Photoindused toxicity of PrF_3 nanoparticles and luminescence nanothermometry based on Pr^{3+}:LaF_3 nanoparticles of different size, shape, and structure

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Abstract— **Pr^{3+}:LaF_3 (C_{Pr}=1-30%) nanoparticles (NPs) demonstrate temperature sensing properties into the temperature range from -196 to 60ºC. The relative sensitivities (S_r) of Pr^{3+}:LaF_3 (C_{Pr}=12%, 20%) spherical NPs (at 45ºC) were 0.5 and 0.3% °C^{-1}, respectively. Surprisingly It was found that S_r and temperature dependence of luminescent spectra of Pr^{3+}:LaF_3 nanoparticles strongly depend on shape, size and structure of NPs. We did not detect formation of superoxide and hydroxyl radical by PrF_3 nanoparticles under CW laser irradiation. Finally, the mechanism of photoinduced toxicity can be related to local heating of cellular components by nanoparticles.**

Keywords—nanobioscience, temperature sensors

I. INTRODUCTION (*HEADING 1*)

Earlier we observed the phenomenon of photoinduced toxicity (PT) of PrF_3 and LaF_3 nanoparticles (NPs) [1]. The mechanism of PT of fluoride NPs is still unclear. It can be related to the local heating and/or formation of reactive oxygen species (ROS). Conventional methods of temperature measurement are not acceptable It requires luminescent nanothermometry having a sub-micrometric spatial resolution. Here we analyze the temperature dependent luminescence features of Pr^{3+} doped LaF_3 NPs of different shape and structure and demonstrate the opportunity to applied these technique for measurement temperature of local heating. We analyze the possibility of formation of ROS by PrF_3 NPs under CW and pulse laser irradiation in order to define the mechanism of PT of PrF_3 NPs.

II. MATERIALS AND METHODS

The Pr^{3+}:LaF_3 (C_{Pr}=1, 3, 7, 12, 20, 30%) and PrF_3 spherical NPs (SNPs) were synthesized. Additionally, the Pr^{3+}:LaF_3 (C_{Pr}=1%) plate like NPs (PNPs), Pr^{3+}:LaF_3 (C_{Pr}=1%)@LaF_3 core shell PNPs, Pr^{3+}:LaF_3 (C_{Pr}=1%) SNPs and Pr^{3+}:LaF_3 (C_{Pr}=1%)@LaF_3 core shell SNPs were also synthesized.

III. RESULTS AND DISCUSSION

All the Pr^{3+}:LaF_3 (C_{Pr}=1-30%) NPs demonstrate relative sensitivities (S_r) at 45ºC in to the range from 1.0 to 0.2 °C^{-1}. Temperature sensitivity of Pr^{3+} doped NPs is related to the energy gap between $^3P_0$ and $^3P_1$,

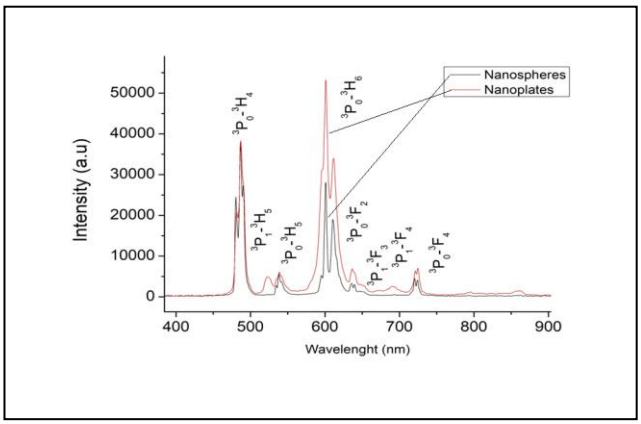

Fig. 1. Spectra of luminescence of Pr^{3+}:LaF_3 (C_{Pr}=1%) nanospheres and nanoplates at 80 K (λ_{ex}=444 nm, pulse duration 10 ns, pulse repetition 10 Hz)

and $^3P_1$ becomes thermally populated following $^3P_0$ excitation, and the luminescence spectrum contains both $^3P_0$ and $^3P_1$ emissions. Surprisingly, the luminescence dependence on temperature is strongly depends on the shape of NPs (SNPs or PNPs) and structure (single-core, core-shell) of the NPs (Fig.1). For PNPs at 80 K the emission from $^3P_1$ state takes place and in case of SNPs this phenomenon is not observe. It is probably related to the different volume to surface ratio of the NPs and as consequence in case of PNPs It is at least 5 times more Pr^{3+} ions located on the surface into distorted crystal field in proximity with surface ligands. The formation of superoxide and hydroxyl radical does not occur..

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