3D light confinement in air : the photon cage

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It is emphasing that Micro-Nano-Photonics can be defined as the control of photons within the tiniest possible space during the longest possible time. Optical microresonators are considered as the basic conceptual and technological bricks for that purpose. They are meant to provide strong spectral and spatial confinement of photons, which is essential for the efficient operation of a wide range of active micro-nano-photonic devices, including low threshold micro-lasers, non-linear optical devices and biochemical sensors. The general approach to achieve strong confinement of photons consists in high index contrast structuring of space at the wavelength scale. The progress in micro-nano-photonic integration technology has resulted in a large variety of photonic devices, fabricated along planar technological schemes, but mainly restricted to 2D operation. This way, multiple demonstrations have been made based on microdisk-, micropillar- and photonic crystals microcavities.

Significant progress for quasi 3D control of photons has been achieved in our group along a 2.5D nanophotonics approach which can be considered as an extension of planar 2D photonic crystal-based technology exploiting the vertical direction[1-4].

In this paper we propose a new concept for the 3D control of light in real 3D optical microresonators that can be assimilated to 'cages', where photons are trapped efficiently. The main attractive feature of this photon cages lies in their ability to result in a considerable enhancement of the electromagnetic field in the central part of the cage, that is in the air region, opening the way to new sensing or trapping of nanoparticles in fluidic (gas or liquid) ambiances.

We will present the basic concepts we exploit to confine photons in air using cylindrical or spherical structures based on a periodic lattice of pillars (or stripes). These structures act as 2D/3D mirrors to trap photons in a small volume of low index material (e.g. air). Numerical results, based on FDTD simulations, will illustrate this new idea. Finally, an original technological approach, based on mechanical relaxation of strained microstructures, will be proposed for the fabrication of such 'photon cages'.

References

[1] X. Letartre et al, *Journal of Lightwave Technology*, 21, 1691 (2003).

[2] B. Ben Bakir et al, *Appl. Phys. Lett.* 88, 081113 (2006) and *Virtual Journal on Nanoscale Science & Technology* (2006), 13 n°10.

[3] S. Boutami et al, *Appl. Phys. Lett.* 91, 071105 (2007)

[4] L. Ferrier et al, *Optics Express* 16, 3136-3145 (2008)