Luminescence of irradiated CsI:Eu crystals: emission centers and energy transfer

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Motivation

High efficiency of Eu^{2+} radiative transitions is the main feature of new scintillators based on alkali earth halide crystals.

General trends in luminescence behavior in the case of divalent activator (Eu^{2+} in particular) is the driving force for this study.

Introduction

CsI crystals doped by isovalent impurity (Tl^+, In^+, Na^+) are well investigated scintillators. That is why this host was chosen for divalent activator influence. Eu^{2+} centers have various structures in different alkali halides [1-3].

It allows to justify specific of the energy transfer and luminescence parameters in a broad range of concentration and temperature.

Material and methods

CsI:Eu crystals were grown by Czochralski method.

Spectral characteristics of photoemission were studied using FLS920 fluorescence spectrometer. Excitation and emission spectra of UV-VUV region were carried out in the HASYLAB at DESY (Hamburg, Germany) using synchrotron radiation stations SUPERLUMI.

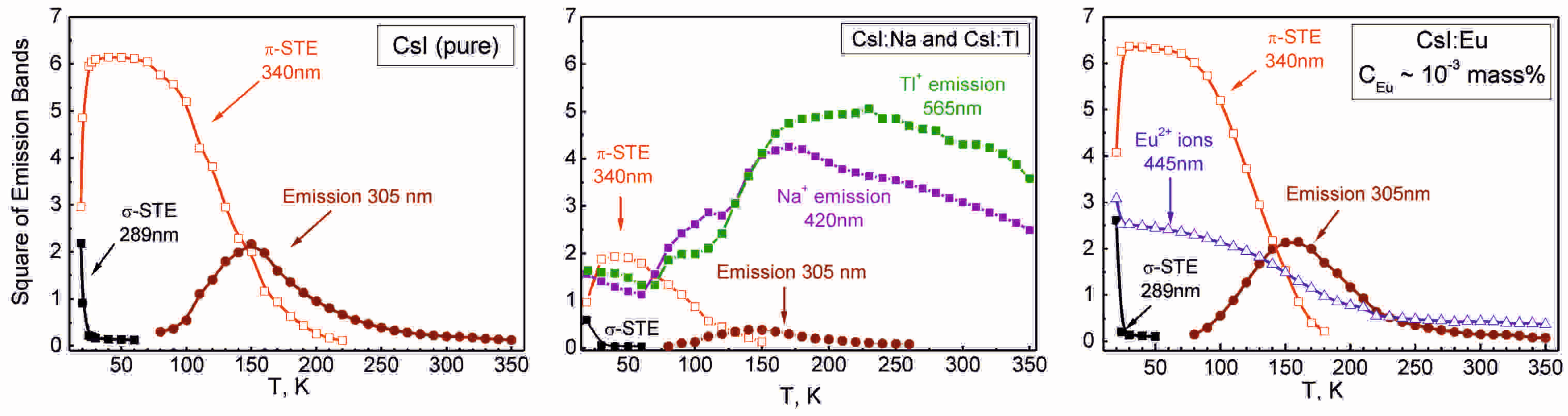
X-ray luminescence spectra were measured (X-ray tube, Tungsten anod, V = 30 kV, A = 30 mA). Irradiation of the samples was realized by X-ray tube (W, 10 mA, 150 kV).

Measurement of thermostimulation luminescent curves was carried out at heating rate of 0.08 K/sec and 0.2 K/sec in the range of 20-350 K and 290-550 K correspondingly.

The goal: The current work is aimed to research the influence of this divalent impurity on the energy transfer processes in the CsI crystals.

Results

Evolution of emission bands excited by X-ray in CsI as a function of temperature

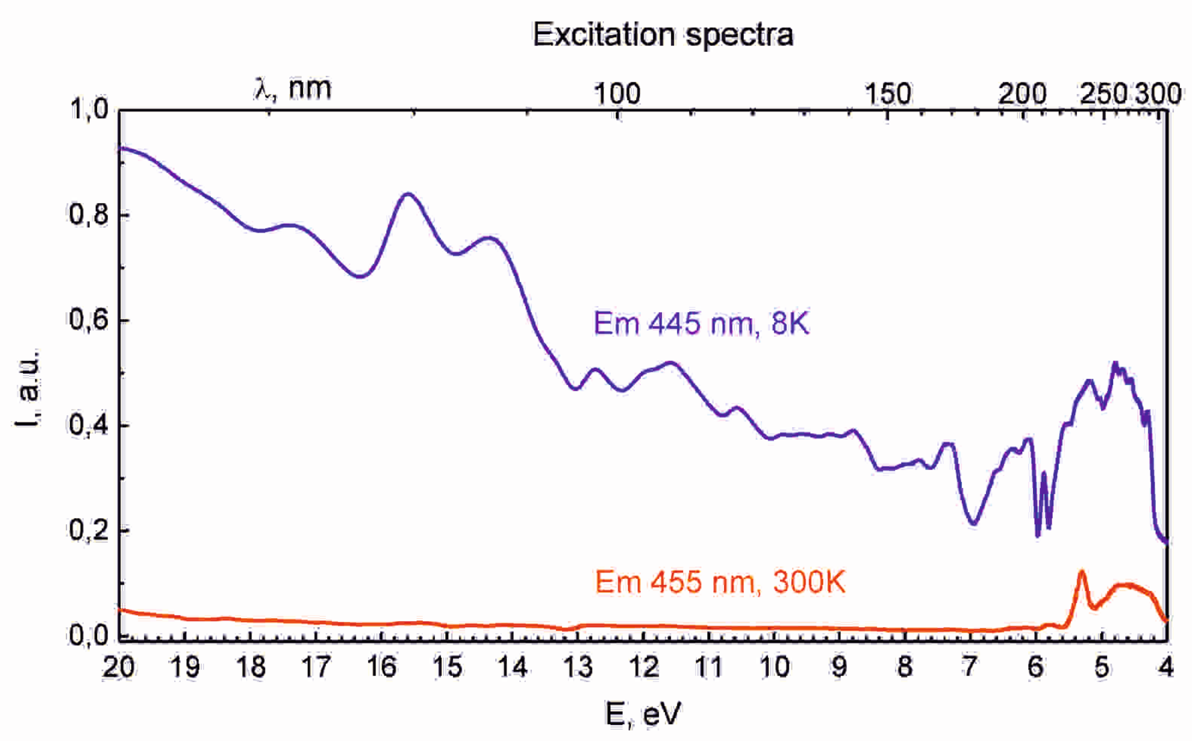


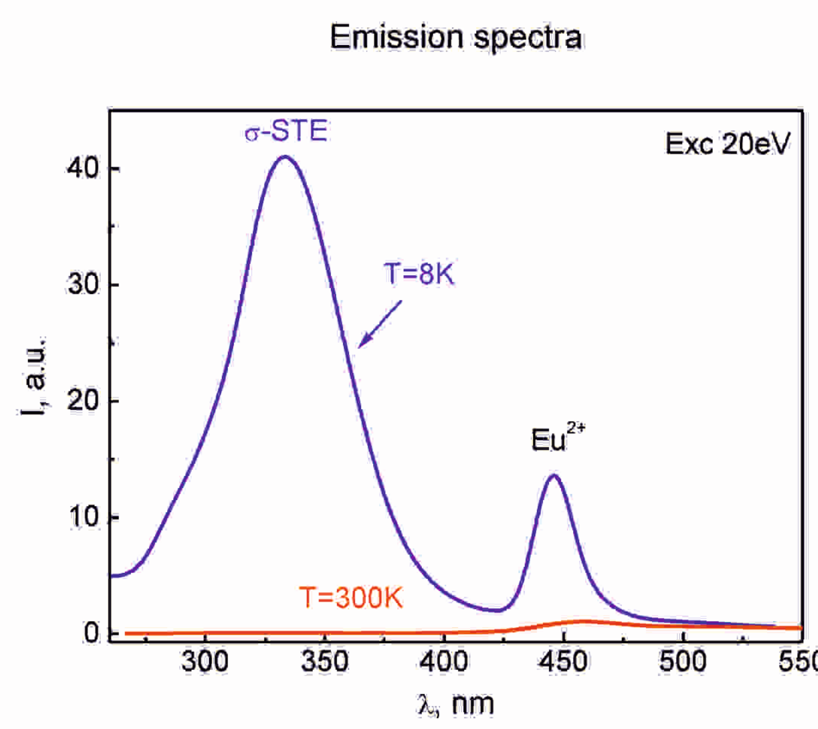
Spectra of isovalent (Na^+, Tl^+, In^+) [4] and divalent (Eu^{2+}) doped crystals are significantly different.

Luminescence yield increases with temperature decreasing like STE in pure CsI. In the case of Na^+, Tl^+ and In^+, the temperature dependence is reversed.

What are the main reasons of considerable difference?

Energy Transfer



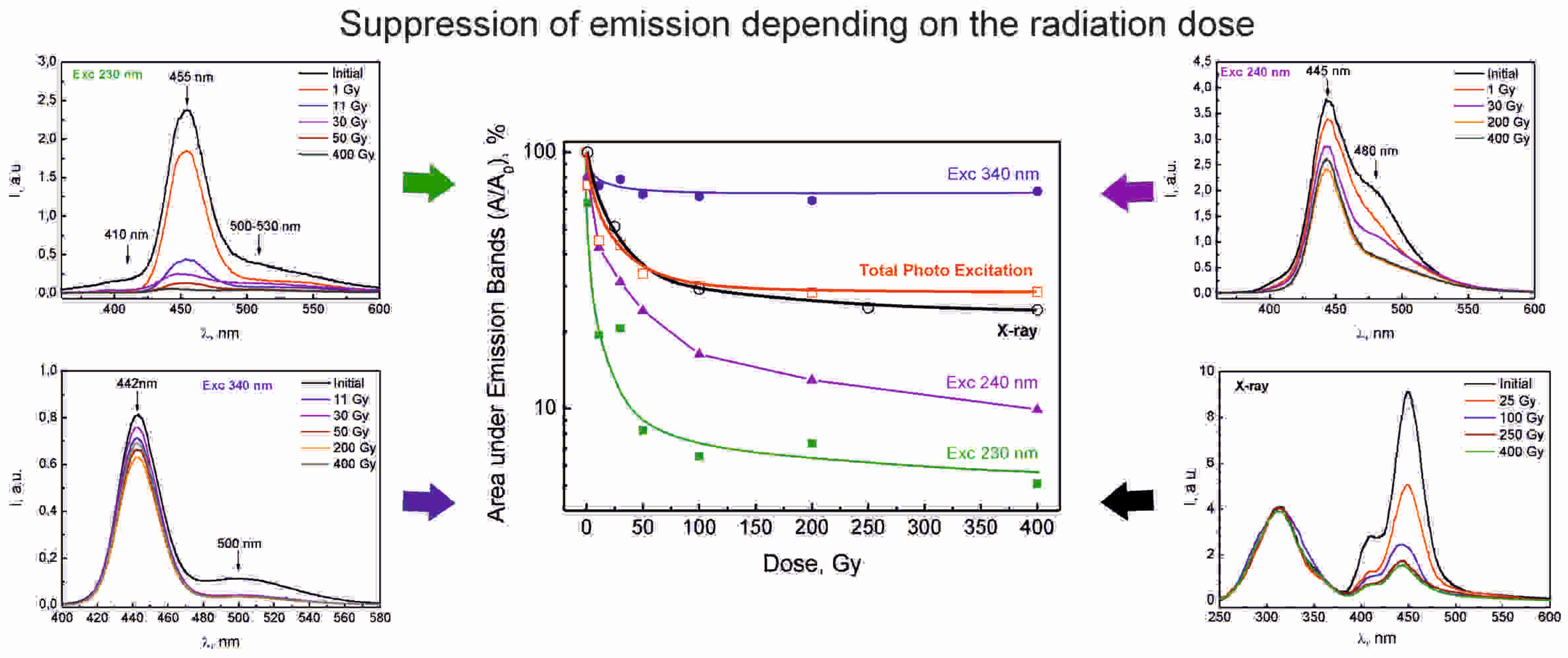


Excitation efficiency decreases with the temperature growth (see left fig.). It looks like STE luminescence quenching. Exciton transfer is not visible at all at RT. At the same time the contribution of electron-hole mechanism both at low and at room temperature is insignificant.

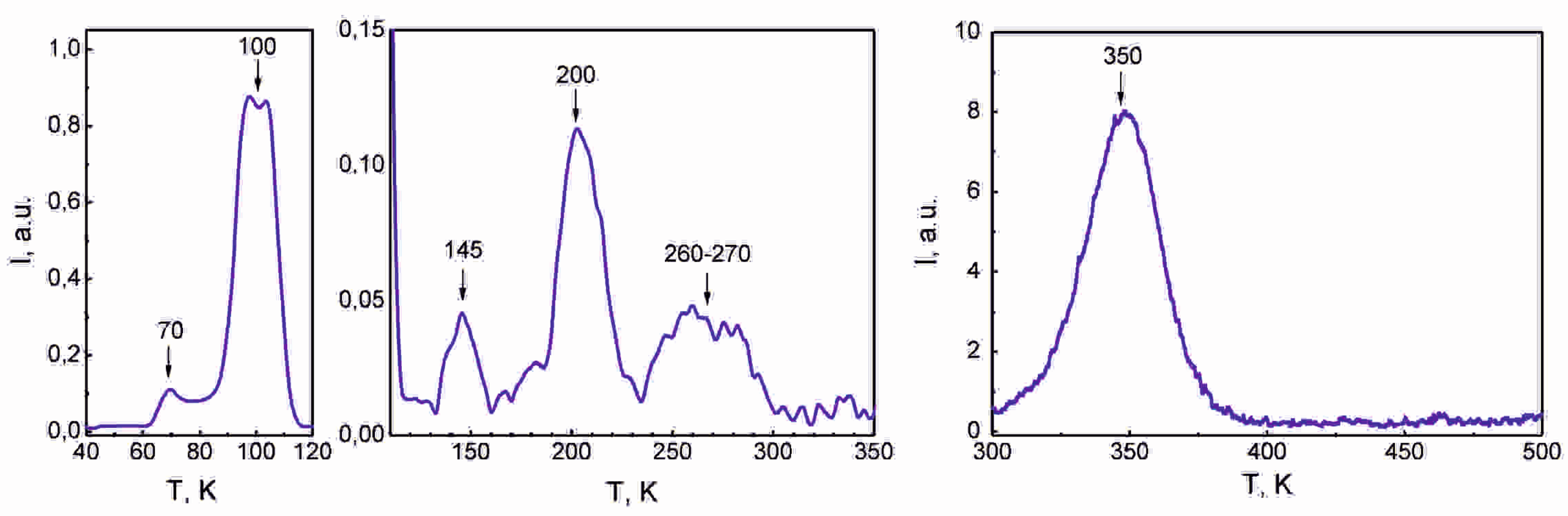
At RT the scintillation yield does not exceed 8000 ph/MeV that is in 6 times lower than that of CsI:Tl (52 000 ph/MeV).

Radiation Influence and Luminescence Centers Modifications

Suppression of emission depending on the radiation dose



Energy Storage



Different types of emission centers in Eu doped CsI crystals were observed. Contrary to isovalent doped CsI, CsI:Eu is not radiation hard, i.e. the part of absorbed energy is directed to the carrier capture and Eu^{2+} center transformations to "nonradiative" state.

All addition centers are not stable upon irradiation as well.

Conclusions

Luminescence and energy transfer in isovalent and divalent activated CsI crystals are significantly different. Difference of temperature dependence of the yield for Na^+, Tl^+, and Eu^{2+} luminescence confirms this resume.

At low temperatures the excitonic transfer to Eu-centers provides a high yield. At higher temperatures (with STE quenching) electron-hole energy transfer mechanism is very weak and does not allow to obtain high light output at RT.

The part of dissipated X-ray energy is directed to the Eu^{2+} centers modification. It is shown that luminescence centers in CsI:Eu are unstable, tend after irradiation to nonradiative structures. This is an extra reason for low CsI:Eu scintillation efficiency.

Reference:

1. F.J, Lopez, H.Murrieta S., J. Hernandez A. and Rubio O. Journal of Luminescence 26 (1981) 129-140
2. N. Shiran, A. Gektin, Y. Boyarintseva, S. Vasyukov, et. al. Optical Material 32 (2010) 1345-1348
3. A. Gektin, N. Shiran, A. Belsky, S. Vasyukov, Optical Material 34 (2012) 2017-2020

Acknowledgments

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