Optical nanocomposite materials for applications in Photonics

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Abstract— The transparent optical medium for recording photonic crystals by holographic lithography method was developed. Optical and rheological properties of the nanocomposite material were investigated. Application of these materials in integrated optics were demonstrated.

Keywords— nanoparticle, nanocomposite materials, low light scattering, photonics.

Summary

Photopolymerizable nanocomposite materials, providing high modulation of the refractive index in the process of holographic lithography, were currently the fastest growing class of optical materials. They are quite technological and have high sensitivity, wide range of refractive indices and low cost. It might be assumed that, photopolymer nanocomposites become promising materials for manufacturing of integrated optics elements, such as photonic crystals. These materials typically consist of a homogeneous mixture of photocurable monomers of different functionality, nanoparticles and photoinitiator of polymerization. Holographic recording is carried out by means of the photoinduced modulation of the refractive index occurred as a result of periodic changes in the composition and density at the photopolymerization of monomers and simultaneous mutual diffusion component when recording interference pattern [1].

The influence of ZnO and SiO₂ nanoparticles on optical (refraction index, light scattering, transmission, FTIR spectra) and rheological properties (Brinell’s hardness, water sorption, AFM, TGA spectra) of polymer composite was investigated [2, 3]. Transparent nanocomposite materials, consisting of commercially available nanoparticles (ZnO or SiO₂) and monomers, suitable for holographic recording, with low light scattering were developed (Fig.1).

Diffraction elements based on such materials were obtained by holographic lithography. Gratings with 2μm period and diffraction efficiency up to 60% were recorded on various nanocomposites [4].

Fig.1 Nanocomposite material with composition of acrylate monomers and different nanoparticles: left — photo of transparent film; right — transmission spectra: (1) pure matrix, (2) acrylate matrix with 12 wt.% SiO₂ nanoparticles, (3) acrylate matrix with 10 wt.% ZnO nanoparticles.