



Varied Protrusion
10-15 µm by 1 µm



By adjusting these variables, observations concluded that widths of 12-18 µm, thicknesses of 9-10 µm and protrusions of 12-13 µm held the fiber in place and accurately positioned it without instability or damage.

Significance:

Unlike common cable connectors that use clips, (set) screws, mated-indentions and other mechanisms to hold a cable in place, little work has been done to examine mechanical connectors at such a small scale. This work offers a foundation to experimentally examine plug-socket type mechanisms that are orders of scale smaller and rapidly prototyped compared to ubiquitous device connections.

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