Light-driven nano-robotics for sub-diffraction probing and sensing

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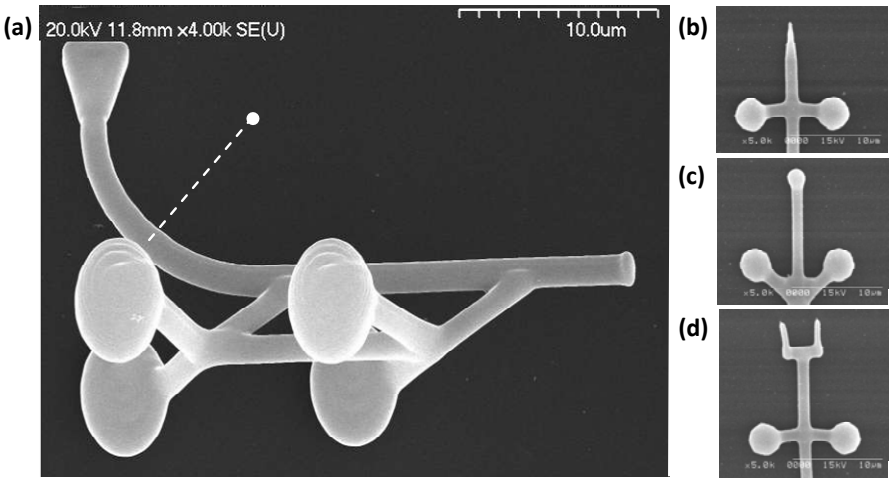
On the macro-scale robotics typically uses light for carrying information for machine vision for and feedback in artificially intelligent guidance systems and monitoring. Using the miniscule momentum of light shrinking robots down to the micro- and even nano-scale regime creates opportunities for exploiting optical forces and sensing in micro-robotic actuation and control. Advancing light-driven micro-robotics requires the optimization of optical forces and torques that, in turn, requires optimization of the underlying light-matter interaction. The requirement of having tightly focused beams in optical trapping exemplifies the need for optimal light-shaping in optical trapping and manipulation. On the other hand, the recent report on stable optical lift shows that optical manipulation can be achieved, even when using unshaped light, by using an appropriately shaped structure instead [1]. Therefore, a generic approach for optimizing light-matter interaction involves the combination of optimal light-shaping techniques with the use of optimized nano-featured shapes in light-driven micro-robotics structures.



In this work, we designed different three-dimensional micro-structures and fabricated them by two-photon polymerization. These micro-structures are subsequently handled using our proprietary BioPhotonics Workstation to demonstrate proof-of-principle experiments of 6 degree-of-freedom optical actuation of two-photon fabricated three-dimensional microstructures [2]. Furthermore, we exploit the light shaping capabilities available in the workstation to demonstrate a new strategy for controlling microstructures that goes beyond the typical refractive light deflections that are exploited in conventional optical trapping and manipulation. We also propose designing micro-structures for so-called structure-mediated access to the nanoscale.

[1] J. Glückstad, “Optical Manipulation: Sculpting the object”, Nature Photonics 5, 7-8 (2011).
[2] D. Palima, A. Bañas, G. Vizsnyiczai, L. Kelemen, P. Ormos and J. Glückstad, “Wave-guided Optical Waveguides”, Optics Express 20, 2004-2014 (2012).