Light Propagation in Opals by Photothermal Radiometry: an Inverse Approach Based on Singular Value Decomposition

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Synthetic opal is the simplest method of synthesis of photonic crystals for visible light. The face-centered-cubic lattice is made up of close-packed submicron spheres (100nm-600nm) of amorphous silica. A sublattice of interconnected pores occupies the space between the spheres. The pores can be filled with semiconductors (for example GaN, VO_2) or metals (for example Cu, Ni, Pd) to create a great variety of 3D photonic crystal nanostructures so to combine the properties of a 3D periodic opal structure and the specific optical and electrical properties of the infiltrating. In this way one may manipulate the fundamental properties of photonic crystals, and in particular the internal light propagation, absorption, and scattering. In this paper we want to discuss theoretically and show experimentally how it is possible to visualize the light propagation in SiO_2/GaN and SiO_2/VO_2 opal structures by applying photothermal radiometry. In the experiment the Ar pump laser beam is modulated by an acousto-optical modulator at a frequency ranging from 1 Hz to 100 kHz, and focused onto the opal structures. The light is partially absorbed in the whole structure by the infiltrates regularly distributed in all the pores. Assuming that the heat is generated proportionally to the light intensity flowing in the structure, one may visualize the internal light propagation by performing the heat depth profile reconstruction from the photothermal radiometric data. All the reconstructed profiles, obtained by using singular value decomposition, exhibit a quasi-exponential behaviour. Excellent agreement between SVD reconstruction and the numerical simulations show how this technique may be applied for nondestructive visualization of light intensity depth profile in these structures.

[1] R. Li Voti et al., presented at Advances in Nanophotonics PhOREMOST, Barcelona, 2008.