Electro-optical characterization of switchable Bragg gratings based on nematic liquid crystal - photopolymer composites with spatially ordered structure

Galena Zharkova, Irina Samsonova *, Sergey Streltsov, Valentina Khachaturyan

Institute of Theoretical and Applied Mechanics SB RAS, 4/1 Institutskaya Street, Novosibirsk, 630090, Russia.

The composites with a spatially ordered structure have been formed as a result of non-uniform photopolymerization (i.e. holographic method) and phase separation processes from initial compositions containing multifunctional acrylate monomer and nematic liquid crystal (NLC). As it was confirmed by scanning electron microscopy (SEM) studies, the structure represents periodic polymer-rich or NLC-rich layers presenting Bragg planes. A bulk refractive index modulation is obtained due to the structure formed. Presently, a 10-μm thick transmission grating with a period of 1.1 μm and with a polymer layer width of 600 nm was written by laser curing at a wavelength of 658 nm. From the study of light-scattering properties of the composites, it is found that the first-order diffraction efficiency amounts to 50-60% at 633 nm and the refractive index modulation amplitude is about 0.015. A full-width at half-maximum of about 1-2° was measured at 633 nm. The fabricated gratings can be electrically switched between the diffracting and non-diffracting states. At the Bragg angle, the transmission grating starts passing to the switched-off state at an electric field of 2 V/μm, and complete switching occurs at about 4 - 5 V/μm at 633 nm. The change in the first-order diffraction efficiency is accompanied by an equal but opposite change in the zero-order transmittance, clearly indicating that the refractive index was indeed modulated by the field. The grating shows a turn-on time of 200 - 300 μs and a turn-off time of about 1.2 - 3 ms depending on the initial composition of the mixture containing 37 wt% of NLC. The further improvement of the electro-optical parameters (driving voltage, diffraction efficiency, switching times) is expected by a formation of high-structured nanocomposites. The obtained composites may find several applications for switchable diffractive optics. Also, the composites may form a key component in photonic devices for use in the red and in the near infrared regions.

* Corresponding author.
Email address: samsonov@itam.nsc.ru (Irina Samsonova).