Fine tuning of light transport in resonant random media

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Abstract

When monodisperse submicron spherical particles assemble, two opposite situations can take place [1]. In the first case, spheres organize into periodic structures originating the well-known photonic crystals. In these materials, the dispersion relation exhibits photonic gaps along determined directions and therefore they behave as three dimensional gratings that Bragg-diffract light. In the other extreme, the spheres assemble into completely disordered structures, giving origin to random media denoted as photonic glasses (PGs) [2]. In these materials, light propagation is described within the diffusive regime, by a random walk with characteristic scattering mean free path. Due to the fact that the building blocks are monodisperse in size and shape, PGs present resonant behavior arising from the collective coupling of Mie modes. In this sense, they present resonant transport parameters namely, the transport mean free path (l), the diffusion constant and the energy velocity [3]. PGs have allowed the study of interesting phenomena with special emphasis in resonant random lasing [4]. In these systems, the lasing frequency is tuned due to the influence of the material characteristic resonances.
In the present work, we report our latest results concerning the modification of the energy transport mean free path in a PG composed of silica spheres. The glass was stepwise infiltrated with additional conformal layers of silica, by using chemical vapor deposition. The sample was characterized from the structural point of view with scanning electron microscopy (Figure 1). Additionally, total optical transmission allowed us to study the evolution of the transport resonances spectral position. Coherent back scattering was also analyzed, by imaging the backscattering cone emanating from the sample. This allowed the detailed characterization of l which revealed an almost tenfold increase, at the end of the process (complete infiltration, see Figure 1b).
We believe that the reported procedure might have impact in further developments of random lasers by allowing to fine tailor the transport properties of the material.

References

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Figures

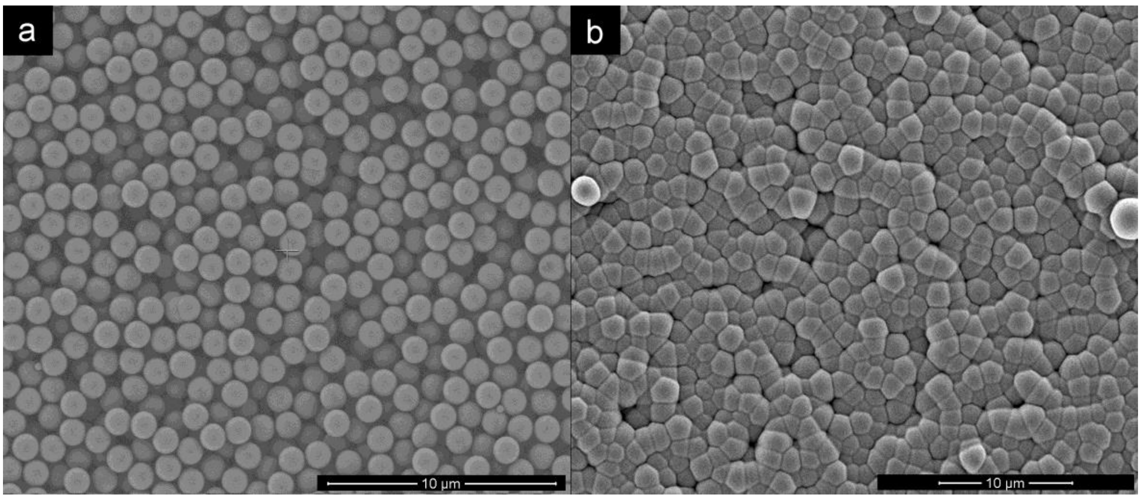

Figure 1. Scanning electron microscopy image of a silica photonic glass (a) and after being infiltrated with silica by chemical vapor deposition (b).