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Published in:
nanoPT 2013

Publication date:
2013

Document Version
Publisher's PDF, also known as Version of record

Structure-mediated nanoscopy

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The science fiction inspired shrinking of macro-scale robotic manipulation and handling down to the micro- and nano-scale regime open new doors for exploiting the forces and torques of light for micro- and nanobiologic probing, actuation and control [1]. 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 tweezing systems exemplifies the need for optimal light-shaping in optical trapping, manipulation and sorting [2]. 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 [3]. Therefore, a generic approach for optimizing light-matter interaction would involve the combination of optimal light-sculpting techniques [4] with the use of optimized shapes in micro-robotics structures [5]. Micro-fabrication processes such as two-photon photo-polymerization offer three-dimensional resolutions for creating custom-designed monolithic microstructures that can be equipped with optical trapping handles for convenient mechanical control using only optical forces [6]. These microstructures can be effectively handled with simultaneous top- and side-view on our BioPhotonics Workstation to carry out proof-of-principle experiments illustrating the six-degree-of-freedom optical actuation of two-photon polymerised microstructures equipped with features easily entering the submicron-regime. Furthermore, we exploited the light shaping capabilities available on the BioPhotonics Workstation to demonstrate a new strategy for controlling microstructures that goes beyond the typical refractive light deflections that are utilized in conventional optical trapping and manipulation. We took this approach to extend the opto-mechanical light-force driven capabilities by including functionalised mechanisms to the fabricated monolithic structures. Aided by collaborators who fabricated test structures with built-in waveguides for us, we were able to put the idea of optically steerable freestanding waveguides – coined: wave-guided optical waveguides - to the test using our BioPhotonics Workstation [7]. We also proposed designing micro-structures for so-called structure-mediated access to the nanoscale and real-time sculpted light for the strongly emerging areas of neurophotonics and optogenetics.

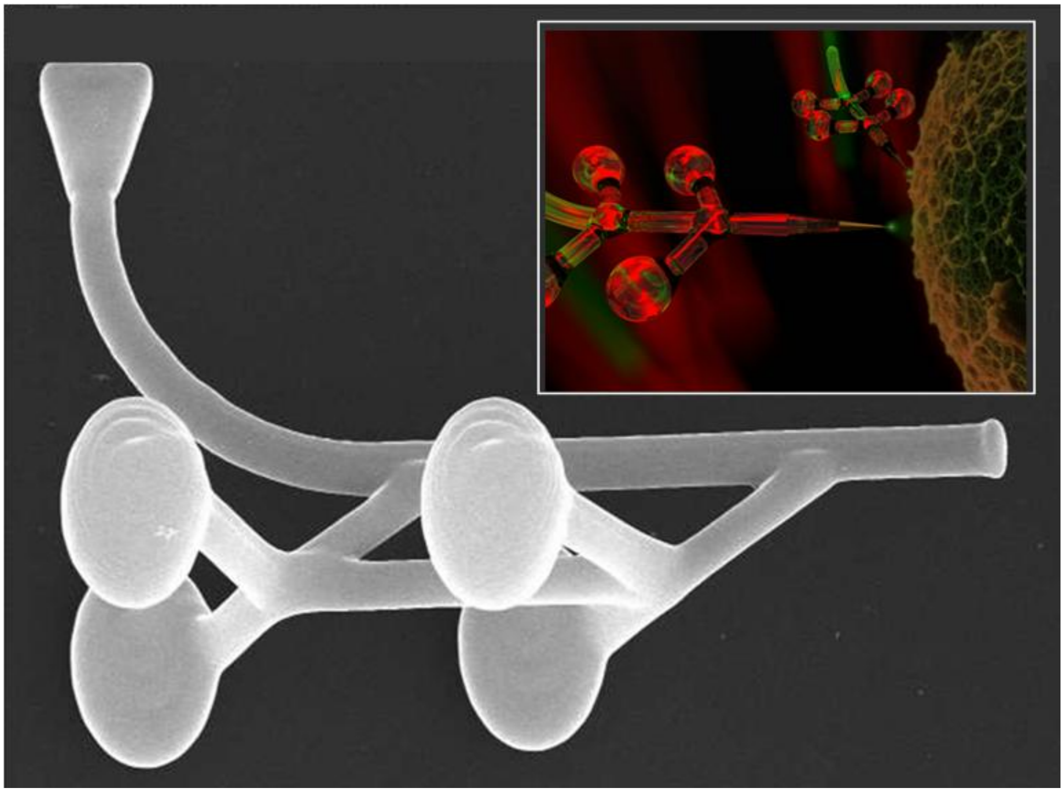

Figure: *Structure-mediating tool for nanoscopic probing, analysis and excitation. Adapted from reference [5].*

References

[1] P. Rodrigo, L. Kelemen, D. Palima, C. Alonzo, P. Ormos, and J. Glückstad, "Optical microassembly platform for constructing reconfigurable microenvironments for biomedical studies," *Optics Express* 17, 6578-6583 (2009).

[2] J. Glückstad, “Sorting particles with light,” *Nature Materials* 3, 9-10 (2004).

[3] J. Glückstad, “Optical manipulation: Sculpting the object,” *Nature Photonics* 5, 7-8 (2011).

[4] E. Papagiakoumou, F. Anselmi, A. Begue, V. de Sars, J. Glückstad, E. Isacoff, V. Emiliani, “Scanless two-photon excitation of channelrhodopsin-2,” *Nature Methods* 7, 848-854 (2010).

[5] D. Palima, A. R. Bañas, G. Vizsnyiczai, L. Kelemen, P. Ormos, and J. Glückstad, "Wave-guided optical waveguides," *Opt. Express* 20, 2004-2014 (2012).

[6] D. Palima and J. Glückstad, “Gearing up for optical microrobotic manipulation: mechanical actuation of synthetic microstructures by optical forces,” Laser & Photonics Reviews (upcoming) (2012).

[7] H. Ulriksen, J. Thøgersen, S. Keiding, I. Perch-Nielsen, J. Dam, D. Palima, H. Stapelfeldt, and J. Glückstad, "Independent trapping, manipulation and characterization by an all-optical biophotonics workstation," *J. Eur. Opt. Soc-Rapid* **3**, 08034 (2008).