Optical Trapping on Waveguides

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Abstract

On the surface of an optical waveguide, there is an evanescent field. The evanescent field decays fast and this steep gradient can be used to pull nano- and microparticles down towards the waveguide surface. Radiation forces will propel the particle forward along the waveguide. Trapping on an optical waveguide can be used to manipulate particles in a lab-on-a-chip system where optical methods are also used to detect and characterize the particles. The particles are normally submerged in water (acting as top-cladding) and various types of particles can be trapped, e.g. gold nanoparticles [1], polystyrene microspheres [2, 3], nanorods [4], red blood cells [5, 6], etc. Several types of optical functions have been demonstrated, e.g. for sorting and steering particles [7], trapping in a gap [8], Raman-spectroscopy [9], etc.

Numerical simulations have been used to study the trapping process and to design new structures for trapping. In this presentation, the method to calculate optical forces will first be reviewed. Normally, optical forces are calculated directly from the Maxwell stress tensor. However, for low index contrast, it can be advantageous to first calculate the optical pressure (Fig. 1) and then integrate up the pressure to find the force. In the second part of the presentation, results will be shown for several types of particles and structures, e.g. microspheres, red blood cells, straight waveguide and a waveguide gap (Fig. 2). In addition to simulation of optical forces, it will be shown how the transmitted amplitude and phase of the light in the waveguide is influenced by the trapping of a particle. Some experimental results will be included.

Reference

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Figures used in the abstract

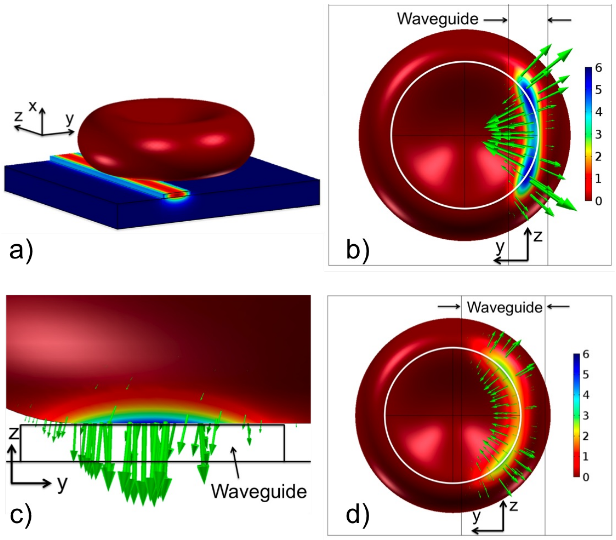

Figure 1: Optical pressure and force density on a red blood cell that is trapped on the surface of an optical waveguide. a) 3D-model. b) Narrow and d) wide waveguides. c) Cross-section of waveguide.

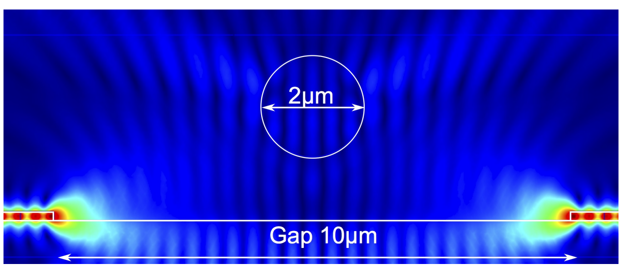

Figure 2: Field distribution (normE) in a 10 um gap between two waveguides, with a levitated polystyrene sphere.