Scattered light spectroscopy of thin film opals and hetero-opals

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The added value of the scattered light spectroscopy of photonic crystals (PhCs) to the transmission one is that the former permits simultaneous examination of the photonic bandgap (PBG) along directions of the light incidence/detection and accounts for all existing optical modes of PhC. The range of demonstrated phenomena, like photon path memory, surface diffraction losses, hyperbolic functional form of the scattered light intensity diagrams, etc. comprises an independent toolbox for characterization of the regime of light scattering, PBG anisotropy, PBG dispersion and anomalous losses.

The magnitude and spatial distribution of light losses in three-dimensional well-ordered opal-based thin film PhCs with mainly ballistic regime of light propagation have been studied. Spectra and intensity angle diagrams of light scattered away from the beam propagation direction have been compared to that of transmitted light.

The scattered light spectroscopy has been applied to assess artificial two-dimensional defects in heterogeneous multiple-layer opal films. Comparison of spectra obtained in different configurations of scattered light collection in association with transmission spectra reveals that a defect becomes the major source of scattering of the traversing probe beam. Nevertheless, ballistic light propagation in hetero-opals dominates because low-angle scattered photons retain the optical path memory, whereas the large-angle scattering becomes diffuse. Due to the deeply embedded source the scattered light angular diagram appears strongly squeezed towards the hetero-opal film normal as compared to that of single opal film.

These and other experiments with scattered light will be presented to justify the advantages of the scattered light spectroscopy to study nearly-ordered PhCs.