Peculiarities of the Eu^{2+} luminescence in the $NaCl-LaCl_3-EuCl_3$ system

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Introduction

In recent years, Eu^{2+} is considered as a promising dopand for scintillator applications due to a high light yield of doped single crystals. In this paper, we report on a study of the luminescent-kinetic properties of Eu^{2+}-doped $LaCl_3$ microcrystals embedded in the NaCl matrix. La-containing Ce^{3+} doped single crystals of UCl_3 structure type show outstanding scintillation properties such as light yield, energy resolution etc. However, it is difficult to grow and study single crystals of such a type due to their considerable hygroscopicity. Therefore, we have performed our experiments on $LaCl_3$ microcrystals embedded in a stable host such as NaCl.

Experiment

Single crystal of the $NaCl–LaCl_3$(1mol%)–$EuCl_3$(0.1mol%) composition was grown in evacuated quartz ampoule by the Bridgman technique. Measurements of the luminescence excitation and emission spectra were performed using the facility of SUPERLUMI station at HASYLAB (DESY, Hamburg). Luminescence decay kinetics of Eu^{2+} centers were measured upon the excitation by optical quanta from flash lamp with the pulse duration of 1 ns and the repetition rate of 10–15 kHz.

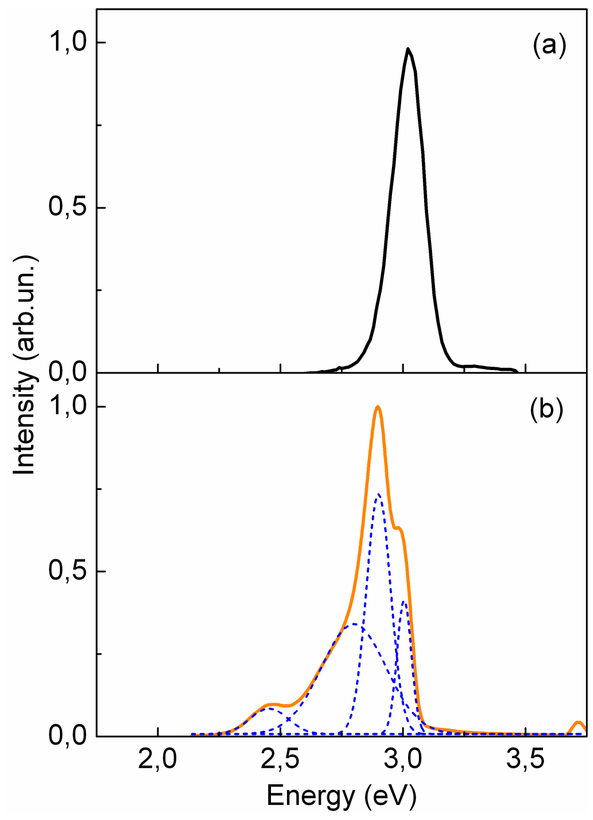

Fig 1. Luminescence spectra of:
(a) $NaCl–LaCl_3$(1 mol.%)–$EuCl_3$(0.1 mol.%) crystal upon the 301 nm excitation and
(b) $NaCl–EuCl_3$(0.01 mol.%) crystal upon the 275 nm excitation decomposed on four components. T=10 K.

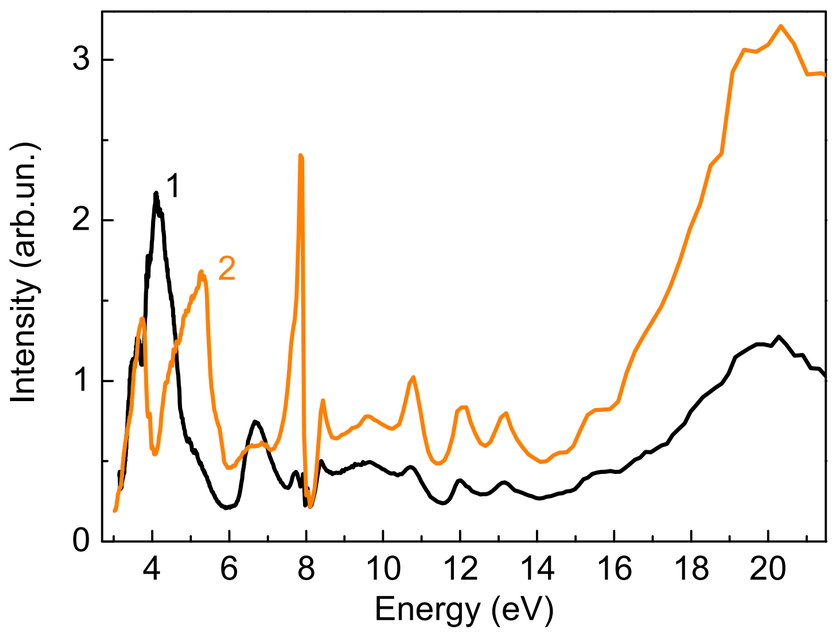

Fig 3. Excitation spectra of the Eu^{2+} emission in the $LaCl_3$ microcrystals (λ_{em}=405 nm, curve 1) and in the $NaCl–EuCl_3$(0.01 mol.%) crystal (λ_{em}=428 nm, curve 2). T=10 K.

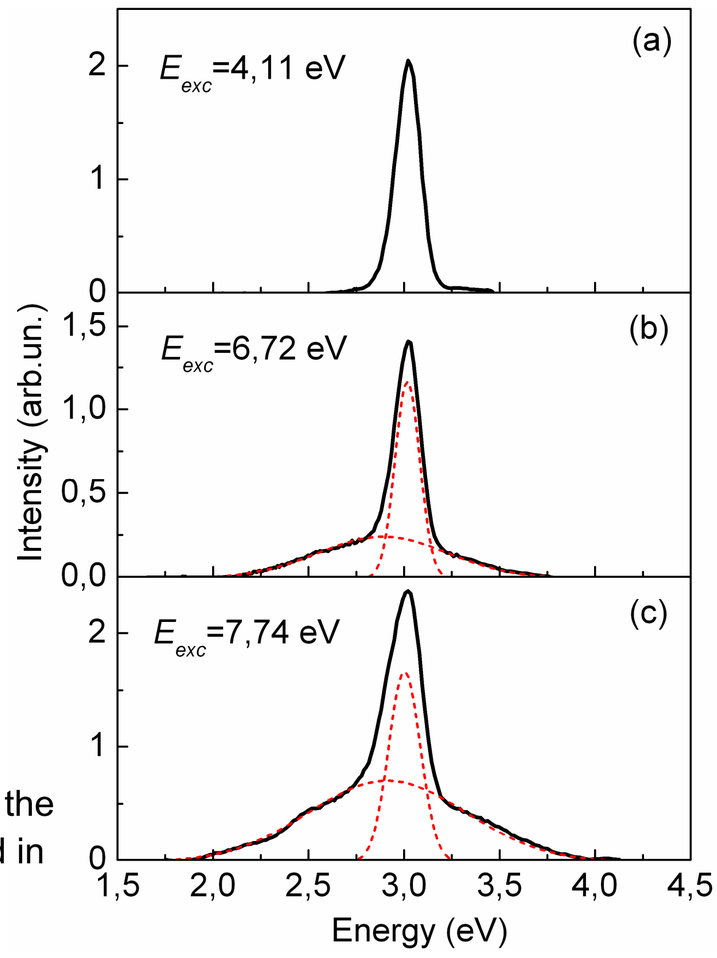

Fig 2. Luminescence spectra of the $NaCl–LaCl_3$(1mol.%)–$EuCl_3$(0.1mol.%) crystal upon the: (a) 4.11 eV, (b) 6.72 eV and (c) 7.74 eV. T=10 K.

Ion	E_{df}, eV	Γ(10K), eV	E_{fd}, eV	ΔS, eV	Crystal field splitting, cm^{-1}
Ce^{3+}	3.43 (360 nm), 3.69 (335 nm)	0.2 0.18	4.43, 4.52, 4.71, 4.96, 5.10	0.72	5600
Eu^{2+}	3.02 (410 nm)	0.15	3.5 4.18	0.44	5485

Table 1. Luminescent parameters of the 5*d*–4*f* emission of Ce^{3+} and Eu^{2+}-doped $LaCl_3$.

Conclusions

$LaCl_3:Eu^{2+}$ microcrystals dispersed in the NaCl host have been grown from the $NaCl–LaCl_3$(1 mol.%)–$EuCl_3$(0.1 mol.%) composition by the Bridgman-Stockbarger technique with subsequent annealing at 600 K during 48 hours. Since europium ions enter NaCl strictly as a divalent impurity, so they enter the $LaCl_3$ microcrystals also in the divalent state during the growth and heat treatment of our crystalline system. The low-temperature luminescence spectrum contains the intensive band peaking at 410 nm (3.02 eV) with half-width of 0.15 eV corresponding to the $4f^65d \rightarrow 4f^7$ transitions of Eu^{2+} ion in the $LaCl_3$ host upon the excitation in the absorption range of europium ions. The Eu^{2+} luminescence excitation spectrum of the $NaCl–LaCl_3–Eu$ crystalline system reveals efficient excitation in the range of:

I) intracenter absorbtion of Eu^{2+} ion with maxima at 3.6 and 4.1 eV;
II) fundamental absorption of $LaCl_3$ peaked at 6.7 eV. The presence of this band indicates the efficient energy transfer from STE of $LaCl_3$ to Eu^{2+} ions;
III) fundamental absorption of NaCl. Here, the excitation of Eu^{2+} emission is the result of the overlapping of p- component of STE emission of NaCl with the Eu^{2+} intracenter absorption and the overlapping of σ-component of STE emission of NaCl with the STE absorbtion band of $LaCl_3$ with subsequent energy transfer to Eu^{2+} ions.

Crystal field 10*Dq* splitting has been estimated for Eu^{2+} in $LaCl_3$ to be about 5485 cm^{-1}. It is in reasonable agreement with the obtained result (5600 cm^{-1}) for Ce^{3+}-doped $LaCl_3$ single crystal. The decay kinetics reveals the single-exponential profile with the decay time constant of about 250 ns without significant temperature dependence.