The Industry-Scale (Gd,Y)AlO_3:Ce Single Crystal: optical, luminescence and scintillation characterization

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In 1990's and first decade of new millenium great effort was devoted to the development of heavy analog of $YAlO_3$:Ce (YAP:Ce) scintillator, namely (Lu,Y)AlO_3:Ce (LuYAP:Ce) and even industrial-scale crystals were prepared [1]. Light yield of such material, however, reached only up to 12 000 phot/MeV, 50-60% of that of YAP:Ce and given the instability of perovskite phase in the growth from the melt the effectivity of crystal growth was low and their practical application failed. Another mixed crystal composition of heavy aluminum perovskite, namely (Gd,Lu)AlO_3:Ce, was also studied in very limited extent in 1990's, see review [2], and using a micropulling-down technique later on [3], but only a focused study of good quality Czochralski grown crystals [4] has shown high light yield exceeding 20 000 phot/MeV for a limited composition island within $Gd_xLu_{1-x}AlO_3$:Ce ($0.3<x<0.6$), which was enabled by fast enough energy migration in Gd sublattice. Consequently, also single crystals of $Gd_xY_{1-x}AlO_3$:Ce (GdYAP:Ce) grown by Czochralski method has recently become studied for scintillator application [5,6].
In CRYTUR, using the Czochralski growth from molybdenum crucible under reduction atmosphere, large size crystals of diameter 43-48 mm a cylinder length 85-90 mm were prepared [7]. The plate-shaped polished samples (1 mm thick) from both the beginning and the end of the crystal were prepared and subjected to a comprehensive set of measurements focused on the optical, luminescence and scintillation characteristics. Scintillation response in Fig. 1 is characterized by fast initial decay of promptly excited Ce^{3+} which is accelerated by the energy transfer towards Gd^{3+} sublattice. The slow component with decay times of few hundreds of ns is due to energy migration in the Gd-sublattice followed by the delayed luminescence at Ce^{3+}. Given such a fast-enough energy migration process, all the delayed luminescence light can be collected within the shaping time (~1-2 μs) of light yield measurement and high values up to 25 000 phot/MeV were reached. Together with excellent energy resolution around 4%@662keV, such a scintillator appears very promising for applications in radioisotope tracing in the environment and applications are under development in CRYTUR.
This talk will summarize the so far achieved results, bottlenecks and perspective of GdYAP:Ce single crystal scintillator.

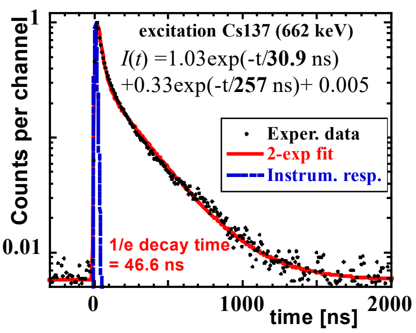

Fig. 1 Scintillation decay of $Gd_xY_{1-x}AlO_3$:Ce single crystal

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