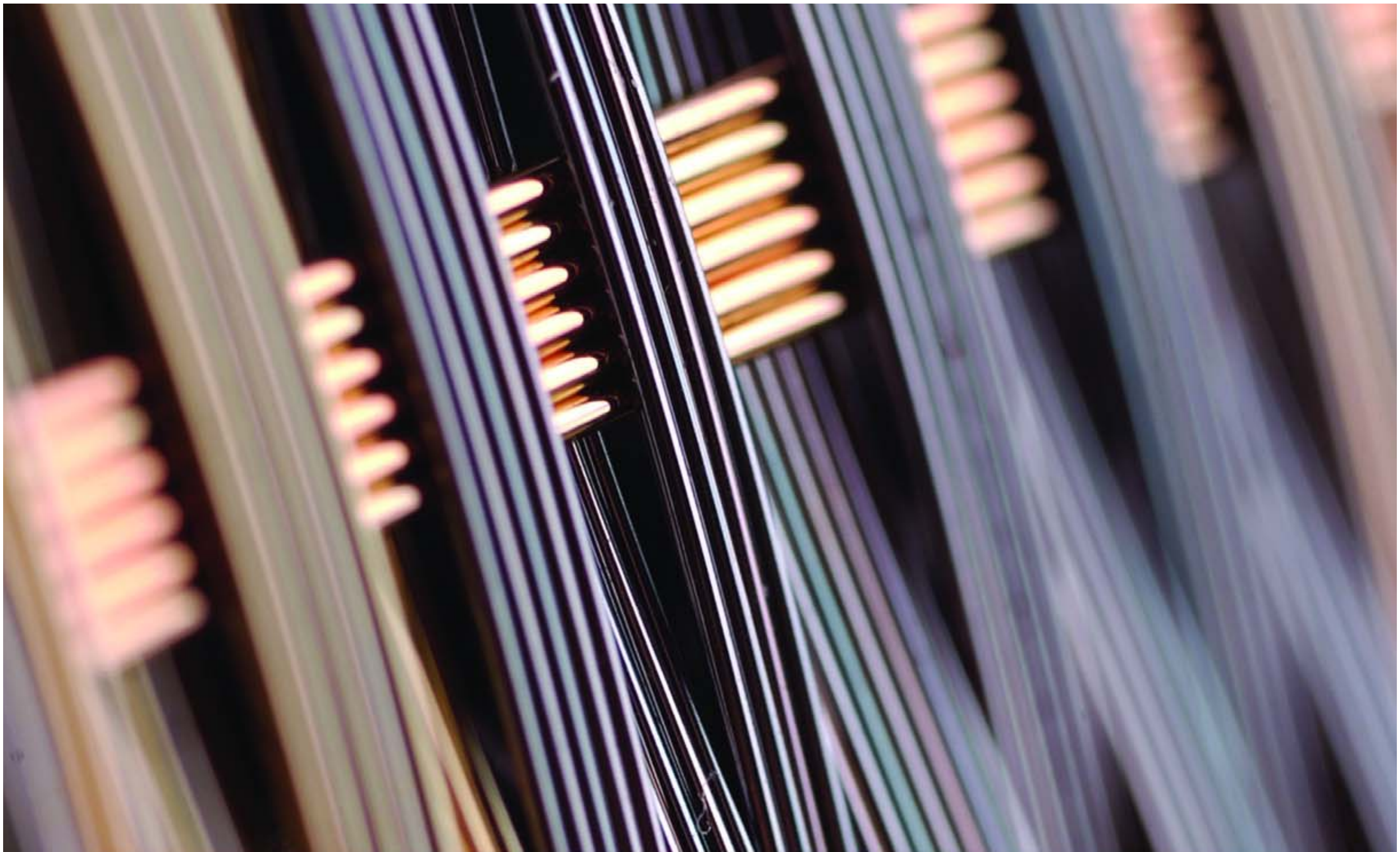

Optics in 2004

Guest Editors: Bob D. Guenther
David Hardwick, Changsheng Li and R. John Koshel

The December *Optics & Photonics News* (OPN) is a special issue that highlights the most exciting research to emerge in the preceding 12 months in the fast-paced world of optics.

"Optics in 2004" offers readers a unique opportunity to access, in a single source, descriptions of cutting-edge optics research reported in the peer-reviewed press. The areas covered in this year's special issue range from semiconductor optics to nanophotonics and from optical engineering to ultrafast technology. This year's issue comprises 31 summaries that represent the work of 155 authors.

A record number of research groups submitted summaries to "Optics in 2004": there were 104 submissions this year, representing the work of 414 authors. This was a significant increase over the total of 61 submissions to "Optics in 2003."

This year as in previous ones, submissions were judged on the basis of the following requirements:

- the accomplishments described had to have been published in a refereed journal in the year prior to publication in OPN;
- the work had to be illustrated in a clear, concise manner, readily accessible to the at-large optics community.

In addition, the authors were asked to describe the topical area as a whole and to detail the importance of their work in that context.

Although OPN makes every effort to ensure that achievements in all optics subfields are recognized, there are no requirements in the selection process for inclusion of specific topical areas. When a large number of submissions is received for a specific area, it is taken as evidence that the topic has been fertile ground for activity and research. OPN strives to ensure that engineering, science and technology are all represented. The number of papers accepted overall is limited by space.

OPN and OSA would like to thank the hundreds of researchers from around the world who submitted summaries of their peer-reviewed articles to "Optics in 2004."

OSA and the OPN staff would like to take this opportunity to express their heartfelt thanks to the panel of OPN Editorial Advisory Committee members who vetted submissions to "Optics in 2004": Bob D. Guenther (Optics in 2004 Panel Chair), Physics Department, Duke University; David Hardwick, Confluent Photonics Corporation; Changsheng Li, Hong Kong Polytechnic University; R. John Koshel, General Dynamics C4 Systems.

(*Background image*) Each fiber in the spectrometric fabric is a photodetector sensitive to external illumination at a particular wavelength range. Credit: Greg Hren Photography-RLE/Fink Lab, Massachusetts Institute of Technology. [From Nature **431**, 826-9, Oct. 2004.]

Optical Manipulation of High- and Low-Index Particles and Living Cells

Peter John Rodrigo, Vincent Ricardo Daria and Jesper Glückstad

For several years researchers have relied on optical forces to trap and manipulate microscopic objects. An optical trap serves as a tool for grabbing and moving a microscopic object in a noninvasive manner. A key reason that optical means are favored for particle manipulation is the fact that light can be fashioned into multiple trapping beams for parallel handling of a plurality of particles. Such parallel trapping functionality has the potential to revolutionize experimental approaches on a microscopic scale in biology, chemistry, colloidal science and fluidics.

We recently reported advanced optical trapping with a method that equips the user with multiple dynamic beams to trap simultaneously and to manipulate independently microscopic materials the indices of refraction of which can be either higher or lower than that of the suspending medium.[1,2] This allows researchers to work simultaneously with materials of varied specifications, such as solid particles and air bubbles.

In Figs. 1(a)–1(c) we show simultaneous optical trapping and real-time interactive manipulation of a particle mixture of three polystyrene microbeads and three hollow glass microspheres in water (refractive index $n = 1.33$). High-index (polystyrene spheres $n = 1.57$) and low-index (hollow glass spheres $n \sim 1.2$) particles are trapped in the transverse plane by an array of confining optical potentials created by beams with top-hat and annular cross-sectional intensity profiles, respectively. By applying the so-called generalized phase contrast (GPC) method,[3,4] a wide variety of scalable intensity profiles can be created. The GPC method maps dynamic spatial light modulator patterns in a way that requires virtually no computational power and allows for arbitrarily profiled trapping beams.

Aside from the ability to synthesize arbitrary trapping profiles, which provides independent transverse particle-position control, we have extended the system to enable simultaneous position control along the depth dimension.[5] To achieve this, first we transform the linearly polarized GPC-generated intensity pattern into an arbitrary elliptic polarization state by using a transmitting liquid-crystal device, which acts as a variable wave plate. Then the generally elliptically polarized intensity pattern is passed through a polarizing beam splitter to form two linearly polarized (orthogonal polarization) images of the intensity pattern. By optically relaying the two intensity images to the sample plane and having them transversely superimposed, an array of counterpropagating beam traps is formed. Figures 1(d)–1(f) show the control of the axial positions of simultaneously trapped yeast cells in five pairs of counterpropagating beams. One can achieve axial position control by simply adjusting the relative strengths of the opposing beams, which is done losslessly by this polarization-encoding scheme. The flexibility of our approach also allows cells to be manipulated even within high-index liquid media. This is important for cell studies that involve various types of microbial solution other than a host medium that is composed mainly of water.

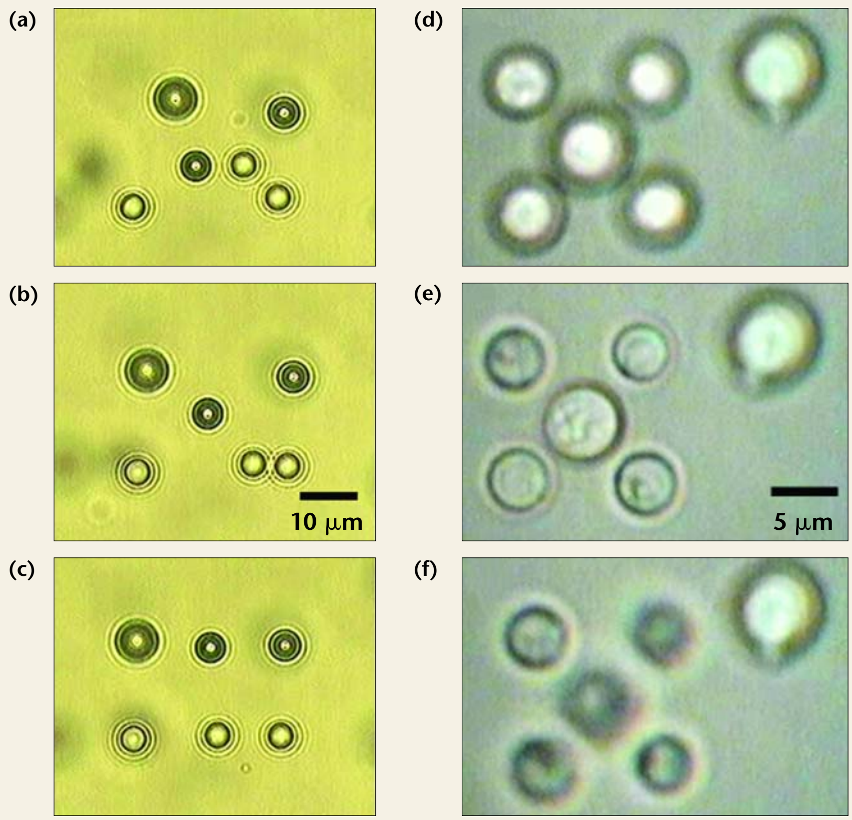

Figure 1. Optical manipulation of high- and low- index particles and viable yeast cells, *S. cerevisiae*. The system is based on the GPC method for high-light-throughput synthesis of arbitrary intensity patterns that form multiple optical traps for dynamic and real-time manipulation of fluidborne microscopic objects.

We believe that the GPC-based optical micromanipulation system could pave the way for numerous applications in the fields of biotechnologies, materials and microtechnologies, including many technical applications that have been unrealizable until now.

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