Luminescent properties of Eu^{2+} doped Sr-containing aggregates in CsI

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Introduction

Scintillation properties of CsI single crystal are known to be dependent on the amount and structure of defects. Activation of CsI by Me^{2+} (Ca, Sr, Ba) enables to form additional vacancies and defects in the crystal modifying its luminescent properties. Hence, the special interest consists in the behavior of Me^{2+} ions in CsI. At higher concentrations of impurity ions of Me^{2+} their aggregation is possible with the formation of stable precipitates or microcrystals. It is convenient to use Eu^{2+} ions as a luminescent probe for such aggregates revealing since in the case of microcrystals containing bivalent cation the impurity Eu^{2+} ions preferably will enter into them.

Experimental details

Single crystals of the CsI-$SrCl_2$(1 mol. %)-$EuCl_3$(0.02 mol. %), CsI-SrI_2(1 mol. %)-EuI_3(0.02 mol. %) composition were grown in evacuated quartz ampoules by the Bridgman technique. Further, the crystals were annealed at 200 ° C during 100 h for stimulation of aggregation processes. Measurements of the luminescence excitation and emission spectra were performed using the facility of SUPERLUMI station at HASYLAB (DESY, Hamburg). Microstructure studies of freshly cleaved surface of CsI-$SrCl_2$-Eu, CsI-SrI_2-Eu samples were performed using JEOL JSM-T220A scanning electron microscopy.

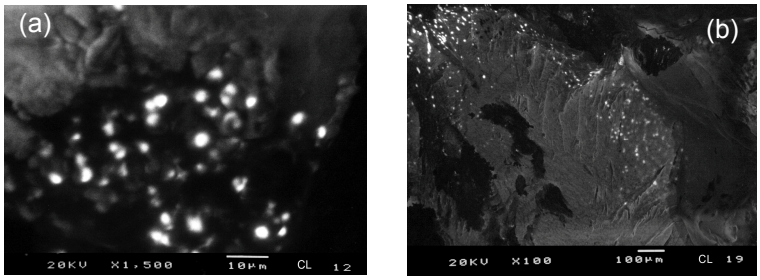

Fig. 1 Microphotos of freshly cleaved surface of CsI-$SrCl_2$-Eu (a), CsI-SrI_2-Eu (b) were performed using JEOL JSM-T220A scanning electron microscope in the cathodoluminescence mode

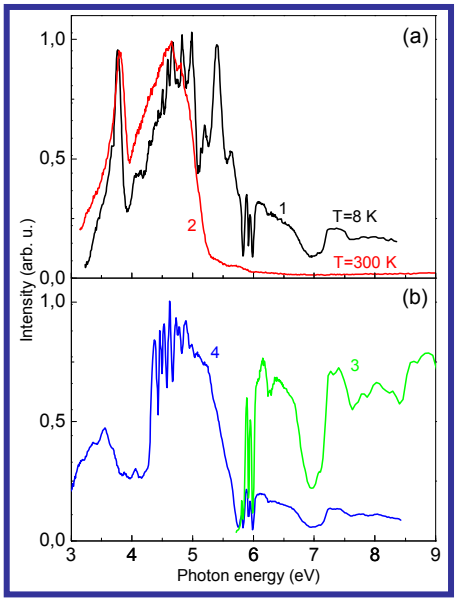

Fig. 4 Excitation spectra of the luminescence band peaked at: (a) 407 nm of CsI-$SrCl_2$-Eu at T=8 K (curve 1), T=300 K (curve 2); (b) 340 nm of CsI (curve 3) and 463 nm of CsI-SrI_2-Eu (curve 4), T=8 K

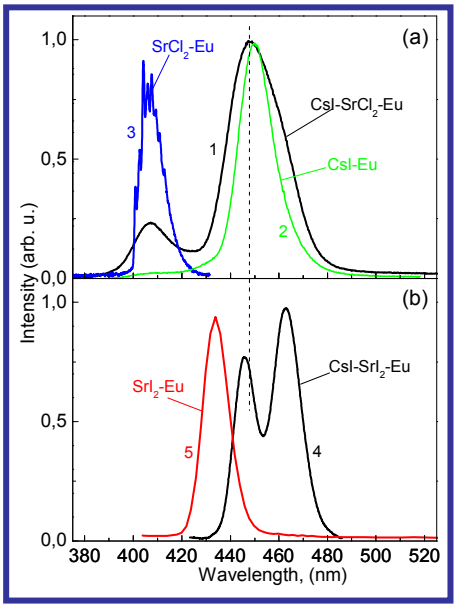

Fig. 2 Normalised photoluminescence spectra of: a) CsI-$SrCl_2$-Eu (curve 1), CsI-Eu (curve 2) and $SrCl_2$-Eu (curve 3); b) CsI-SrI_2-Eu (curve 4) and SrI_2-Eu (curve 5) upon the excitation of 330 nm at 8 K.

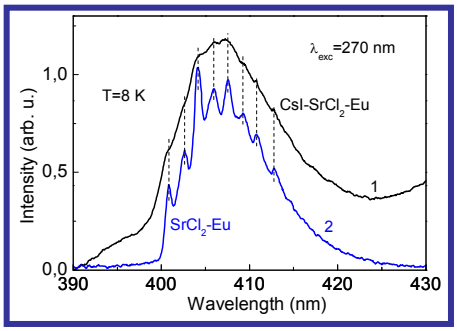

Fig. 3 Luminescence spectra of CsI-$SrCl_2$-Eu (curve 1), $SrCl_2$-Eu (curve 2)

Results and Discussion

The microcrystals of $SrCl_2$ with average size of 1-10 µm were revealed in CsI-$SrCl_2$(1 mol.%)-$EuCl_3$(0.02 mol.%) by electron beam analysis (fig. 1, a). Similar situation of effective formation of $BaCl_2$-Eu microcrystals are observed for CsI-$BaCl_2$-Eu [1]. In the case of CsI-SrI_2(1 mol.%)-EuI_3(0.02 mol.%), microcrystals with 1-20 µm with chemical composition corresponding $CsSrI_3$ phase (fig. 1, b). The luminescence band peaked at 407 nm of CsI-$SrCl_2$-Eu upon optical excitation (T=8 K) corresponds the europium emission in $SrCl_2$ microcrystals (fig. 2, a curve 1). The 448 nm band at relates to the europium emission in CsI.

The 463 nm luminescence band of CsI-SrI_2-Eu crystal corresponds to the Eu^{2+} ions emission in the $CsSrI_3$ aggregates embedded into CsI matrix (Fig. 2, b, curve 4). The vibronic structure of the luminescence spectrum is observed for $SrCl_2$-Eu microcrystals embedded into CsI similar to the single crystal (fig. 3). Luminescence of Eu ions in microaggregates embedded in CsI matrix is excited mainly in the 4f-5d transition range (3.3–5.2 eV) (fig. 4). In the fundamental absorbtion range of CsI matrix (>5.8 eV) the excitation of europium centers occurs due to the reabsorbtion of the STE emission of CsI. The structure of excitation spectrum in this region is similar to the one of the STE emission of CsI (fig. 4 b, curve 3). At T=300 K the excitation of Eu^{2+} centers in the range of the band-to-band transitions of CsI host is absent since the energy transfer mechanism from matrix to impurity phase through electron-hole pairs does not realize. The absence of the luminescence band peaked at 435 nm in the crystalline systems of CsI-$SrCl_2$-Eu and CsI-SrI_2-Eu (fig. 2, curves 1 and 4 respectively) which spectrally coincides with the emission band of Eu^{2+} in SrI_2 matrix indicates the absence of aggregation processes of impurity Sr^{2+} ions with the formation of SrI_2 phase.

References

[1] A. Pushak, V. Vistovskyy, S. Myagkota, A. Voloshinovskii, N. Shiran. Book of Abstract "Engineering of Scintillations Materials and Radiation Technologies" – 2010. – Nov. 14-19. – Kharkiv, Ukraine. – P. 90.