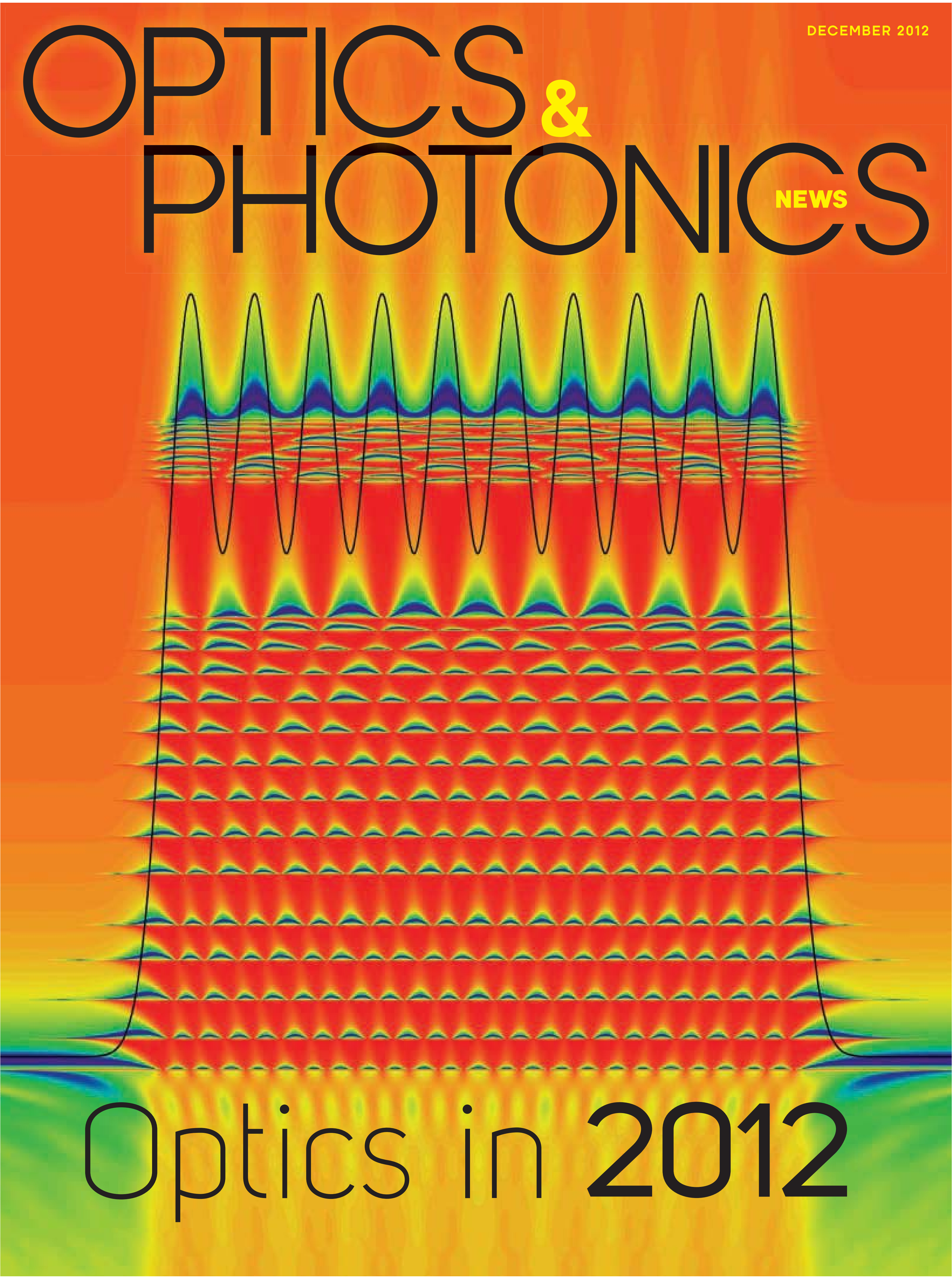

OPTICS & PHOTONICS NEWS
DECEMBER 2012
Optics in 2012

Optics in 2012

Panel chair: **Robert D. Guenther**, Duke University, U.S.A.

Guest editors: **Alex Fong**, Gooch and Housego, U.S.A.; **Yannick Lize**, AppliedMicro, U.S.A.; **James McGuire**, NASA, U.S.A.; **Alessandro Restelli**, NIST, U.S.A., **Yanina Shevchenko**, Carleton University, Canada; **Elena Silaeva**, Rouen University, France

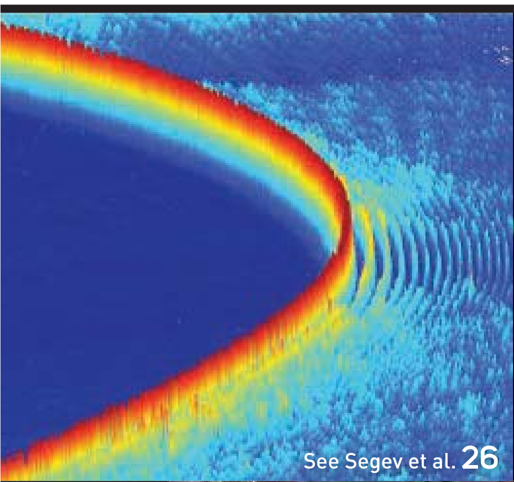
This special issue of *Optics & Photonics News* highlights the most exciting peer-reviewed optics research to have emerged over the past 12 months. Our panel of editors reviewed close to 80 submitted summaries from scientists all over the globe. They selected for publication the 30 stories that they felt most clearly communicated breakthroughs of interest to the optics community. Eleven of those have multimedia components that you can access at www.opnmagazine-digital.com/opn/201212 or through our main web site, at www.osa-opn.org. Thanks to all who submitted summaries as well as to our panel of guest editors.

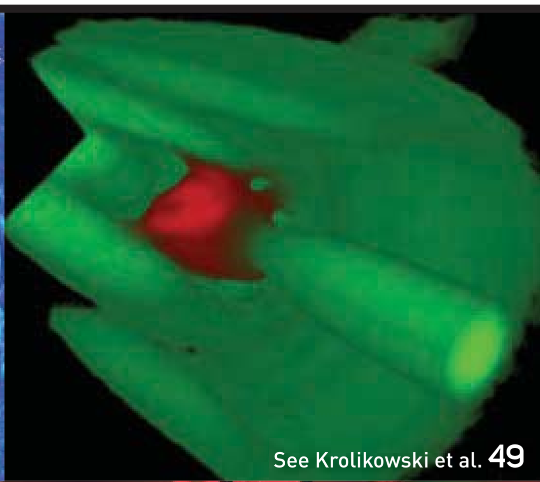
Online Extra: Visit www.osa-opn.org to watch a video highlighting the "best of the best" of our Optics in 2012 research findings.

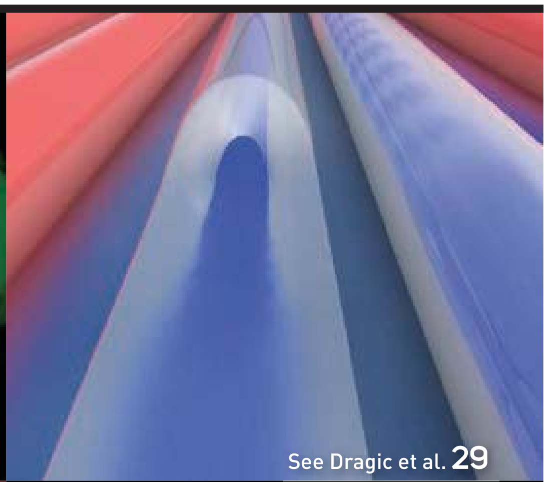
Artist's interpretation of photophoretic light cages. (See Alpmann et al., p. 48.)

SPECIAL ISSUE OPTICS IN 2012

VOLUME 23 NUMBER 12


See Segev et al. 26


See Krolikowski et al. 49


See Dragic et al. 29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FIBER TECHNOLOGY

Mobile Waveguides: **Freestanding Waveguides Steered by Light**

Spatial light modulators enable us to create reconfigurable light distributions for the targeted delivery of optical energy and momentum. However, distribution possibilities are constrained by Maxwell's equations. Waveguides are needed for integrated optics and light delivery applications with challenging light paths and confinement—but most waveguide solutions tend to have static architectures.

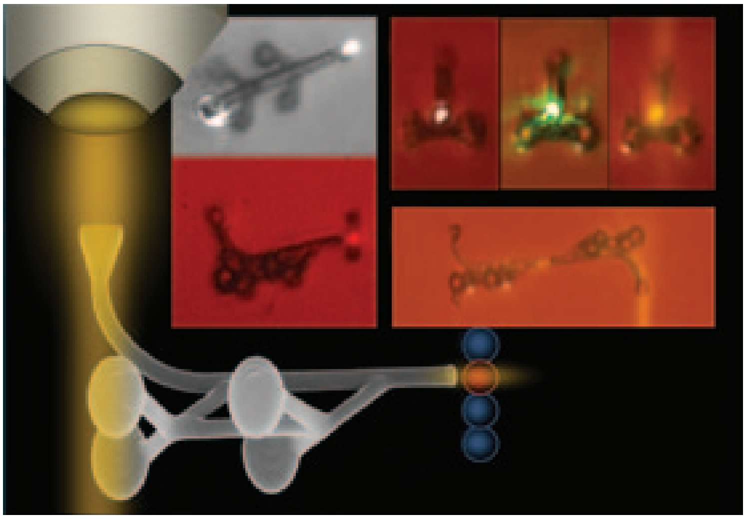
We have demonstrated reconfigurable micro-environments by optically manipulating microfabricated building blocks.[1] We advanced the idea of reconfigurable microstructures using optically steerable freestanding waveguides that can break away from static waveguide limitations.[2]

Microfabrication by two-photon polymerization offers 3-D resolutions for customized monolithic microstructures equipped with optical trapping handles for mechanical control.[3] We extended this capability by including functional structures in the fabricated structures.

We tested the idea of optically steerable freestanding waveguides using our BioPhotonics Workstation (BWS).[4] BWS uses real-time reconfigurable counter-propagating beam traps controlled by direct spatial mapping from an addressable light-shaping module. Axial manipulation is achieved by balancing the intensity ratios of the counter-propagating beams. A side-view microscope offers vision feedback for active trap stabilization.[5] By controlling multiple traps in 3-D, we have simultaneously and independently manipulated complex microstructures with six degrees of freedom.

Experiments show that we can couple in a low-NA beam through a high-NA bent waveguide that is steered by optical traps to position and orient its exit tip. Simulations show a much narrower exit beam, which can be tailored by the waveguide's tapering profile. We can position trapped micro-optics at the tip to modify the exit beam. The bidirectional waveguide can redirect light back to the limited NA of an observing microscope.

Combining microfabrication with optical trapping and micromanipulation allows us to exploit waveguides in versatile and dynamically reconfigurable architectures. This technique can help realize waveguide-based light delivery and/or light sensing in application geometries that would otherwise be challenging for static waveguides. OPN



Versatile light delivery through a freestanding waveguide manipulated by optical traps. The narrow beam exiting the tip selectively excites fluorescence on a microsphere within a vertical stack. (Left inset) Top- and side-view snapshots from actual experiment. (Right inset) Composite side-view microscope snapshots of tip emissions for different input wavelengths; right-most image shows fluorescence from surrounding medium. The schematic overlays graphics onto an actual SEM image of a two-photon polymerized structure.[2]

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PHASE CONTROL

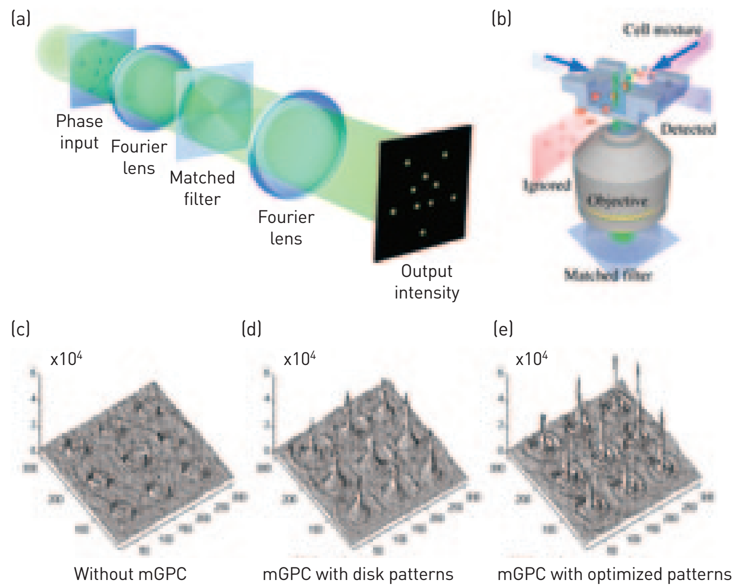
Robust and Low-Cost **Light Shaping**

Phase-only spatial light modulation is used to shape light in microscopy, micromanipulation, microfabrication and biophotonics. One application of phase modulation is the creation of dynamic optical traps for directly controlling the motion of microscopic particles by using programmable spatial light modulators (SLMs).[1,2] Similarly, light can be phase-sculpted to match and target biological material or trigger localized biochemical reactions.[3] Despite its versatility, phase-only spatial light modulation requires pricey SLMs, which limit its use in photonics research. However, consumer projectors are much more affordable. Researchers have started to explore using projectors based on liquid-crystal-on-silicon (LCoS) as binary-only phase modulators by replacing the incoherent light source with a laser of appropriate polarization.

Using two modified pocket pico-projectors, we have demonstrated beam shaping based on matched filtering generalized phase contrast (mGPC).[4] One projector is encoded with dynamic correlation target phase patterns that are directly mapped into intensity spikes. The other projector acts as a tunable matched filter combining GPC and phase-only correlation.

Although these modified projectors can be operated as binary holograms, mGPC offers advantages similar to GPC. Because mGPC is based on a 4*f* geometry, it does not have a strong undiffracted zero-order light that would disturb the sample plane or waste optical energy. The fast encoding into the LCoS by copying and translating a basis correlation target pattern enables real-time reconfigurability of multiple intensity spots without the need of high-end resources. Such simplicity also prevents the formation of ghost orders, speckles and spurious phase variations. Therefore, mGPC-generated light propagates in a well-defined manner and is useful for axially extended applications like active optical sorting or counter-propagating traps.[2,5] Since mGPC borrows features of phase-only optical correlation, the generated output spikes are significantly stronger than the background noise caused by surface imperfections in consumer LCoS devices.

Because many research applications require a specific fixed beam size (e.g., manipulation of microscopic tools or cells, programmable microscopy or microfabrication), a fixed fabricated matched filter can be used to increase overall light efficiency. Replacing the second projector would also make the beam-shaping system more compact. The correlation pattern and filter can be optimized to increase the space bandwidth, thus producing narrower, more intense output spikes.[4] OPN



(a) An mGPC is used to generate intense light for particle sorting. (b) Intensity profiles are generated using two LCoS pico-projectors as binary phase input and matched phase filter: (c) without the filter, (d) using phase disks as the input phase pattern and (e) using an optimized binary input phase and matched filter.

Visit www.opnmagazine-digital.com to view the video that accompanies this article.

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