NON-PROPORTIONALITY EFFECTS IN A CLASSICAL CROSS-LUMINESCENCE MATERIAL BaF_2

Vitali Nagirnyi[1], Marco Kirm[1], Sergey I. Omelkov[1], Ivo Romet[1], Irina Kudryavtseva[1], Sanu Bifal Maji[1], Kirill Chernenko[2], Aleksei Kotlov[3], Yevheniia Smortsova[3]

[1]Institute of Physics, University of Tartu, Estonia, [2]MAX IV Laboratory, Lund University, Sweden, [3]Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

e-mail of presenting author: vitali.nagirnoi@ut.ee

Recent advances in the development of silicon photomultipliers towards high temporal resolution and ultra-violet light sensitivity renewed the interest to fluoride cross-luminescence (CL) materials, driven by their potential application as radiation detectors in high-energy physics experiments and time-of-flight positron emission tomography. The first known cross-luminescent material BaF_2, possessing one of the highest yields of CL [1], originating from the radiative recombination of electrons from the valence band with holes in the outermost core band, became again a potential candidate for fast timing. Moreover, additional ultra-fast components have recently been discovered in BaF_2 CL decay, looking promising for achieving very high time resolution [2].

In the present work, we investigate processes determining the lifetime of core excitations in pure and doped BaF_2, using several setups for time-resolved luminescence spectroscopy at the FinEstBeAMS and FemtoMAX beamlines of MAX IV Lab (Lund, Sweden), P23 and P66 beamlines of DESY (Hamburg, Germany), and a pulsed cathodoluminescence setup at the Institute of Physics (Tartu, Estonia), covering in total the excitation energy range from 4 eV to 120 keV and providing time resolution 30-160 ps. We report on the dynamics of ultrafast CL in various BaF_2 crystals. The CL process was modelled based on the GEANT4 software and the results of simulation were compared to the experimental CL excitation spectra. The CL decay kinetics is shown to be determined by mutual interaction of core excitations and their interaction with excitons, influenced by excitation density, impurity content and crystal surface quality. The ultra-fast CL decay components are proved to be related to quenching processes deteriorating the performance of a potential radiation detector.

References

1. P. Dorenbos et al., *IEEE TNS*, 40 (1993) 424-430.

2. S. Gundacker et al., *Phys. Med. Biol.,* 66 (2021) 114002.