Growth and study of multicomponent garnet scintillators

Aluminum garnets, $(Y,Lu)_3Al_5O_{12}$:Ce are a promising candidate for the next generation of the efficient scintillators [1]. However, they suffer from the contribution of the undesired slow component in the scintillation response [2]. The Mg^{2+} codoping strategy might improved some scintillation characteristic.

During my stay in Professor Yoshikawa Laboratory at the Institute for Materials Research, Tohoku University I received accurate training in the growing of single crystals of oxides from the melt. My training was focused on the micro-pulling-down method. Using this technology, I successfully grew mixed garnet scintillation fibers. Totally I grew 2 series (10 single crystals) of Ce-doped and Mg-codoped LuYAG single crystals with various Lu/Y ratio to test the influence of Y admixture and Mg-codoping on the scintillation response. The Mg content in the grown crystals was 200 and 400 ppm, whilst the concentration of Ce was 200 ppm in all grew samples. Figure 1 shows the example of the grown $Y_{0.25}Lu_{0.75}Al_5O_{12}$:Ce,Mg single crystal (length ~4 cm, diameter ~2.5 cm). The Mg^{2+} codoping creates an additional fast radiative recombination pathway, which can efficiently compete in electron trapping from the conduction band with the shallow electron traps in the YAG and LuAG host lattice [3]. Such a pathway is realized by the stabilization of a tetravalent Ce^{4+} center in the garnet lattice by divalent rare earth ion co-doping.

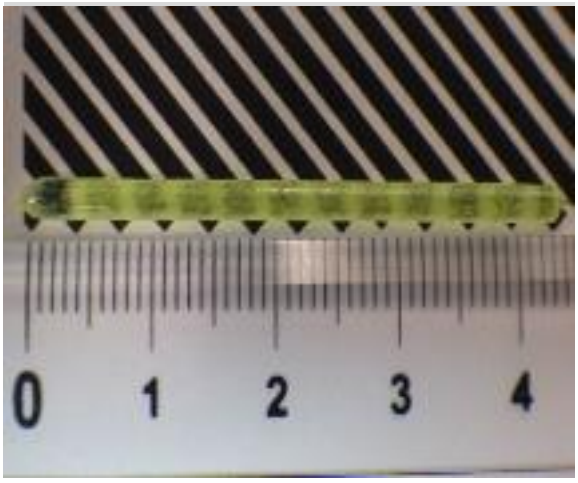

Fig. 1. Picture of $Y_{0.25}Lu_{0.75}Al_5O_{12}$:Ce,Mg single crystal

The presence of the stable Ce^{4+} luminescence centers in the grown crystals is clearly visible on the Fig. 2 by fingerprinted charge transfer absorption transition of the Ce^{4+} starting form 360 nm [4].

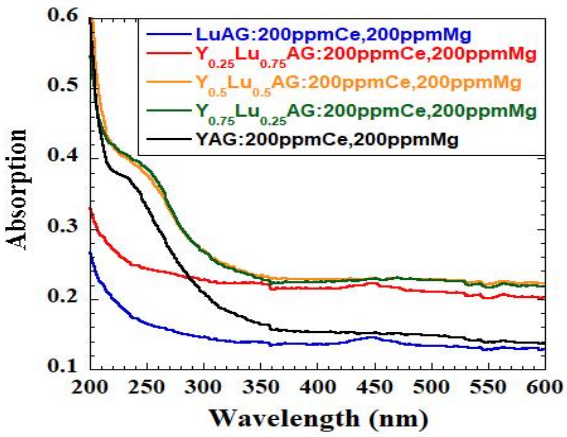

Fig. 2 The RT absorption spectra of $(Y,Lu)_3Al_5O_{12}$:Ce single crystals

Moreover, the $4f \rightarrow 5d_2$ and $4f \rightarrow 5d_1$ absorption transitions of the stable Ce^{3+} are not detected on the absorption spectra. This observation might suggest that relatively high content of Mg^{2+} ions transforms almost all stable Ce^{3+} luminescence centers into stable Ce^{4+}, which was the aim of this study. The high content of the of the stable Ce^{4+} luminescence centers in the grown single crystals might have positive impact on the scintillation characteristics. Namely, can significantly increase scintillation response and eliminate undesired rise time. However, at the same time it can reduce scintillation light yield value. More detailed measurements of the grown crystals will be performed at the group of Professor Marin Nikl at the Institute of Physics of the Czech Academy of Sciences in Prague, Czech Republic.

References

[1] M. Nikl, A. Yoshikawa, Adv. Optical Mater. 3, 463-481 (2015).
[2] M. Lucchini et al., Instr. Meth. Phys, Research A 852, 1-9 (2017).
[3] M. Nikl, et al., Growth Des. 14, 4827 (2014).
[4] Y. Wu, et al., Phys. Rev. Applied 2, 044009 (2014),

Keywords: crystal growth, luminescence, optical absorption
Full Name (Division Name or Affiliation) Karol Andrzej Bartosiewicz, Institute of Physics, Academy of Sciences of the Czech Republic
E-mail: karol@imr.tohoku.ac.jp