Polyfunctional photo-thermo-refractive glass: combining photo-thermo-induced crystallization, chemical etching and ion exchange technologies

Yevgeniy Sgibnev*[1], Nikolay Nikonorov*[1], and Alexander Ignatiev[1]

[1]ITMO University [Russia] – 49 Kronverksky Pr., St. Petersburg, 197101, Russia

Abstract

Nowadays, commercially available photoetchable materials are Foturan (Schott, Germany) and PEG3 (Hoya, Japan) that are used for fabrication of microreactors, various sensors, "lab-on-a-chip" devices. However, these materials possess low optical characteristics, which limits their applications in optics, photonics, and plasmonics. On the other hand, photo-thermo-refractive (PTR) glass is well-known material for recording Bragg gratings with diffraction efficiency up to 99%. PTR glass is a multicomponent one that changes its refractive index after an exposure to the near UV radiation and the subsequent heat treatment that leads to the formation of silver nanoparticles and NaF nanocrystals in the glass host.

We present the results of studies on ion-exchangeable and photoetchable properties of PTR glass. PTR glass based on Na2O–ZnO–Al2O3–SiO2–F–Br system doped with CeO2, Sb2O3, SnO2, and Ag2O was synthesized for further investigation. Irradiation of the samples were carried out by either high-pressure mercury lamp or pulsed fs Ti:Sapphire laser (790 nm).

The rate of chemical etching PTR glass ceramics in the HF solution greatly exceeds that for the glass. It can be explained by a good solubility of NaF crystals in hydrofluoric acid and nanoscale effect. Hollow 3D channels were formed in the bulk of PTR glass with fs laser irradiation, subsequent heat treatment and chemical etching. Such hollow structures can be used for developing various sensors and "lab-on-a-chip" devices based on PTR glass.

The presence of sodium in PTR glass composition allows one to focus on the ion exchange technology widely used for formation of silver nanostructures. Moreover, silver ions in the ion-exchanged layers of PTR glass can be transformed into either luminescent silver molecular clusters or plasmonic silver nanoparticles by adjusting temperature of subsequent heat treatment. Such structures can be used for developing integrated microfluidic-plasmonic sensors.

Thus, combining photo-thermo-induced crystallization, chemical etching, and ion exchange technologies in the glass opens up new prospects for developing "lab-on-a-chip" devices with luminescent and plasmonic nanostructers formed directly in 3D hollow channels.

This work was supported by the Ministry of Education and Science of Russian Federation (Project 16.1651.2017/4.6).

*Speaker

Keywords: photothermorefractive glass, chemical etching, ion exchange.