Defect-Related Effects in the Modified Chalcogenide Glasses Caused by Gamma-Irradiation

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Ge-Ga-S/Se chalcogenide glasses have shown many advantages for potential applications in optical modulators or frequency converters, as efficient laser host materials and for fiber-optical amplifiers in the IR spectral region. Their structural and electronic modification by thermal annealing processes and irradiation results in changes of their functional properties [1].

The process of crystallization in $80GeSe_2$-$20Ga_2Se_3$ glasses influences their optical transmission spectra. Non-annealed glassy samples show maximum optical transmittance at the level of 65 %. Annealing at 380 °C decreases this transmittance and shifts optical transmission edge towards long-wave side. The appearance of growing of Ga_2Se_3 and $GeGa_4Se_8$ nanocrystals inside the glassy matrix induces light scattering at shorter wavelengths. Generally, this phenomenon shows the presence of large crystals that deteriorate optical transparency of the material rapidly, leading progressively to its complete opacity in the IR range.

The influence of gamma irradiation on optical properties of Ge-Ga-S/Se glasses was investigated using Co^{60} source. The dose of gamma-irradiation was near 0.8 MGy and the total duration of this procedure was 2 months [2].

The slight long-wavelength shift of the fundamental optical absorption edge and the decrease in transmission are observed in $80GeS_2$-$20Ga_2S_3$ glasses after irradiation. This indicates possible formation of additional defects in $80GeS_2$-$20Ga_2S_3$ glasses and their observed darkening. After irradiation, nanovoids with different size are created as intrinsic structural defects associated with topologically uncoordinated negative-charged centers. These defect centers form additional energy levels both near the bottom of the conduction band and in the vicinity of the valence band, as well as additional intrinsic electric fields. The mechanism of irradiation-induced darkening of $80GeS_2$-$20Ga_2S_3$ glasses is connected with oxidation processes most probably related with the appearance of GeS_2 phase at the surface of the glasses.

Gamma irradiation practically does not alter the optical transmission spectra in the modified $80GeSe_2$-$20Ga_2Se_3$ glasses. The position of optical transmission edge and the spectra profiles in the saturation region coincide before and after irradiation. Such radiation stability of $80GeSe_2$-$20Ga_2Se_3$ glasses allows their use as radiation-stable optical sensors in the visible and IR spectral region.

[1] P. Masselin, D. Le Coq, L. Calvez, E. Petracovschi, E. Lepine, E. Bychkov, X. Zhang, CsCl effect on the optical properties of the $80GeS_2$–$20Ga_2S_3$ base glass, *Appl. Phys. A* **106** (2012) 697-702.

[2] H. Klym, A. Ingram, O. Shpotyuk, O. Hotra, A.I. Popov, Positron trapping defects in free-volume investigation of Ge-Ga-S-CsCl glasses, *Radiation Measurements* **90** (2016) 117-121.