The effect of annealing and co-activation by Nd^{3+} ions on the temperature dependence of the spectral and kinetic characteristics of YF_3:Eu^{3+} nanoparticles

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Abstract— The studied YF_3: Eu^{3+}, Nd^{3+} and YF_3: Eu^{3+} nanoparticles demonstrated, that annealing in air at 400 ^{0}C for 4 hours increases the rise times by about 2 times and the luminescence decay times by about 1.2 times. Stronger temperature dependence of decay time was observed for samples without annealing. The addition of Nd^{3+} leads to the increase of temperature sensitivity of spectral characteristics of YF_3: Eu^{3+} nanoparticles

Keywords— YF_3: Eu^{3+}, Nd^{3+}, the effect of annealing on spectral kinetic characterization, luminescent thermometry

I. Introduction

During past decade, the luminescent thermometry became very promising way to measure temperature with high resolution. The most promising phosphors for this purpose are fluoride nanoparticles doped with rare-earth ions. To increase the temperature sensitivity, various methods are used: double doping, annealing, and many others. In this paper, we investigate the effect annealing and Nd^{3+} co-doping on temperature sensitivity of spectral-kinetic characteristics (SKC) of YF_3: Eu^{3+} nanoparticles.

II. Materials and Methods

The nanoparticles were synthesized via co-precipitation method in water with subsequent hydrothermal treatment. The excitation of the nanoaprticles was performed via LOTIS TII tunable laser LT-2211A (λ_{ex} (Eu^{3+}) = 394 nm, (pulse duration and repetition were 10 ns and 10 Hz, respectively). The spectra were recorded via StellarNet (CCD) spectrometer. The kinetic characterizetion was carried out via monochromator connected with photomultiplier tube FEU-100 and digital oscilloscope Rhode&Schwartz with 1 GHz bandwidth.

III. Results and Discussions

In the first half of the work, the effect of annealing in air (400 ^{0}C, 4 hours) on the temperature sensitivity of the SKC of YF_3: Eu^{3+} (2.5; 5.0 and 7.5 mol.%) was investigated. Kinetic characterization was carried out in the temperature range of 80-320 K at 589.5 nm wavelength (Eu^{3+}). The luminescence decay time function decreases with the increase of temperature (Fig. 1). It cab be explained by multiphonon quenching by defects. And the probability of this process increases with temperature. This behavior is observed for all the samples. Additional

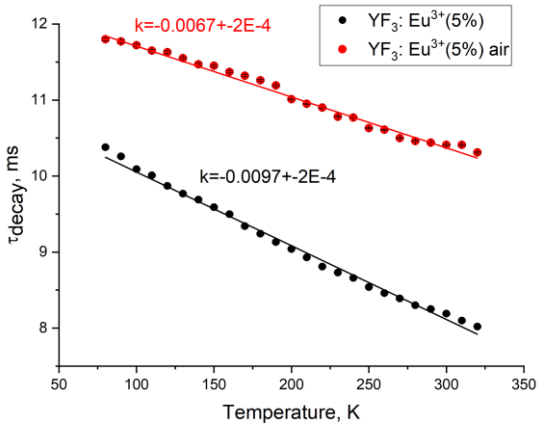

Fig. 1. Luminescence decay time at a wavelength of 589.5 nm of the samples YF_3: Eu^{3+} (5 mol.%): without annealing (black) and annealed in air (red), in the temperature range 80-320K

general trends in decay time were also observed: annealing increases the luminescence decay time due to an increase in the crystallinity of samples (i.e. a decrease in the number of quenching defects). With the increase of Eu^{3+} concentration, concentration the temperature sensitivity becomes less due to the predominance of energy diffusion over the process of multiphonon relaxation on defects, for the same reason, for samples after annealing, the temperature sensitivity is lower. The rise time increases with the increase of temperature. This is due to the compression of the crystal lattice at low temperatures [1], which reduces the probability of a cross-relaxation process between Eu^{3+} ions.

The effect of double doping on temperature sensitivity was also investigated. In particular, annealed YF_3: Eu^{3+} (5.0 mol.%) Nd^{3+} (0 and 2.0 mol.%) samples were examined. The luminescence spectra of this sample are almost independent of temperature in the range of 80 - 320K. The doping with Nd^{3+} ion increases the temperature sensitivity kinetic characteristics which allows obtaining competitive temperature sensitivity (0.0104±5E-4 ms/K).

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References

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