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Nanobiophotonics using Light Robotics

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Abstract
A confluence of developments is now ripe for the emergence of a new area within nanobiophotonics – *Light Robotics* – combining advances in microfabrication and optical micromanipulation together with intelligent control ideas from robotics and Fourier optics.

1. Introduction

Scientific disciplines constantly evolve and create new offspring or subdisciplines that combine the favorable characteristics from its forerunners. The merger of biology and photonics has within the last decade produced one such off-spring, Biophotonics, which harnesses light to study biological materials. More recently we have seen the exciting merger of biophotonics with contemporary nanophotonics into so-called NanoBiophotonics culminating with the recent Chemistry Nobel Prize for super-resolution microscopy. After years of working on light-driven trapping and manipulation [1-13], we can see that a confluence of developments is now ripe for the emergence of a new area that can contribute to nanobiophotonics – *Light Robotics* – which combines advances in microfabrication and optical micromanipulation together with intelligent control ideas from robotics, wavefront engineering and Fourier optics. In the Summer 2017 we published a 482 pages edited Elsevier book volume [14] covering the fundamental aspects needed for Light Robotics including optical trapping systems, microfabrication and microassembly as well as underlying theoretical principles and experimental illustrations for optimizing optical forces and torques for Light Robotics. The Elsevier volume is presenting various new functionalities that are enabled by these new designed light-driven micro-robots in addition to various nano-biophotonics applications demonstrating the unique use of biophysical tools based on light robotic concepts. We have endeavored to make this new discipline accessible to a broad audience from advanced undergraduates and graduate students to practioners and researchers not only in nanobiophotonics and micro- and nanotechnology but also to other areas in optics, mechanical engineering, control and instrumentation engineering and related fields.

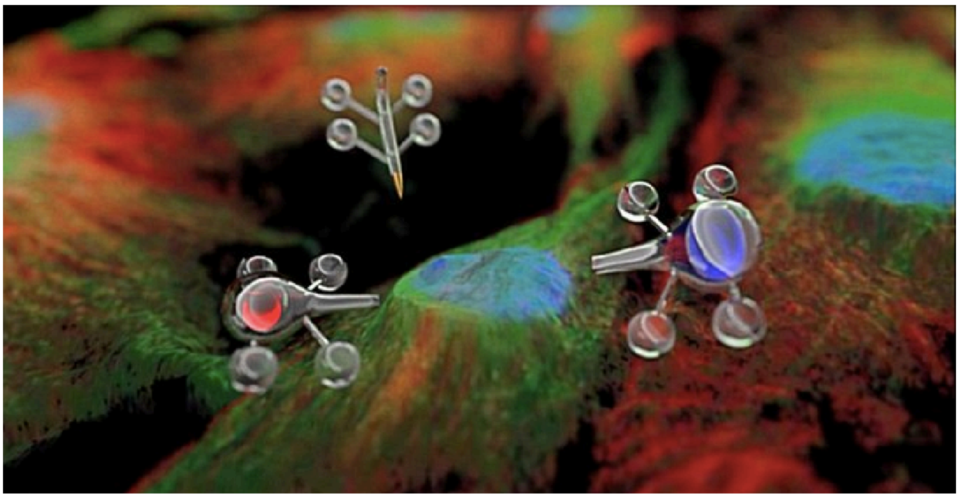

Figure 1 *Illustration of Light Robotics in a microbiologic environment.*

2. Light Robotics

Light robotics combines the aforementioned developments to achieve an all-optical toolbox in probing micro- and nano-environments, opening up new avenues of applications of structure-mediated control of tiny biological constituents. The dynamic optical trapping can be used for on-site assembly or disassembly of larger structures into component parts as well as their actuation to pre-determined sites. The optically manipulated and controlled fabricated structures can also be used to carry loads that can as well be functionalized to perform some specific and predefined tasks. Structure-mediated transport provides convenience over direct particle trapping without compromising how precise particles can be moved and positioned. In cell trapping or transport, for example, damage due to direct irradiation can be substantially minimized by loading the cell into a prefabricated platform that is illuminated and moved around instead. Not only does this lessen the negative impact of high-intense radiation, but it also adds the benefit of having 6 degrees-of-freedom control over the structure, hence on the specimen itself.

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