Extending the possibilities of optical manipulation with microstructures of special shape

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In the basic form, optical tweezers are used to trap plastic beads of spherical shape. In this system, the location of the beads is determined but not the orientation. It would give additional control if the orientation, position of the grabbed particle could also be determined and controlled. There are several ways to achieve orientational control. It is an efficient possibility to use non spherical particles as test objects. The interaction of light with objects of special shape results in orientational effects upon the trapped particle. If the light has also additional anisotropic character, e.g. it is linearly or circularly polarized, even more complex manipulation schemes become possible.
We explore the possibilities of extended control of optical trapping by microsctructures of special shape. We use two photon exctitation induced photopolymerisation to produce objects with shapes of arbitrary complexity, with submicrometer resolution. I will show the procedures and examples of microsctructure building by photopolymerization as well as their application in optical manipulation.

I will introduce three basic approaches for the application of the test objects.

1. Complex shapes can be grabbed with several independently directed optical traps (generated e.g. by spatial light modulators (SLM)) acting on different parts of the structure. In this system total spatial control is achieved. With appropriately shaped structures optically actuated microtools are realized opening up new manipulation possibilities in biology.

2. If we generate a helical shape, light scattering will result in torque acting on the grabbed object, the object will rotate in the optical traps. Such rotors, propellers can utilize different components of the momentum of light. They can be applied to drive complex optomechanical systems. They can also be used to model and quantitatively characterize biological motions.

3. If the optical tweezers are formed by linearly polarized light, a flat object will be oriented in the trap. This effect can be used to order, orient particles. Torque can be measured and exerted by this system, giving a versatile tool for single particle manipulation. In addition, the torque exerted can be adjusted largely independently from the trapping force. We used this method to determine torsional properties of biopolymers like actin, dsDNA.