Optical Manipulation and its Applications

Jonas Enger
Atomfysik
Experimentell fysik
Göteborgs Universitet
Chalmers Tekniska Högskola

Abstract

With increasing possibilities for observing biological processes, the need is felt almost automatically to manipulate the object under study. In this thesis I describe how optical manipulation techniques, i.e. optical tweezers and laser scissors, in combination with advanced imaging techniques and lithographic methods, can be a powerful method for advanced studies in research both within biology and physics. The thesis reports on four different experiments.

First, I demonstrate how optical tweezers, laser scissors, confocal as well as epi-fluorescence microscopy can be combined with a microfluidic system to create a versatile microlaboratory. A pattern of channels and reservoirs was generated and lithographic methods were applied to create microchannels in rubber silicon. Bacteria were injected into and extracted from the platform using a mechanical micromanipulator. Cells were moved between different media in a few seconds by the optical tweezers. They were then stored in a reservoir, manipulated by the laser scissor and transported for subsequent experiments.

Second, I will present a study of *Escherichia coli* bacteria that fail to fuse the membrane during septum formation, and therefore tend to form chains. The analysis showed that the fluorescing molecule propidium iodide was unable to diffuse between adjacent cells in the chains. Thus, the cytoplasm of the cell compartments in the chains seems to be fully separated.

In the third example, it is shown how silver nanoparticles in a colloidal solution can be selected and manipulated using the optical tweezers. Single trapped particles are characterised by measuring their elastic light scattering spectra, which gives information on the localized surface plasmon resonances of the particles. A trapped particle with selected localized surface plasmon resonance characteristics can then be used as a mobile near-field optical probe.

Finally, an experiment where the angular momentum of circularly polarised light is transferred to particles resulting in a rotation, is presented. Absorbing CuO particles trapped in a focused doughnut shaped laser beam started to rotate as a result of the helical phase structure of the beam. By changing the polarisation of the light from plane to circular caused a change in the rotation frequency.

Keywords: optical tweezers, laser scissors, microfluidic system, lab-on-a-chip, lithography, nanoparticles, orbital angular momentum