Research Highlights

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Nanoscale optical traps

Optical tweezers are well-known and well-investigated tools to non-invasively trap and manipulate individual objects such as particles and cells. However, the strength of the trap is limited by the fact that focussing of light is diffraction limited. As a consequence, optical tweezers are best-suited to trap objects with a certain size and composition. To confine light to subwavelength volumes, near-field approaches have been developed, but these techniques have limitations concerning complexity and precision. Recently, a research team from Cornell University (Ithaca, NY) have presented an alternative solution.[1] As shown in Fig. 1, they used a one-dimensional photonic crystal resonator with a specific architecture. Coupling the resonator to a single mode waveguide results in an extremely small and strong field confinement and amplification within the cavities (see Fig. 1). In such cavities it is now possible to stably trap tiny particles with diameters ranging from 50 to 500 nm. Particles are transported towards the traps using flow. Once the particle is in close proximity to the cavity it experiences a tweezing force and is trapped. Variations of the optical field and/or the microflow particle movement can be induced and manipulated, which is demonstrated for 500 nm sized polystyrene particles. Besides experimental demonstrations, the trapping performance depending on particle position and size is characterized by numerical analysis. The authors state that this new optical trapping platform could, in future, enable single molecule manipulation and support the directed assembly of nanoscale materials.

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Microperfusion of brain slices

Investigation of tissue slices can reveal morphological, physiological and pharmacological properties of the tissue. In contrast to imaging methods in live animals, the use of tissue slices allows high resolution imaging using confocal microscopy, and thus enables visualization of processes and events with subcellular resolution. One crucial requirement is the preservation of the viability of the tissue, preferably over a long period of time. In a study published in the current *Lab on a Chip* issue, David Juncker and co-workers from McGill University in Quebec (Canada) introduce a microfluidic perfusion to study organotypic brain slices.[2] The setup comprises a perfusion chamber that allows mounting and cultivation of brain slices for several hours. Importantly, the design of the chamber is suitable for confocal imaging on an inverted microscope and compatible with objectives with high numerical aperture (and short working distance). Furthermore, a microfluidic probe made entirely in PDMS with several injection/aspiration apertures is used for local perfusion of the slices. The researchers describe fabrication and assembly of the device, and characterise the performance. Hippocampal brain slices from mice were successfully imaged with high resolution and the perfusion of a fluorescent dextran was demonstrated. Hence, the device has the great potential to facilitate studies of processes in brain such as neuron interactions, at the same time multiple chemicals and drugs can be delivered, or neurons can be locally transfected by viruses.

Biosensor array for label-free molecular detection

High throughput measurements of molecular binding reactions are required in many fields such as genomics, proteomics and drug screening. A versatile sensing device for these applications must be capable of analyzing different reactions with high sensitivity, which can be realized in an array of sensing elements. In a recent publication, a research team from the National Research Council Canada in Ottawa has described such a biosensor array, that is integrated with a microfluidic chip for sample delivery.[3] Each sensor element is a spiral waveguide, folded within a 130 μm diameter spot. The silicon waveguides with a width of 0.45 μm were

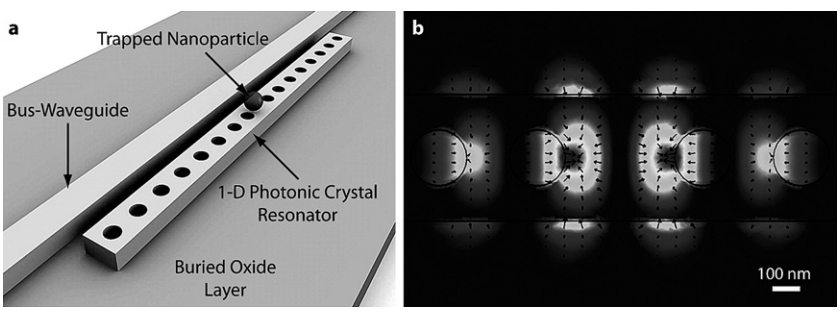

Fig. 1 (a) Illustration of the photonic crystal resonator for trapping of nanoparticles with diameters between 50 and 500 nm. High optical forces can be achieved by confining light into subwavelength volumes, defined by the one-dimensional silicon photonic crystals. (b) Three-dimensional simulation of the field confinement. The black arrows indicate the direction and magnitude of the optical forces. (Reprinted with permission from ref. 1. Copyright American Chemical Society 2009.)

defined using electron beam lithography and reactive ion etching on a silicon-on-insulator (SOI) wafer with a 0.25 μm thick silicon layer and a 2 μm buried oxide. The spiral geometry provides a compact geometry, yet offers the high sensitivity of a long linear waveguide. The sensors are incorporated in a so-called Mach–Zehnder interferometer, *i.e.* in a configuration that enables label-free sensing of binding events at the surface. One important aspect of the sensor design is its compatibility with automated commercial spotting tools to deposit receptor molecules on individual sensor elements. The performance of the sensor array is demonstrated by monitoring an antibody–antigen reaction using complementary and mismatched immunoglobulin G receptor–analyte pairs and bovine serum albumin (BSA). For the measurements, laser light (wavelength: 1560 nm, about 100 nW) is delivered through an optical fiber to the sensor array, and the signal (*i.e.*, the phase shift) is detected by means of a InGaAs camera that is sensitive in the near infrared wavelength regime. The signal of each sensor is monitored in real-time and indeed, the expected response could be detected for complementary receptor analyte pairs.

References

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