Template Synthesis and Luminescent Properties of Lanthanide Impurities Doped YBO_3 Nanoparticles

T. Malyi[1], A. Zhyshkovych[1], M. Chylii[1], V. Vistovskyy[1], A. Zaichenko[1,2], A. Voloshinovskii[1]

[1]*Ivan Franko National University of Lviv, 8 Kyryla i Mefodiya Str., 79005 Lviv, Ukraine*
[2]*Lviv Polytechnic National University, 12 S. Bandera Str., 79013 Lviv, Ukraine*

YBO_3 nanoparticles doped with lanthanide elements attract the attention of researchers because of its possible application for creation of luminescent materials which possess spectrally separated narrow luminescence bands in the visible range of the spectrum [1, 2]. This will provide simultaneous marking of several types of biological objects in mixed biological cultures for visualization of processes at the cellular level. Nanosized borate particles doped with lanthanide luminescent impurities can be synthesized by different methods, such as nucleation, hydrothermal, solvothermal, sol-gel method, solid state reaction, etc.

YBO_3-Ln nanoparticles obtained via nucleation method are characterized by 10 nm size and amorphous state. However, they possess low luminescence intensity. To increase the intensity of luminescence it is necessary to anneal the nanoparticles at high temperatures, which usually leads to unwanted effects of nanoparticles aggregation. The organic surfactants as templates for the nanoparticle growth can be used to prevent the formation of aggregate structures. In order to study the influence of synthesis conditions on the structural and luminescent properties the YBO_3-Ln nanoparticles were prepared using oligoperoxide templates of different types and different concentrations and annealing of samples at temperatures of 400, 600 and 800 °C.

It was revealed that nanoparticles annealed at 800 °C for 30 minutes possess sufficient luminescence intensity. The change of annealing temperature in the range of 200 – 800 °C effects insignificantly on the nanoparticles sizes which are within the 37-50 nm. However, as a result of high-temperature annealing the nanoparticles undergo aggregation. The aggregation is reduced if the nanoparticles are synthesized in the presence of oligomers and additionally covered with the polymer shell after annealing. In this case, most of the nanoparticle aggregates are about of 100 nm size.

The doping of YBO_3 nanoparticles with lanthanide ions provides the triple colour of luminescence under excitation at 366 nm. The obtained YBO_3-Ce nanoparticles possess blue colour of luminescence with λ_{em} = 420 nm. YBO_3-Ce,Tb system possess spectrally narrow green colour luminescence band at λ_{em} = 543 nm due to excitation energy transfer from cerium to terbium ions, as well as narrow red colour luminescence band at λ_{em} = 617 nm in YBO_3-Ce,Tb,Eu nanoparticles due to energy transfer from Ce^{3+} to Tb^{3+} ions and subsequently from Tb^{3+} to Eu^{3+} ions.

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