Acoustic vibration-assisted self-assembly of 3D photonic crystals

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Among various routes of the fabrication of three-dimensional photonic crystals (PhCs) structures, self-assembly of opals stands out as a low-cost, relatively fast and essentially simple method. A variety of methods to self-assemble colloidal spheres have been successfully demonstrated, however, due to the small difference in Gibbs free energies, the mixture of face-centred cubic and hexagonal closed-packed structures is often observed. Furthermore, misorientation of the crystals planes is one of key factors that inhibit the fabrication of defect-free opal PhCs.

In this report, we present an improvement of self-assembled technique, namely, acoustic-vibration assisted growth (AVAG), where the acoustic vibration is applied to the suspension of silica beads. In the conventional scheme of opal assembling in a moving meniscus, the wetting force counteracts gravity and supplies beads to the meniscus. The acoustic field gives the spheres a chance to find a thermodynamically most stable position, thus leading to face-centred cubic symmetry of an opal lattice. This effect is similar to stochastic resonance. Moreover, the opal films crystallized under acoustic agitation consist of mutually aligned crystallites extending over several hundreds of micrometers. The evidence of true fcc lattice formation and lack of stacking faults is presented.