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Physical Background for Luminescence Thermometry Sensors Based on Pr^{3+}:LaF3 Crystalline Particles

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Abstract

© 2017 Maksim S. Pudovkin et al. The main goal of this study was creating multifunctional nanoparticles based on rare-earth doped LaF 3 nanocrystals, which can be used as fluorescence thermal sensors operating over the 80-320 K temperature range including physiological temperature range (10-50°C). The Pr 3+ :LaF 3 (CPr = 1%) microcrystalline powder and the Pr 3+ :LaF 3 (CPr = 12%, 20%) nanoparticles were studied. It was proved that all the samples were capable of thermal sensing into the temperature range from 80 to 320 K. It was revealed that the mechanisms of temperature sensitivity for the microcrystalline powder and the nanoparticles are different. In the powder, the 3 P 1 and 3 P 0 states of Pr 3+ ion share their electronic populations according to the Boltzmann and thermalization of the 3 P 1 state takes place. In the nanoparticles, two temperature dependent mechanisms were suggested: energy migration within 3 P 0 state in the temperature range from 80 K to 200 K followed by quenching of 3 P 0 state by OH groups at higher temperatures. The values of the relative sensitivities for the Pr 3+ :LaF 3 (CPr = 1%) microcrystalline powder and the Pr 3+ :LaF 3 (CPr = 12%, 20%) nanoparticles into the physiological temperature range (at 45°C) were 1, 0.5, and 0.3% °C -1 , respectively.

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