Nanocomposite Sensor of Biological and Chemical Agents

Based on Resonant Photonic Crystal Structure

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We study waveguide photonic crystal (PC) structures based on volume gratings recorded in a nanocomposite by a holographic method. Under the resonant conditions, series of strong peaks appear in the reflection spectra of such structures. The central wavelength of these peaks can be changed by varying PC structure parameters and environment permittivity. Therefore waveguide PC structures can be used as sensors of analytes deposited on PC surface by monitoring the resonance wavelength shift. Resonance conditions also results in the strong enhancement of the field in the waveguide and near its surface (local field). The excitation of local field can promote high enhancement of fluorescence and Raman scattering of analytes (enhancement effect).

In this work we investigate the sensor using wavelength shift of resonant peaks. It was found that PC structures with a thickness (*d*) of 1 - 2 μm, period (Λ) ≤ 400 nm and the amplitude of refractive index modulation (*n*1) ≥ 0.01 are the most suitable for effective operation of the sensors. We developed pressing methods for the fabrication of liquid nanocomposite photosensitive layers with a thickness of 0.5 - 2 μm and high quality of the surface. Volume gratings with period 395 nm were recorded in nanocomposite layer by holographic lithography method. Their characteristics are follows: *d* = 1.25 ÷ 1.7 µm *n*1=0.012 ÷ 0.017.

We investigated the resonant properties of fabricated structures. Two peaks were observed in the reflection spectrum. Their spectral positions depend on the angle of incidence of the radiation on the grating-waveguide. The reflection coefficient reaches 23%. The spectral half-width of the resonance peak did not exceed 0.012 nm and was limited by the resolution of spectral equipment. Thus PC structures created on the basis of volume diffraction gratings recorded in the organic-inorganic nanocomposite are characterized by Q-factor > 50000.

The characteristics of the sensor based on nanocomposite PC waveguide structure were examined. In order to study the properties of the sensor a special fluid cell was fabricated. The cell consists of a PC grating on the substrate, silicone spacer of 3 mm thickness and a second substrate, limiting the volume of the tested liquid. The cell was placed in the holder with clamps, which ensured its tightness. The cell was mounted on a goniometric stage.

In the standard measurement method, the light irradiation enters the cell from the side of a substrate, on which the PC-grating is located. The defined sensor sensitivity in this case varies within 0.4÷12 nm/RIU. A minimum detectable change in the refractive index, Δnmin, varies in a range 0.0279 ÷ 0.001 RIU.

We proposed new modified measurement method that allows increasing the sensitivity up to 122 nm/RIU and Δnmin up to 1×10-4 RIU. The characteristics obtained coincide in order of magnitude and, in some cases, exceed those achieved for the sensors based on relief structures.

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