EPJ Web of Conferences **161**, 03012 (2017) DOI: 10.1051/epjconf/201716103012
PECS-2017

Luminescence decay of Sm:LaF_3@LaF_3 core-shell crystalline nanoparticles

Elena Lukinova*, *Eduard* Madirov, *Maxim* Pudovkin, *Darya* Koryakovtseva, *Stella* Korableva, *Alexey* Nizamutdinov, and *Vadim* Semashko

Kazan Federal University, Institute of Physics, 18 Kremlevskaja str., Kazan, 420008 Russia

Abstract. Luminescent properties in visible spectral range of crystalline LaF_3 nanoparticles containing 1 % and 5 % of Sm^{3+} ions before and after microwave hydrothermal treatment and also Sm:LaF_3@LaF_3 core-shell nanoparticles were studied. The LaF3 surface layer resulted in lowering the luminescence decay time apparently due to eliminating surface quenching factors. This opens the way to manage luminescence and energy transfer properties of the material.

1 Introduction

Crystalline nanoparticles of LaF_3 compound, doped with various rare-earth ions are of great interest today for unique combination of optical and physical properties. Depending on luminescence and excitation spectral ranges of action these materials are prospective in bioimaging, lamp phosphors, quantum cutting, up-conversion, luminescent material for combined photodynamic therapy [1,2]. Composite materials based on these nanoparticles can be utilized as elements for quantum devices. Aim of this work is to study opportunities to manage luminescence decay properties of Sm^{3+} ions in LaF_3 nanoparticles by chemical approach.

2 Experimental

Crystalline Sm:LaF_3 nanoparticles were fabricated via co-precipitation method described earlier [3,4]. Nanoparticles of Sm:LaF_3 (C_{Sm} = at. 1 %, C_{Sm} = at. 5 %, samples N1 and N2 respectively) were used in experiments after washing and drying directly after synthesis. The hydrothermal treated (60 minutes exposure in the microwave oven) samples were prepared as it can improve crystallinity of the particles (sample N3). Also the approach of core-shell was tested. The sample of N2 was dispersed in distilled water by sonication treatment. Then 1.2 mmol of NH_4F was added into suspension. Then the solution was heated to 50 °C, and stirred for 15 min and the 0.4 mmol of $La(NO_3)_3\cdot$was introduced to it. The prepared suspension was placed into the microwave oven for 60 minutes. The following procedures of washing and drying were the same as that was stated for previous samples.

---

* Corresponding author: elena.v.lukinova@gmail.com

3 Results and discussion

Luminescence spectra of all Sm:LaF$_3$ samples registered under 405 nm excitation contain well known lines of transitions from $^4G_{5/2}$ state to ^6H_J terms (see Fig. 1a).

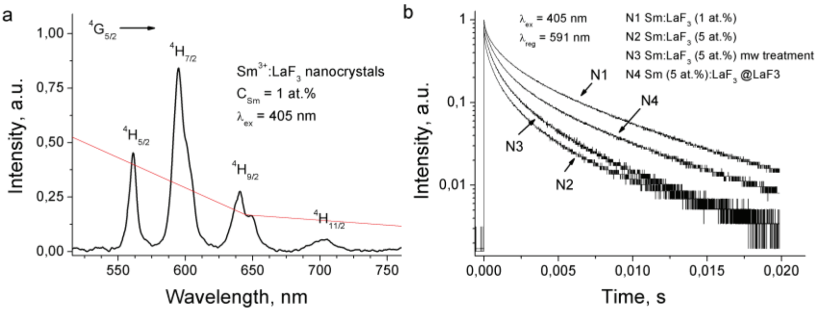

Fig.1. Room temperature luminescence spectrum (a) and luminescence decay curves (b) of LaF$_3$:Sm nanoparticles dried sample under 405 nm excitation.

Changes in preparation method have found reflection in luminescence decay of the samples. The decay curves of all four samples of Sm:LaF$_3$ nanoparticles are presented in Figure 1b. All samples of Sm:LaF$_3$ nanocrystals have exhibited non-exponential decay which is common for nanoparticles due to large surface to volume ratio and significant amount of surface perturbed sites [5] and which empirically can be divided into fast and slow components. The results of two-exponential fitting are presented in Table 1.

Table 1. Luminescence decay components of Sm:LaF$_3$ nanoparticles samples.

	N1 (C_{Sm} 1%)	N2 (C_{Sm} 5%)	N3 (C_{Sm} 5% microwaved)	N4 (C_{Sm} 5% core-shell)
t1, ms	4.79±0.02	3.27±0.02	3.33±0.02	4.26±0.02
t2, ms	0.85±0.02	0.67±0.02	0.66±0.02	0.77±0.02

The decay of heavier doped sample N2 is faster both in slow and fast components as it should be due to concentration quenching. Existence of LaF$_3$ shell lowers the decay times back apparently due to covering impurity sites at the surface thus eliminating surface quenching factors. The microwave treatment of nanoparticles on the contrary has not introduced any effect in implemented conditions which can speak for deficient fluorination or exposition during reaction.

The work was supported by the subsidy of the Russian Government (agreement No.02.A03.21.0002) to support the Program of Competitive Growth of Kazan Federal University and for the subsidy allocated to Kazan Federal University for the state assignment in the sphere of scientific activities [3.1156.2017/4.6].

References

[1] K. Binnemans, Chemical Reviews **109**, 4283 (2009)

[2] Q.Y. Zhang, X.Y. Huang, Progress in Materials Science **55**, 353 (2010)

[3] F. Wang, Y. Zhang, X. Fanc, M. Wang, J. Mater. Chem. **16**, 1031 (2006)

[4] J. Shao, Z. Wang, R. Wang, Z. Liu, L. Wang, J. Guo, X. Li, M. Zhang, C. Zhang, H. Zheng, J. of Solid State Chem. **49**, 199 (2017)

[5] M. Runowski, S. Lis, Journal of Alloys and Compounds **661**, 182 (2016)