SOL-GEL SILICA GLASS DOPED WITH TRANSITION METAL NANOCRYSTALLINE PARTICLES

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Sol-gel glasses are promising matrices for forming nano-dimensional optical composites (glass ceramics). Glass ceramics combines in itself advantages of optical and laser materials activated with ions of transition metals coupled with the possibility to create on its basis of optical a fiber for various applications in the devices for transmission and processing of information in practically important spectral bands of 1.3 and 1.5 mcm [1-2].

One of the problems, presenting difficulties in producing high quality optical ceramics, is a cracking of molded silica gel in the course of thermal treatments - drying and sintering - as a consequence of high volume shrinkages and heterogeneities of the structure. For monolithic samples with cross-sectional dimensions of more than 1 cm, the strain at dehydration may lead to a catastrophic destruction and forming cracks. The most thoroughly studied alkoxy sol-gel process, which uses silica acid esters as initial reagents - TEOS, TMOS and others, does not provide the possibility to produce molded xerogels and glass of a sufficient dimensions and configurations. Several variants of classical sol-gel process's modifications have been proposed with the end purpose to eliminate the phenomena of cracking and to increase a controllability of the process for sol-gel synthesis. In Gomel STU (Belarus) and Institute of Surface Chemistry (Ukraine) it was suggested to incorporate into sol produced by TEOS hydrolysis- polycondensation, highly dispersed fillers which enhanced the content of a solid phase that, in turn, resulted in the increase of an average size of pores and strengthening of their structure [1]. Fumed silicas – Aerosils modified with transition metal oxide nano-crystalline particles - with a specific surface of 175 - 380 m^2/g were used as active fillers. Such silicas have high purity, nano-dimensional level of particles and compatibility with water-alcohol-hydrochloride systems used for TEOS hydrolysis.

Sol-gel synthesis of silica glass and optical composites doped with ions and nanoparticles of *d*-transition elements (V, Fe, Cu) has been developed. The investigations were focused on the preparation technique of the xerogels, 3D-dimention glasses, and nanocomposites by the new method including the TEOS-hydrolysis and introduction of fumed silica into sol with ultrasonic activation of the colloidal system. The researches were carried out in the field of structure, optical and mechanical properties of silica sol-gel glass doped with transition metal oxides, semiconductor or metal particles. For the analysis of the formed material properties the methods of XRD, XPS, TEM, RBS, and optical spectroscopy in UV-VIS-IR range were used. The silica sol-gel glasses doped with Cu_xSe nanoparticles were realized as saturable absorbers in passive Q-switching of Nd^{3+}:YAG, Nd^{3+}:YAP lasers emitting at 1.06, 1.067 and 1.34 mcm and 1.54 mcm Er^{3+}:glass lasers. The average sizes of Cu_xSe nanoparticles formed in the monoliths sol-gel glasses according to TEM data are of 20 to 80 nm. The colored sol-gel glasses and nanocomposites were fabricated for optical filters and luminescent materials.

1. E. N. Poddenezhny, I. M. Melnichenko, B. V. Plusch et.al., Inorg. Mater., 35(1999)1309.
2. E. N. Poddenezhny, A. A. Boiko, Sol-gel synthesis of optical silica glass/ Gomel, "P.O.Sukhoi GSTU", 2002. (Russ.) – 210 p.