Technical University of Denmark

Mobile Waveguides: Freestanding Waveguides Steered by Light

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FIBER TECHNOLOGY

Mobile Waveguides: **Freestanding Waveguides Steered by Light**

Spatial light modulators enable us to create reconfigurable light distributions for the targeted delivery of optical energy and momentum. However, distribution possibilities are constrained by Maxwell's equations. Waveguides are needed for integrated optics and light delivery applications with challenging light paths and confinement—but most waveguide solutions tend to have static architectures.

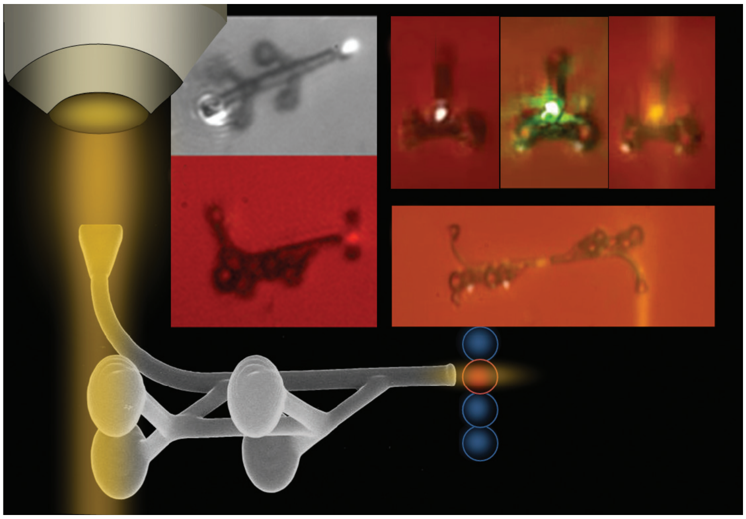
We have demonstrated reconfigurable micro-environments by optically manipulating microfabricated building blocks.[1] We advanced the idea of reconfigurable microstructures using optically steerable freestanding waveguides that can break away from static waveguide limitations.[2]

Microfabrication by two-photon polymerization offers 3-D resolutions for customized monolithic microstructures equipped with optical trapping handles for mechanical control.[3] We extended this capability by including functional structures in the fabricated structures.

We tested the idea of optically steerable freestanding waveguides using our BioPhotonics Workstation (BWS).[4] BWS uses real-time reconfigurable counter-propagating beam traps controlled by direct spatial mapping from an addressable light-shaping module. Axial manipulation is achieved by balancing the intensity ratios of the counter-propagating beams. A side-view microscope offers vision feedback for active trap stabilization.[5] By controlling multiple traps in 3-D, we have simultaneously and independently manipulated complex microstructures with six degrees of freedom.

Experiments show that we can couple in a low-NA beam through a high-NA bent waveguide that is steered by optical traps to position and orient its exit tip. Simulations show a much narrower exit beam, which can be tailored by the waveguide's tapering profile. We can position trapped micro-optics at the tip to modify the exit beam. The bidirectional waveguide can redirect light back to the limited NA of an observing microscope.

Combining microfabrication with optical trapping and micromanipulation allows us to exploit waveguides in versatile and dynamically reconfigurable architectures. This technique can help realize waveguide-based light delivery and/or light sensing in application geometries that would otherwise be challenging for static waveguides. OPN



Versatile light delivery through a freestanding waveguide manipulated by optical traps. The narrow beam exiting the tip selectively excites fluorescence on a microsphere within a vertical stack. (Left inset) Top- and side-view snapshots from actual experiment. (Right inset) Composite side-view microscope snapshots of tip emissions for different input wavelengths; right-most image shows fluorescence from surrounding medium. The schematic overlays graphics onto an actual SEM image of a two-photon polymerized structure.[2]

Visit **www.opnmagazine-digital.com** to view the video that accompanies this article.

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