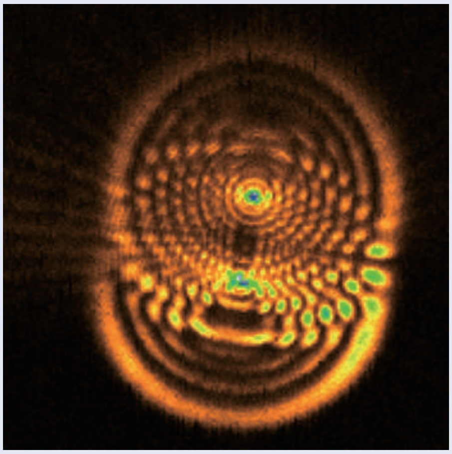
IMAGING

Second-harmonic nanoprobes

Inorganic non-centrosymmetric nanocrystals — subwavelength structures capable of supporting the second-harmonic generation of light — are receiving growing attention as useful imaging probes for bioimaging or applications in nonlinear optics and micromanipulation. They can be excited at any wavelength — unlike fluorescent molecules or quantum dots — and do not suffer from blinking or bleaching.



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Scientists in Germany have now dispersed nanocrystals of potassium titanyl phosphate (KTP, a common nonlinear optical material) over a planar optical waveguide and shown that the evanescent field from a guided mode in the waveguide can generate second-harmonic light (*Opt. Express* **18,** 23218–23225; 2010). Furthermore, generation of the second harmonic was shown to be coherent with the signals from adjacent nanoparticles, thereby forming interference patterns (see image). The discovery of a convenient and practical means of exciting such nanocrystals without the need for direct scanning illumination suggests that they may become useful for probing biological samples deposited on a planar optical chip.

The research was carried out by Ronja Bäumner and co-workers from Laser Laboratorium Göttingen, the University of Geneva and Georg August University. They first fabricated a 159-nm-thick planar waveguide of Ta$_2$O$_5$ on a 0.7-mm-thick glass substrate. Pulses from a frequency-doubled erbium-doped fibre laser (central wavelength of 780 nm and pulse duration of 150 fs) incident on the waveguide were coupled to a guided mode using a grating coupler. KTP nanoparticles with an average size of 185 nm were dispersed on the waveguide surface a few millimetres from the grating coupler. Light emitted from the nanoparticles was collected by an objective lens, passed through a polarizer plate and then detected by a CCD camera.

NORIAKI HORIUCHI

OPTICAL MANIPULATION

Sculpting the object

Using intricately sculpted light fields to control tiny objects is a well-understood and important technique. Now, the concept of sculpting the object rather than the light field promises to propel light–matter research in an exciting new direction.

Jesper Glückstad

Arthur Ashkin first used light to manipulate dielectric microparticles over 40 years ago[1]. Since this pioneering work, scientists have been using the radiation pressure of light to move and manipulate small objects in space. Although initially a single focused laser beam was used to control individual particles one at a time, recent developments in the generation of more complex and spatially sculpted light fields have opened up exciting new prospects in the field of optical manipulation[2,3]. Moreover, the ability to sculpt such light fields using intricately and dynamically controlled spatial and temporal light modulation schemes allows us to revolutionize the way we engineer interactions in the microscopic world[4].

Until today, however, only a few studies have looked at this intriguing light–matter interaction from the other side of the table — sculpting the object itself instead of the light field. Reporting in *Nature Photonics*, Grover Swartzlander and co-workers address this less-visited area by describing how an asymmetric airfoil-shaped refractive object placed in a uniform stream of light experiences a transverse lift force[5], in an optical analogue to the Bernoulli principle of hydrodynamic lift. This seems to be a simple, general and surprisingly new avenue of research into optical micromanipulation that involves shaping the object, rather than the light.

The basic principle of traditional optical manipulation is relatively well-described for objects either much smaller or much larger than the wavelength of light used. When trapping small objects, in what is known as the Rayleigh regime, an electric dipole moment develops in response to the electric field of the light. Larger objects, which can be considered in the Mie regime, act like a ball lens by refracting the light and thus redirecting the photon momentum. In the Mie regime, both the magnitude and the direction of the light forces depend on the particle shape, and optical trapping is generally possible for objects with some sort of spherical symmetry. The conservation of momentum by ray optics is considered applicable in this regime; any changes in momentum occurring when individual rays of light strike the object result in a recoil effect, with an equal and opposite momentum