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Structure-mediated nano-biophotonics

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The latest Nobel Prize in chemistry on Nanoscopy has cemented that optics is a key enabling technology for getting a grasp of the micro- and nano-world. By creatively combining a host of complementary approaches one can today realize advanced optical modalities that integrate an increasing number of functionalities and augment not just passive observation but also active access and control over the nanoworld.[1,2] Using a merger of light and matter sculpting, we have 2PP-fabricated free-floating waveguides that can be optically trapped and "remote-controlled" in a volume; hence coined Wave-guided Optical Waveguides (WOWs). Combining micro-fabrication with optical trapping and manipulation allows us to exploit these WOWs in versatile and dynamically reconfigurable architectures.[3] A plurality of counter-propagating beam-traps relayed to the trapping volume by low-NA microscope objectives on our Biophotonics Worskstation (BWS)[4] control the WOW-structures demonstrating the possibility for a structure-mediated paradigm where micron-sized tools are used to achieve optical near-field tip-size access. However, realizing the full potential of this new structure-mediated approach in challenging microscopic geometries requires a versatile 3D light coupling that can dynamically track a plurality of WOWs to ensure continuous optimal light coupling on the fly.

To maintain high light throughput for the WOWs, we have integrated computer generated holography that can dynamically control the 3D focus position of the coupling beams. Our results show that we can simultaneously maneuver the WOWs in 3D space while dynamically coupling light through them (see Fig. 1a and 1b).[5] This structure-mediated approach enables a host of new microscopic functionalities. WOWs with metal-coated tips can exploit plasmonic effects to achieve extreme confinement for localized light excitation and acquisition. Nanowires that exhibit particular optical properites can be attached to the WOWs to obtain tunable and fully maneuverable "nano-torches". Another potential application is for advanced Tip-Enhanced Raman Spectroscopy in a full 3D-manuevarable configuration. The micro-to-nano light coupling and the possibility of integrating material transport in the WOW-structures can be a new gate-way for life sciences at the sub-cellular level. The design possibilities offered by 2PP-fabricated WOWs, the augmented holographic light coupling combined with the advanced 3D micromanipulation opens the possibility for performing exciting precision engineered light-matter interaction where it is needed.

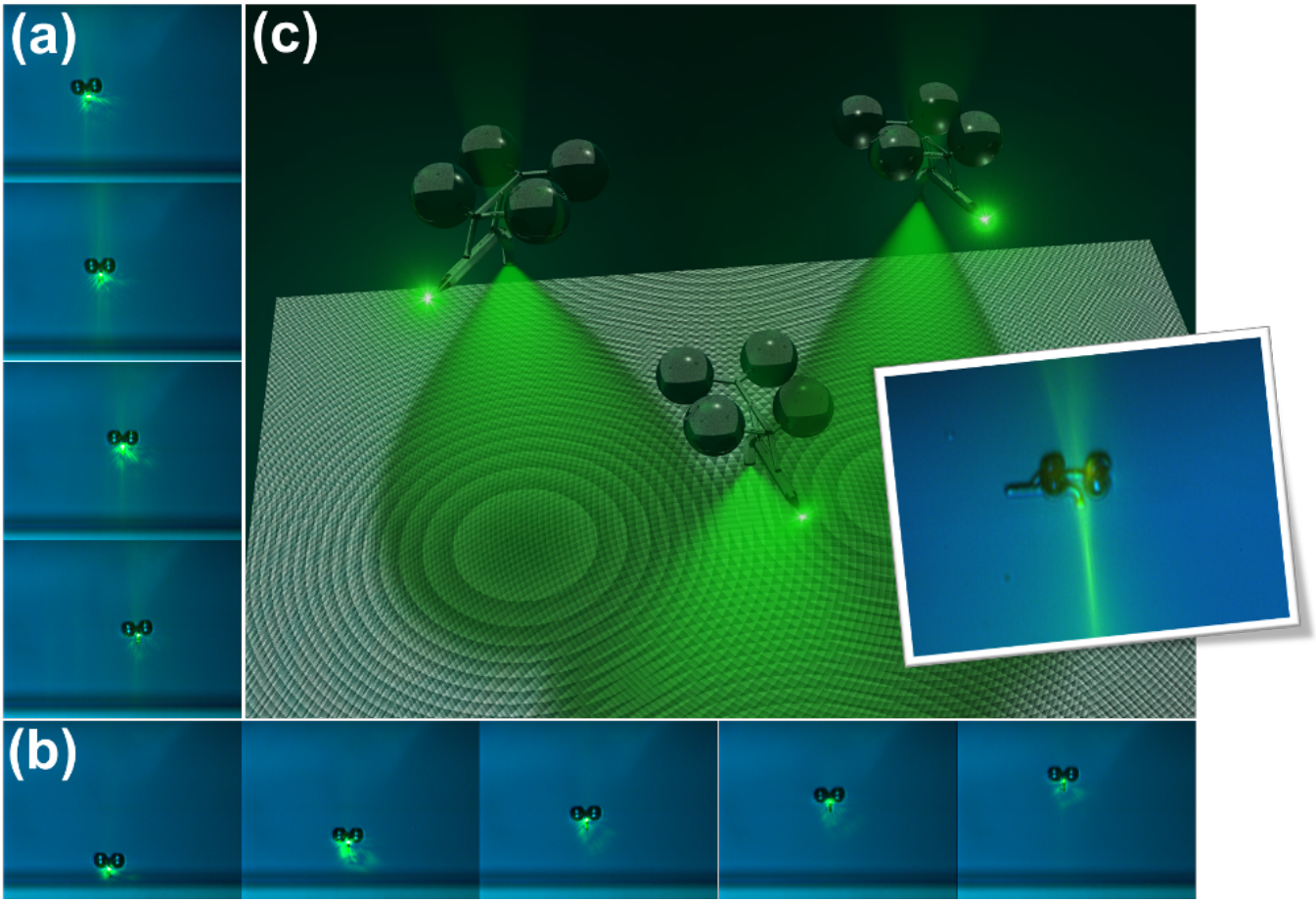

Fig 1. Dynamic coupling of light to 3D-manipulated Wave-guided Optical Waveguides (WOWs). The coupling beams are positioned holographically at the input facets of each WOW making targeted light-delivery at the sub-micron level possible at the WOW-tips. Experimental results show (a) lateral and (b) axial tracking of the coupling beams. (c) A concept art showing the holographically coupled WOWs and snapshot from the experiment.

References

1. D. Palima and J. Glückstad. Laser Photon. Rev. **7**, 478–494 (2013).

2. J. Glückstad. Nat. Photonics **5**, 7–8 (2011).

3. D. Palima et al. Opt. Express **20**, 2004–2014 (2012).

4. H.-U. Ulriksen et al. J. Eur. Opt. Soc. Rapid Publ. **3**, 08034 (2008).

5. M. Villangca et al. Opt. Express **22**, 17880–17889 (2014).