Electronic excitations in $LuPO_4$-Eu and $LuPO_4$-Pr nanoparticles

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Introduction

The dependence of luminescence intensity on the nanoparticle size is not only fundamental but also applied task important for elucidation of possible application of nanoparticles for creation of new nanocomposite materials or even the nanoscintillators for medical use. The first experimental evaluation of luminescence intensity dependence on nanoparticle size has been done for Lu_2O_3:Eu^{3+} and Lu_2O_3:Tb, $LaPO_4$-Ce and $LaPO_4$-Ce,Tb [1-3], where the authors mainly interpret the observed changes of luminescence parameters as the result of surface loses and the ratio between the mean free path of electron excitation and particle size.

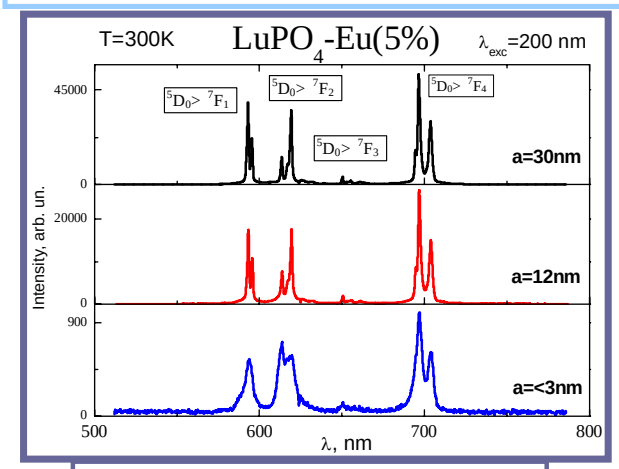

Fig.1 Luminescence spectra of LuPO4-Eu

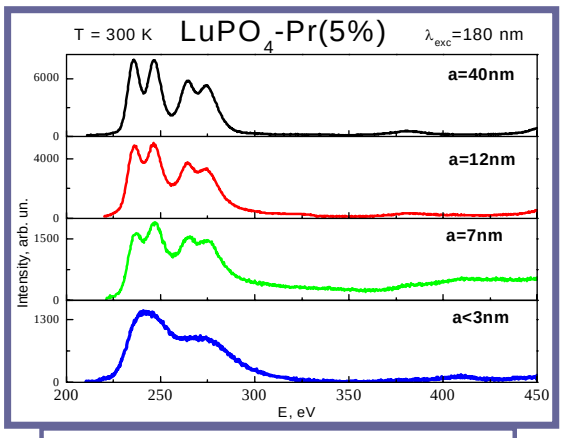

Fig.2 Luminescence spectra of $LuPO_4$-Pr

Experiment

In the present work we studied the size effect influence for luminescence of $LuPO_4$-Eu and $LuPO_4$-Pr nanoparticles upon high energy excitation (4 - 42 eV) provided at the SUPERLUMI station of HASYLAB at DESY. $LuPO_4$-Eu and $LuPO_4$-Pr nanoparticles have been synthesized by the template micelle method using the surfactant species. The nanoparticles with size in range of 3-40 nm were fabricated in process of temperature annealing.

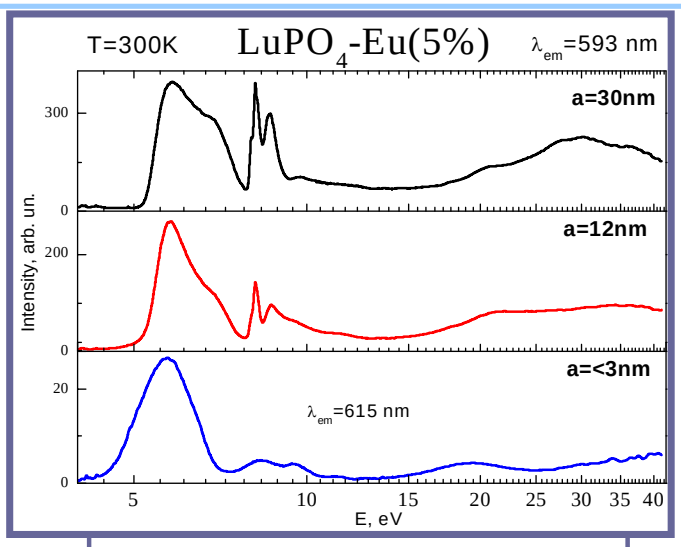

Fig.3 Luminescence excitation spectra of $LuPO_4$-Eu

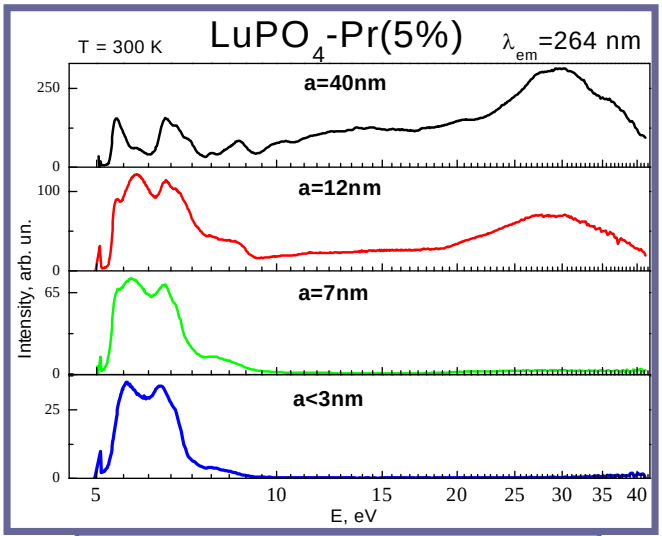

Fig.4 Luminescence excitation spectra of $LuPO_4$-Pr

Result and discussion

The emission spectrum of Eu^{3+} in $LuPO_4$-Eu and Pr^{3+} in $LuPO_4$-Pr nanoparticles with < 3 nm are slightly broadened in comparison with luminescence spectra in samples with greater size (7-40 nm). The structure of the luminescence bands does not depend on nanoparticle size and is typical for the tetragonal crystal lattice symmetry.

The intensity of luminescence generally decreases with decrease of nanoparticles size. It can be explained by greater influence of near surface defects in nanoparticles with smaller sizes. However, the tendencies of luminescence intensity decrease differ for different energy of excitation quanta. Thus, the intensity decrease upon excitation in the charge transfer band (~6.5eV) for $LuPO_4$-Eu and in the range of 4*f*-5*d* transitions in Pr^{3+} ions (5.0-7.5 eV) in $LuPO_4$-Pr nanoparticles are not so sharp as in the range of band-to-band transitions (10-15 eV). For small (<7 nm) $LuPO_4$-Pr nanoparticles the range of multiplication of electronic excitation (MEE) is not observed and for the $LuPO_4$-Eu small (<3 nm) nanoparticles the MME mechanism is connected with secondary charge transfer transitions.

Observed luminescence intensity dependences on the nanoparticle size and the energy of incident quanta are explained in terms of energy losses on the surface of nanoparticles, the electron-phonon and inelastic electron-electron scattering, the ratio between the mean free path of electronic excitations and nanoparticle size.

References

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