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Optimization of the photonic crystal colloidal films deposition by means of atomic force microscopy

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This article describes the results of optimization of the colloidal photonic crystal (PhC) opal films deposition by means of atomic force microscopy investigation. The main factors affecting the quality of the PhC films are studied. Ordered structure is critical for the formation of the photonic band gap (PBG) because Bragg diffraction occurs in the periodic distribution of colloidal spherical particles.

For preparing samples authors used a colloidal solution of polystyrene monodisperse latex of particles diameters ranging from 220 nm to 330 nm and sitall substrates. The original technology of opal matrices fabrication by vertical lifting from a colloidal solution [1] is described. The structure of the obtained films was monitored by measuring the relative area of ordered structure by means of scanning atomic force microscope Solver Next (NT-MDT, Russia) in semi-contact mode [2]. The photonic crystal properties were monitored by measuring the reflectance at the PBG by means of Epsilon spectrophotometer (IZOVAC, Belorussia). It was found that lifting velocity and solution concentration are the most significant factors for obtaining an ordered structure of photonic crystals.

Full factorial experiment was used to optimize the effect of the above-mentioned factors. The revealed dependences allowed to determine the optimal conditions for obtaining high photonic crystalline quality of opal film: the highest values of the relative area of ordered structure and reflectance at the PBG. Figure 1 shows an AFM-image of the obtained at optimal conditions opal film surface. This film has closest packed structure consisting of hexagonal close packed layers.

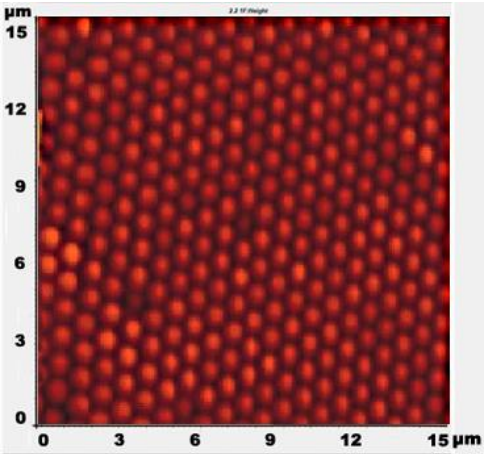

Figure 1. AFM-image of 220 nm polystyrene particles opal film fabricated at 0.3 mm/min lifting velocity and 5% concentration of solution.

The presented results may be used for the development of the colloidal monolayer technology for microsphere lithography.

1. V.L. Kuleshova, E.V. Panfilova, E.P. Prohorov, *2018 International Russian Automation Conference (RusAutoCon)*, 1-5 (2018).
2. A.B. Syritskii, E.V. Panfilova, *IOP Conf. Series: Mat. Sci. Eng.* **443**, 012035 (2018).