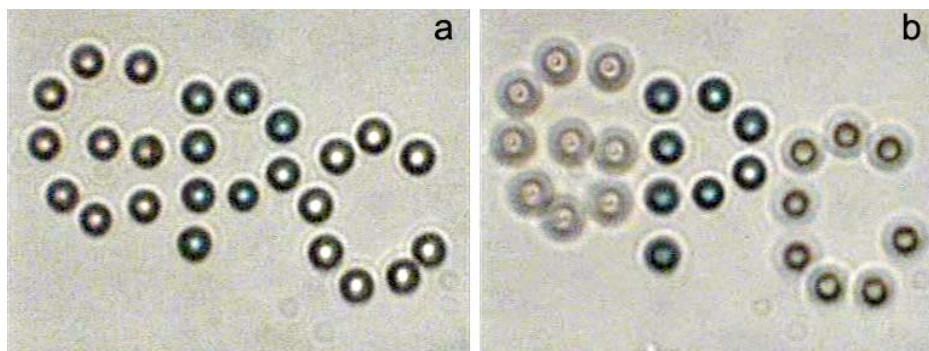


# Real-time 3D microscopic manipulation and simultaneous observation of a plurality of particles

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The Generalized Phase Contrast (GPC) method enables conversion of spatial phase-only modulation to highly photon efficient light distributions using a non-holographic approach. GPC can be applied in a number of applications requiring parallel light-beam encoding such as in advanced user-controlled optical micro-manipulation, wavefront sensing and generation, adaptive optics, optical phase-only encryption and for integrated micro-optical implementations. In this presentation, we outline the concept for a complete GPC-platform for advanced and user-interactive manipulation of fluid-borne colloidal structures with state-of-the-art controllability and versatility in time and space. Real-time reconfigurable light patterns in 3D-space with sub-micron accuracy are obtained from a direct map of phase patterns addressed on programmable phase-only spatial light modulator devices. A graphical user-interface enables real-time, interactive and arbitrary control over the dynamics and geometry of synthesized light patterns. Experimental demonstrations have shown that GPC-driven micro-manipulation can be used for fully user-guided assembly of particles in a plane, control of particle stacking along the beam axis, manipulation of multiple hollow beads, real-time sorting of inhomogeneous mixtures of micro-particles and the organization of living cells into colloidal structures.



**Fig. 1.** User-coordinated patterning of commercially dried polystyrene micro-spheres in (a) 2D and (b) 3D.

These experiments illustrate that GPC-driven micro-manipulation can be utilized not only for the improved synthesis of functional microstructures but also for their non-contact and parallel actuation crucial for sophisticated micro-fluidic based lab-on-a-chip demonstrations.

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