THE MEDIUM INFLUENCE ON THE LUMINESCENCE INTENSITY OF SnO_2 NANOPARTICLES ENSEMBLES IN A POROUS SILICATE GLASS MATRIX

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Introduction

Tin dioxide nanoscale forms, besides their stability in most of aggressive media, and high gas sensitivity, appear luminescence in the visible range. This makes the material promising for the creation of contactless sensors of various composition environments [1].

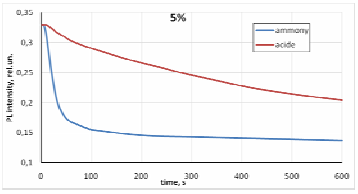
The aim of this study is to elucidate the medium influence (with alkaline and acid components) on the luminescence of SnO_2 nanoparticles ensembles in a porous silicate glass matrix.

Methods

The ensembles were formed by impregnating glass samples with alcohol solutions of $SnCl_4$ of various concentrations, followed by thermosynthesis of SnO_2 directly in the pores [2]. The obtained ensembles' samples of tin dioxide NPs being in media with NH_4OH and HCl vapors showed number of photoluminescence characteristic dependences on the composition of the environment.

Results

In an alkaline medium, the luminescence intensity decreased by more than half in the interval of 10-20 sec. In an acidic medium, the same samples' luminescence intensity also decreased, but, by only 5% in tens of minutes.



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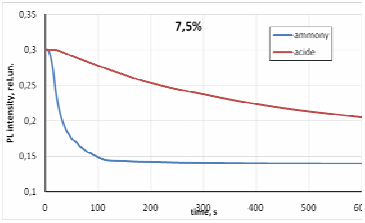

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Fig.1. The PhL intensity changes of SnO2 NPs ensembles obtained at impregnation concentrations for SnCl4 solution of 5% (a) or 7.5% (b) in an alkaline and acidic medium.

The luminescence kinetics changes for SnO_2 nanoparticles ensembles obtained at $SnCl_4$ concentrations of 5 %, 7.5 %, 12.5 %, and 25 % were considered during the first minute after placing the samples in alkaline and acidic media.

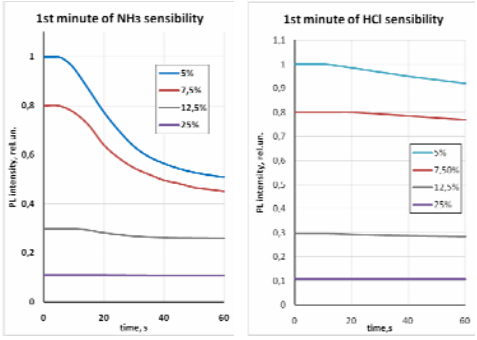

Fig. 2. Kinetics of luminescence of ensembles of SnO2 nanoparticles obtained at concentrations of 5%, 7.5%, 12.5% and 25% measured during the first minute after placing the samples in alkaline and acidic environments

Table 1 Photoluminescence of ensembles of SnO2 nanoparticles in an alkaline medium

Concentration of $SnCl_4$ at thermosynthesis (%)	Latent period (s)	Decrease in luminescence intensity of SnO_2 NPs	
		after 1 min, (times/per min.)	after 10 min, (times/per min)
5	5	1,96	2,4
7,5	8	1,77	2,14
12,5	15	1,15	1,23
25	20	1,006	1,012

Table 2 Photoluminescence of ensembles of SnO2 nanoparticles in an acidic medium

Concentration of $SnCl_4$ at thermosynthesis (%)	Latent period (s)	Decrease in luminescence intensity of SnO_2 NPs	
		after 1 min, (times/per min.)	after 10 min, (times/per min)
5	15	1,086	1,6
7,5	15	1,04	1,46
12,5	15	1,035	1,05
25	15	1,0005	1,001

The proposed behavior models for the luminescence of samples in alkaline and acidic media are based on the nature of ammonia and hydrogen chloride vapors interaction with nanoparticles' surfaces in ensembles. A sharp photolumiscence intensity decrease in an alkaline medium is explained by the unstable ammonia complexes $SnO_2[NH_3]$ formation. When, in acidic environments such complexes are not formed, and a slow change of photoluminescence intensity is associated with the penetration of hydrogen chloride molecules into the pores with a subsequent dissociation.

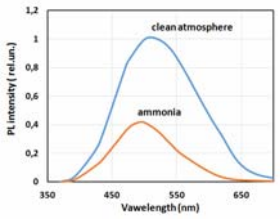

Fig. 3 The luminescence spectra of an ensemble of SnO2 nanoparticles obtained using a 5% SnCl4 solution: in a clean atmosphere and immediately after their extraction from an ammonia medium after 10 min stay in it.

Complete self relaxation to the initial luminescence intensity values of the SnO_2 nanoparticles ensembles within 10-12 hours after extraction from the aggressive medium allows using them as reliable active elements of a luminescent ammonia sensor.

Conclusions

Changes in luminescence are associated with the interaction nature of alkaline or acid ions with nanoparticles in the pores of silicate glass.

The SnO_2 nanoparticles' ensemble in a type A silicate porous glass can be used as an active medium for a luminescent ammonia sensor. The advantage of such a system is in the almost absolute chemical inertness of the working substance, which increases its reliability, and in the possibility of spontaneous restoration of the sensor's performance during the day after operation.

References

1. Batzill M, Diebold U, Prog. Surface Sci. **79**, 47 (2005)
2. S.A. Gevelyuk, V.S. Grinevich, I.K. Doycho, Y.I. Lepikh, L.M. Filevska. J. Nano- Electron. Phys. **12** (3), 03020 (2020)