Ceriu legiruotų daugiakomponenčių granato tipo scintiliatorių, kurių sudėtyje yra skirtingi retųjų žemių elemenetų jonai, optinės savybės

Optical properties of Ce-doped multicomponent garnet-type scintillators containing different rare earth ions

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The applicability of scintillators for the detectors of ionizing radiation depends predominantly on their light yield, scintillation decay time, afterglow, radiation tolerance, and energy resolution. Cerium-doped multi-component garnet structure scintillators show a high light yield and a strong resistance to ionizing radiation. These features enable their application in high-energy physics experiments, medical imaging, and other applications. However, these crystals are prone to the formation of substitution-type defects degrading their scintillation response time parameters that is important for the application of these scintillators in ionizing radiation detectors. A solution to this problem is growing the scintillators by liquid-phase epitaxy (LPE) favourable for diminishing the density of the defects due to a lower growth temperature. The aim of this study is to investigate the influence of composition on the optical properties of scintillators grown by LPE.

Four samples of cerium-doped multicomponent garnet structure scintillators grown on an undoped YAG substrate were investigated: lutetium aluminum garnet ($Lu_3Al_5O_{12}$:Ce), yttrium aluminum garnet ($Y_3Al_5O_{12}$:Ce), terbium aluminum garnet ($Tb_3Al_5O_{12}$:Ce), and gadolinium-lutetium aluminum garnet ($Gd_{2,5}Al_{0,5}$AG:Ce). All the layers were ~22 µm thick.

The experimental setup used to study the optical properties of consists of a WITec alpha300 S scanning confocal microscope equipped with 0.55 numerical aperture objective. The photoluminescence was excited using a Kimmon Koha continuous wave He-Cd gas laser IK5451RE operating at 442 nm with a TEM_{00} transverse mode. The signal was recorded using a WITec spectrometer UHTS 300 with photodetector with thermoelectric cooling at -70°C. All measurements were performed at room temperature.

The analysis of the measurement results showed that YAG:Ce garnet has the highest photoluminescence intensity, whereas GdAG:Ce has the lowest intensity (see Fig. 1). The photoluminescence spectrum is most redshifted in GdAG: Ce, whereas $Lu_3Al_5O_{12}$: Ce exhibits the most blueshifted photoluminesnce.

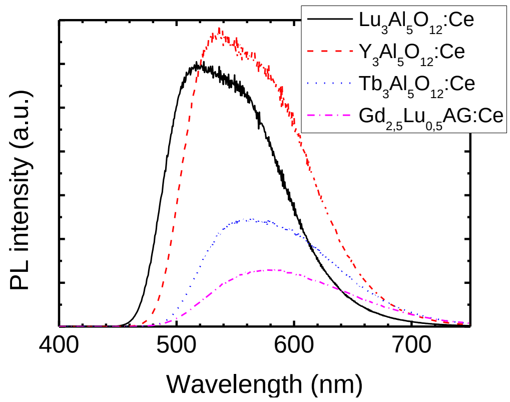

Fig. 1: Photoluminescence spectra of scintillating layers with different compositions (indicated)

The spatial distributions of different photoluminescence parameters (integrated intensity, mean wavelength, FWHM) were also measured and evidenced substantial differences in the layers of different compositions. These results are interpreted by the difference in ionic radius of Lu^{3+}, Y^{3+}, Tb^{3+} and Gd^{3+} ions in the scintillator matrix and the interaction of the lattice-building atoms with activator ions Ce^{3+}, as well as by the structural inhomogeneities in the layers occurring in the growth process.

Keywords: scintillators, confocal microscopy, yttrium aluminium garnet, lutetium aluminium garnet, terbium aluminium garnet, gadolinium-lutetium aluminium garnet, cerium.