Colloidal optical waveguides with integrated local light sources built by Capillary Force Assembly

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Dielectric microspheres are key nanophotonic building blocks thanks to their excellent coupling and optical confinement (high Q-factor) properties that make them good candidates both to guide light[1,2] at the wavelength scale and to perform strong local light emission[3] (i.e. dye doped microspheres).

In this work, we demonstrate the interests of the Capillary Force Assembly (CFA) technique to build a wide variety of coupled-resonator optical waveguides (CROWs) with a fast, five-step and low-cost fabrication process. Indeed, among the large amount of technologies that are available to build these objects[1,2], a recently developed convective assisted CFA technique[4] was chosen in order to perform the large-scale assembly of waveguides with integrated local sources.

The fabrication of the waveguides consisted in creating a Polydimethylsiloxane (PDMS) patterned sample from a silicon mold (fig. 1a). The sample is a posteriori used as assembly surface in the CFA step. A colloidal suspension mixing a ratio of plain and fluorescent 1 µm polystyrene (PS) microspheres, is employed for the assembly step. Thanks to a precise control of the solvent evaporation, 5 mm-long waveguides with variable widths and key functions such as bottlenecks or forks are obtained (fig. 2).

A first optical characterization of short CROWs was next performed using a microspectroscopy set-up. The device collects the scattered or emitted light at the surface of the sample in a 1 µm circular area. The fluorescence illumination mode was chosen to collect only the light coming from the fluorescent beads and scattered into each CROW. Light scattering attenuation curve as a function of the position in the microstructure were experimentally measured for two CROWs on PDMS trenches (fig. 3). First, results show a measurable scattering along the whole CROWs. Next, a drop of the attenuation at the extremities of each waveguides is clearly visible more particularly for the chain 2 (fig. 3b) showing that light emitted in the waveguides is effectively driven into the CROWs.

Finally, we demonstrate that it is possible to transfer the assembled microstructures by stamping on a glass substrate (fig. 1a, step 5)) that is previously patterned with plain dielectric waveguides made with SU8 resist. Thanks to this technique, fully fluorescent bead chains are aligned under microscope with these waveguides and are deposited on the same surface (fig. 4). Thus, our CFA-based technology may be used to position, on a deterministic way, several local emitters nearby the entrance of "classical" waveguides.

In this presentation we will detail the fabrication of colloidal components and the study of their optical performances.

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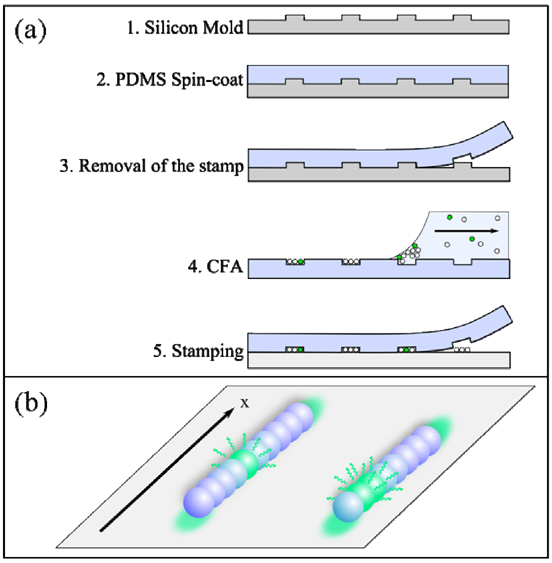

Figure 1. (a) *Fabrication process*: spin-coat of a PDMS layer on a silicon mold, use of the stamp as template for the CFA and optional stamping step to transfer the fabricated microstructures on a glass substrate. **(b)** Schematic view of typical waveguides fabricated with 1 and 2 fluorescent microspheres.

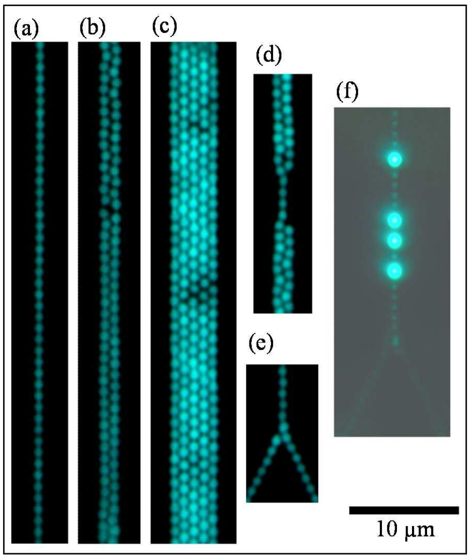

Figure 2. *Fluorescence micrographs of long PS CROWs.* Simple chains with 1 **(a),** 2 **(b)** and 5 **(c)** rows of particles and chain with a bottleneck **(d)** or a fork **(e),** built with fully fluorescent beads. (f) Fork built from a mix of fluorescent and non-fluorescent beads.

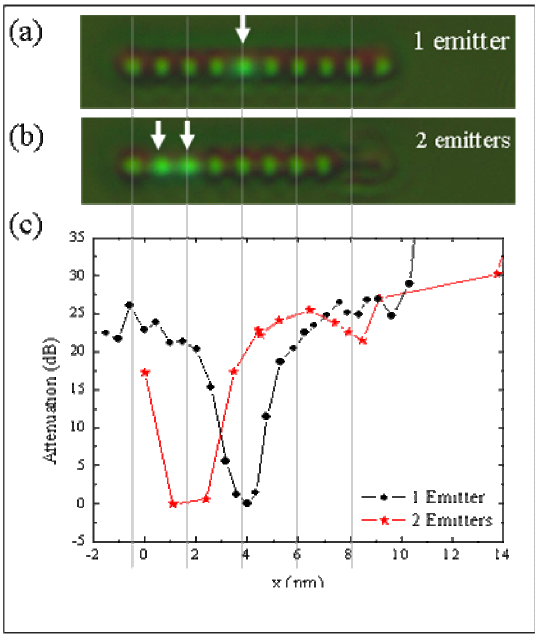

Figure 3. (a), **(b)** Optical micrographs of two waveguides with 1 and 2 emitters (white arrows) respectively. **(c)** Corresponding experimental light scattering attenuation curves showing a stronger scattering at the end of each chain.

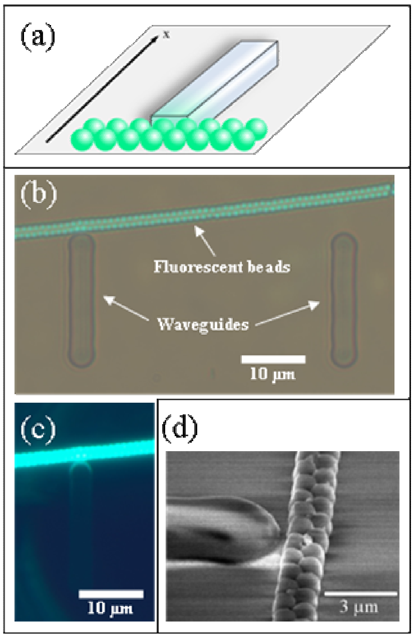

Figure 4. (a) Schematic view of a classical dielectric waveguide coupled to localized light emitters. Corresponding optical **(b),** fluorescence **(c)** and SEM **(d)** micrographs.