Design and fabrication of optical micro-tools for bio-manipulation

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Sujet : Design and fabrication of optical micro-tools for bio-manipulation

Microrobots gives access to unreachable tiny scales allowing vast amount of in vivo or in vitro biological applications, ranging from minimally invasive intervention to exploration of fundamental biological phenomenon.

Among a variety of microrobotics techniques, Optical Tweezers are one of the most suitable for biological characterization and manipulation [1]. Using the radiation pressure of a tightly focused laser beam is possible to trap a micro-object in liquid solution [2]. Multiple traps can be controlled independently to move a plurality of microscopic objects simultaneously in volume. [3,4]

With recent advances if microfabrication using 2 photon polymerization techniques, it is possible to couple as the end-effector a complex micro-tool with definite function that be controlled by light. This kind of optical micro-tool will extend optical manipulation in fascinating new ways.

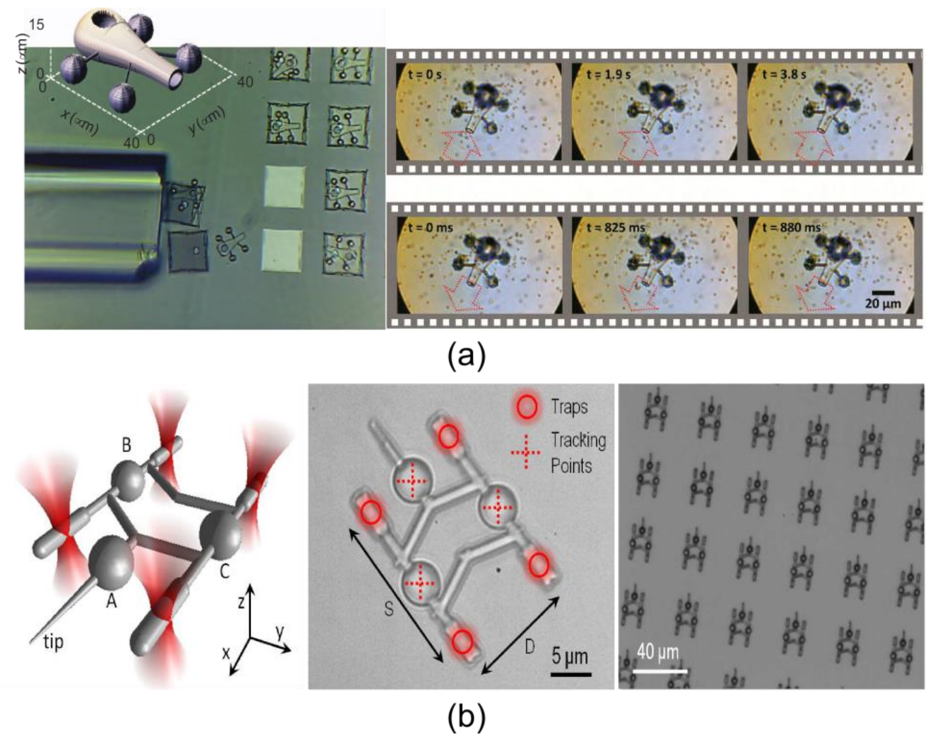

Figure 1: Examples of optical micro-tools. (a): Micro-tools for material transport via enhanced light-induced thermal convection. By changing the location of the beam in the metal layer, the micro-tool can be used to collect or eject the captured particles [6]. (b): Optical micro-tool design with four cylindrical trapping handles and three tracking points [8].

Using contemporary two-photon polymerization* we can directly 3D-print a plurality of optical robot's structures with high resolution and fidelity. Each Light Robotic structure is printed with convenient micron-sized spherical "handles" that allow for volumetric laser-manipulation with six-degrees-of-freedom (6-DOF). Pioneers optical-tool that have been designed include wave-guided optical waveguides [5], micro-robots for material transport that integrated metallic structures in the micro-structure [6] (see figure 1.a), and other mechanicals structures like optical screw-wrench for micro-assembly [7].

The objective is to design different types of micro-structures with optically trappable handles. It will provide 6 degrees of freedom ad its dimensions, weight and inertia should be adapted to the force range that can be supplied by optical traps. The shape design of the trapped structure need to be take in to account as they highly influence the optical trapping force and allows the possibility to optimize the maximize momentum transfer [8].

The printed models of functional tools will be coupled with our home-made optical tweezers set-up [9,10] and controlled by teleoperation via a haptic interface in a six DoF.

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*https://www.nanoscribe.de/en/