Abstract

Dominik Kowal

PERIODIC STRUCTURES IN POLYMER OPTICAL FIBERS

PhD Thesis

Supervisor: prof. dr hab. inż. Wacław Urbańczyk

The goal of this work was to elaborate techniques allowing for inscription of permanent Bragg gratings and long period gratings in polymer optical fibers (POFs). Large efforts were also put on investigations of potential sensing applications of the fabricated gratings.

The starting point of the conducted experiments was the literature study concerning previous attempts of grating inscription in POFs. Gathered information was used for building the setups for gratings fabrication. Then the setups were gradually improved in order to obtain structures with optimal transmission parameters and temporal stability. Optimization of the grating inscription process also concerned the preparation of fibers e. g. through thermal annealing. To evaluate sensing capabilities of the fabricated structures, their responses to hydrostatic pressure, elongation, temperature and humidity were measured.

Two methods of long period gratings fabrication in POFs were developed. The first one involved mechanical imprinting of the desired modulation in the fiber at elevated temperature. Gratings fabricated in this way were tested for the response to hydrostatic pressure and elongation, yielding linear characteristics. It was shown in the thesis that the main drawback of these gratings was low resistivity to temperature, as their transmission spectra were degraded at about 60 °C. In the second fabrication method the He-Cd laser (λ=325 nm) was used to locally irradiate the POF with a focused UV beam. This technique showed particularly good results for special fibers with doped external cladding (doping by trans-4-stilbenemethanol or azobenzene). Moreover, a simple and very effective doping method by diffusion of photosensitizer from solution in methanol was developed in this work. The gratings fabricated by UV irradiation possess larger temperature resistivity (up to 80 °C) than the gratings inscribed mechanically.

For the Bragg gratings fabrication in POFs a phase mask method and a He-Cd laser were used. Successful grating inscription was presented in two types of fiber: a microstructured PMMA fiber and a *step–index* type fiber with a core made of PMMA/PS copolymer. Significant differences were observed in the dynamics of Bragg peaks growth in both fibers, which was a consequence of larger photosensitivity of PS than PMMA. An

influence of higher order beams diffracted on the phase mask on the Bragg grating's spectrum was also studied in this thesis. It was presented that the multi wave interference behind the phase mask produces additional Bragg peaks in different areas of grating's reflection spectrum. This fact is of great importance for Bragg gratings fabrication in POFs, as large attenuation is a limit for the operation at longer wavelength range. The last important results presented in this thesis were measurements of temperature and humidity responses of the fabricated Bragg gratings. As it was shown, the grating's temperature response depends on thermal history of the fiber. The gratings were damaged at the temperature of 80 °C.