Chalcogenide As-S Glass Infilled Colloidal Photonic Crystals

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In this work, we have studied porous colloidal particle assemblies deposited onto glass substrates. The assemblies consist of silica nanoparticles (d~250nm), organised into regular 3D patterns. Initially, the voids between the particles are filled with air. These structures have been prepared by three different methods: controlled evaporation [1], under-oil crystallisation [2] and the Langmuir-Blodgett method [3].

An SEM examination of the cross-sections of the resulting structures reveals differences in assembling of the SiO_2 nanoparticles that can only be attributed to their respective preparation methods. These differences lead to quantitative changes in reflectance/transmittance spectra that are manifested by Bragg peak maxima shifts.

The assemblies on their own have a refractive index contrast between the constituent materials (SiO_2 and air) which is insufficient for an achievement of a full (3D) photonic band gap. This fact makes them unsuitable for most photonic applications.

To try to obtain a complete PBG, the colloidal crystals made here were used as templates and their voids infilled with a high refractive index chalcogenide $As_{30}S_{70}$ glass [4]. The infiltration, which was carried out by spin-coating method leads to a red shift of the Bragg peak of about 150 nm at an incidence angle of 90 degrees for samples made from spheres of diameter 280 nm using the under oil fabrication method. Red shifts of 160 nm and 192nm were then observed for samples made from spheres of diameters 210 nm and 250 nm assembled using the LB technique. It is calculated that inflling with chalcogenide glass opals increases the effective refractive index of the composite material from n = 1.334 to n = 1.687 for the samples prepared using the under oil method. Comparable increases in effective refractive index occur for the LB grown samples.

Although the refractive index contrast achieved is still insufficient for the achievement of full (3D) PBG, we suggest that the inclusion of the chalcogenide glass opens up the possibility of using the infilled structures for non-linear optical applications, while doping of the glass with rare earth ions can also be exploited to make a range of new or improved photonic devices.

References

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