Luminescent properties of $SrCl_2$-Eu microcrystals embedded in NaCl host

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Single crystals of MeX_2 type (Me=Ca, Sr, Ba; X=Cl, I) doped by the rare-earth ions are of special interest since they are considered as promising materials for effective scintillators [1]. However, the significant hygroscopicity of these crystals prevents their detailed study and practical application. This drawback can be eliminated by the formation of the MeX_2-Eu type microcrystals embedded in insulator matrix. The conditions of the $SrCl_2$-Eu microcrystals formation embedded in NaCl host and the study of the microcrystal luminescence properties upon the excitation in the 4f-5d absorption of Eu^{2+} ions and in the region of band-to-band transitions of the NaCl matrix was the main purpose of this work.

The morphology of NaCl-$SrCl_2$(1 mol.%)-Eu(0.02mol.%) crystalline system was studied using the scanning electronic microscopy. Embedded microcrystals of 1 – 10 μm size were revealed on the microphotos. The electron beam analysis has shown the microcrystalline inclusions that contain Sr and Cl elements in mass ratio corresponding $SrCl_2$ compound. Time-resolved luminescent spectroscopy studies were performed at T=9-300 K using the facility of SUPERLUMI station at HASYLAB.

The luminescence spectra of $SrCl_2$-Eu (a) and NaCl-$SrCl_2$-$EuCl_3$ (b) crystals at 10 and 295 K are presented in Fig. 2. The spectral position of the luminescence band of Eu centers in NaCl-$SrCl_2$-$EuCl_3$ crystal is located at 404 nm and it coincides with the one of $SrCl_2$-Eu single crystal. This fact together with experimental evidences from the scanning electron microscopy allow us to state that in NaCl-$SrCl_2$(1 mol.%)-$EuCl_3$(0.02 mol.%) crystalline system the $SrCl_2$-Eu microcrystals embedded in NaCl host are created.

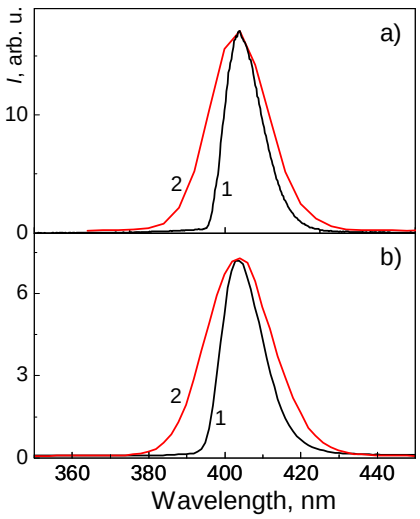

Figure 1: Luminescence spectra of $SrCl_2$-Eu (a) and NaCl-$SrCl_2$-Eu (b) crystals upon the excitation of quanta with λ_{exc}=333 nm at T=10 K (curve 1) and T=295 K (curve 2).

At the same time the absence of the 428 nm luminescence band which is typical for Eu centers in the luminescence spectra of NaCl-Eu system [2], indicates that majority of Eu ions enters in the $SrCl_2$ microcrystals. The Eu center luminescence excitation spectra of NaCl-$SrCl_2$-Eu system in the

transparency region of NaCl and $SrCl_2$ crystals contain two broad bands peaked at 3.7 and 4.8 eV (Fig. 2 b) corresponding to 4f-5d absorption transitions in Eu ions. [3]. These bands by the spectral position and structure coincide with excitation bands of Eu centres of $SrCl_2$-Eu single crystal (Fig. 2 a). It should be noted that the electron-vibrational structure of excitation bands in case of the microcrystals is identical to one in $SrCl_2$-Eu single crystal. This means that the spectral luminescent parameters of the $SrCl_2$-Eu microcrystals in NaCl matrix created during the annealing at 200 ºC are similar to ones of corresponding single crystal.

The Eu ion emission of NaCl-$SrCl_2$-Eu crystal upon the excitation in the NaCl fundamental absorption region (E > 7.5 eV) is mainly observed at low temperatures (Fig. 2 b, curve 1). This emission is appeared due to the reabsorption of self-trapped exciton (STE) luminescence from NaCl matrix. The structure of the excitation spectrum of Eu emission band in this region coincides with the structure of STE luminescence excitation band in NaCl crystal [4].

The decay kinetics of the 404 nm emission of the $SrCl_2$-Eu microcrystals embedded in NaCl matrix is characterized by the decay time constant of 460 ns at T=295 K. This decay time constant is shorter than one for the same luminescence band in the $SrCl_2$-Eu single crystal (670 ns, T=295 K). This difference in the decay time constants of Eu center luminescence is assumed to be caused by the different Eu concentration in the studied microcrystals and corresponding single crystal. It is known that with the increase of the concentration of Eu impurity centers the decay time of the $SrCl_2$-Eu single crystal luminescence is significantly increased [3].

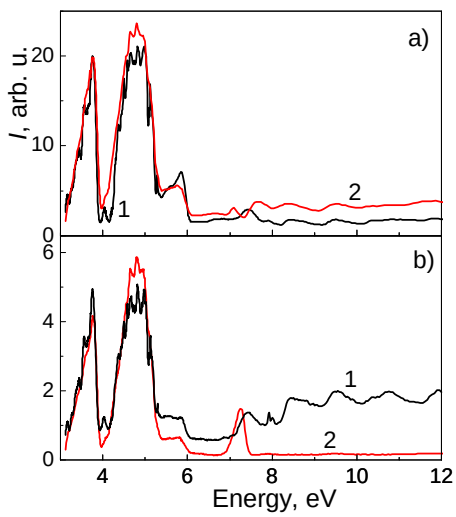

Figure 2: Luminescence excitation spectra of impurity Eu centres: (a) $SrCl_2$-Eu (λ_{em}=404 nm) and (b) NaCl-$SrCl_2$-Eu (λ_{em}=404 nm) at T=10 K (curve 1) and T=295 K (curve 2).

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