Luminescence of Eu$^{2+}$ doped Sr-containing aggregates embedded in KCl matrix

A.S. Pushak, V.V. Vistovskyy$^1$, Z.A. Khapko$^1$, A.S. Voloshinovskii$^1$
T.M. Demkiv$^1$, J.R. Dacyuk$^1$, A.V. Gektin$^2$ and S.V. Myagkota$^3$

Ukrainian Academy of Printing, 19 Pidgolosko Str., 79020 Lviv, Ukraine,
$^1$Ivan Franko National University of Lviv, 8 Kyryla i Mefodiya Str., 79005 Lviv, Ukraine
$^2$Institute for Scintillation Materials, National Academy of Sciences of Ukraine, 60 Lenina Ave, 61001 Kharkiv, Ukraine
$^3$Lviv State Agrarian University, 1 Volodymyra Velykogo Str., 80381 Dublyany, Ukraine

As it was shown in [1, 2] the NaCl-MeCl$_3$(1 mol.%)-EuCl$_3$(0.02 mol.%) (Me=Sr, Ba) crystalline systems are effective for the formation of MeCl$_2$-Eu microcrystals embedded in a NaCl matrix. Because the sodium ions do not form triple halides compounds with strontium or barium ions, the formation of MeCl$_2$ compounds in the matrix NaCl is observed only. However, it is of interest to obtain the microcrystals of ternary compounds (e. g. AMeX$_3$ (A=Cs, K; Me=Ca, Sr; X=Cl, I)) embedded in a dielectric matrix. Europium ions doped AMeX$_3$ crystals possess the good scintillation properties [3, 4]. In the same time, these compounds are strongly hygroscopic. Therefore, the obtaining of AMeX$_3$ compounds in the form of micro- or nanocrystals embedded in a dielectric matrix is of interest to prevent the influence of atmospheric moisture and to simplify their studying procedure. The KCl-SrCl$_2$(1 mol.%)-EuCl$_3$(0.02 mol.%) crystalline system is studied in this work with aim to reveal the formation of Eu$^{2+}$ doped strontium containing microphases embedded in KCl matrix.

The KCl-SrCl$_2$(1 mol.%)-EuCl$_3$(0.02 mol.%) and KCl-EuCl$_3$(0.1 mol.%) crystals were grown in evacuated quartz ampoules using the Bridgman–Stockbarger technique. As-grown KCl-SrCl$_2$-Eu crystals were annealed at 200 °C during 150 h for activation of aggregating processes. Time-resolved luminescent spectroscopy studies were performed at T=9−300 K using the facility of SUPERLUMI station at HASYLAB. The study of the morphology of the KCl-SrCl$_2$-Eu crystal surface was performed using JEOL JSM-T220A scanning electron microscopy.

![Luminescence spectra of KCl-SrCl$_2$-Eu](image)

Figure 1: Luminescence spectra of KCl-SrCl$_2$-Eu (curve 1), KCl-Eu (curve 2), $\lambda_{exc} = 300$ nm, T = 10 K.

The microphases of 1–10 microns size possessing the intensive luminescence were observed on freshly cleaved surface of KCl-SrCl$_2$-Eu crystal in cathodoluminescence mode by the scanning electron microscope. Energy-dispersive X-ray spectroscopy of the freshly cleaved surface revealed that these microphases contain K$^+$, Sr$^{2+}$ and Cl$^-$ ions in the ratio of 1:2:5. It could be the evidence of the KSr$_2$Cl$_5$ microcrystals formation in the KCl matrix.

The dominant band peaked at 426 nm in the luminescence spectrum of KCl-SrCl$_2$-Eu crystalline system (Fig. 1, curve 1) are observed. This band is attributed to the europium ions emission in
KSr$_2$Cl$_5$ microcrystals embedded in the KCl matrix. The week emission located at 418 nm corresponding to the europium ions emission in the KCl matrix (Fig. 1, curve 2) is also observed in the luminescence spectrum of KCl-SrCl$_2$-Eu.

The presence of weak 418 nm (curves 1) band in the luminescence spectra of KCl-SrCl$_2$-Eu crystalline systems indicates that a small number of europium ions remains in the KCl matrix and most of europium ions enter in the microcrystals. This fact demonstrates the high efficiency of formation of europium doped KSr$_2$Cl$_5$ microcrystals embedded in the KCl matrix.

The excitation of the europium ions emission in KSr$_2$Cl$_5$ microcrystals embedded in KCl matrix occurs mainly due to the intracenter absorption of europium ions in the transparency range of the KCl matrix ($E_{\text{exc}} < 7.5$ eV) (Fig. 2 curves 1). It should be noted that in the fundamental absorption range of the KCl matrix ($E_{\text{exc}} > 8.7$ eV) the excitation of europium emission is absent. This fact indicates the absence of reabsorption mechanism of energy transfer from matrix to the KSr$_2$Cl$_5$ microcrystals unlike to the NaCl-MeCl$_2$-Eu (Me=Sr, Ba) [1, 2], NaBr-LaBr$_3$-Ce [5], NaCl-LaCl$_3$-Ce [6], KCl-LaCl$_3$-Ce [7] crystalline systems. Reabsorption of intrinsic emission of KCl matrix is absent because the self-trapped exciton emission band (2.31 eV) of KCl matrix does not overlap the intracenter absorption region of europium ions in KSr$_2$Cl$_5$ microcrystals.

![Luminescence excitation spectra](image)

Figure 2: Luminescence excitation spectra of 426 nm band of KCl-SrCl$_2$-Eu crystal (curve 1) and 418 nm band of KCl-Eu crystal (curve 2) T = 10 K.

Acknowledgments: The authors would like to thank Dr. A. Kotlov for the support in the SUPERLUMI experiments. This work is supported by the 7th FP INCO.2010-6.1 grant agreement No. 266531 (project acronym SUCCESS).

References