Contribution ID: **18** Type: **Poster presentation**

Cerium-doped gadolinium fine aluminum gallate (Ce:GFAG) in scintillation spectrometry

Thursday 21 September 2017 10:03 (1 minute)

Scintillation crystals with high density and high atomic number coupled with photodetectors are commonly used in X-ray and gamma-ray spectrometry. There is continuous demand for new scintillation materials in such applications as industrial radiography, medical imaging techniques and nuclear and high-energy physics. In the case of modern scintillators, parameters such as high light yield, high gamma-ray absorption coefficient, good energy resolution, proportionality, and fast scintillation response, together with chemical and time stability and large sizes o the crystals, are of importance. These requirements were achieved by cerium-activated materials, such as Ce:LSO, Ce:LFS, Ce:GSO, and Ce:LaBr2, or Ce:LaCl3. The discovery of single crystal multicomponent garnet scintillators, based on YAG crystal with admixture of Ga and Gd, presented by Cherepy et al. [1] and Kamada et al. [2] provides new structures with high density and high atomic number. The emission spectrum of these crystals are about 520 nm, which makes them suitable for semiconductor photodetectors. The research on heavy ceramic scintillators led to the discovery of Ce:GAGG , which appeared to be one of the most attractive material for gamma-ray spectrometry, due to its high light output, fast decay time, good energy resolution and absence of intrinsic radioactivity [3]. The next step was the discovery of cerium-doped gadolinium fine aluminum gallate (Ce:GFAG), that has been reported by the manufacturer as faster decay time (about 50 ns of primary component of the light pulse) and better timing resolution than Ce:GAGG. High density of Ce:GFAG (Zeff = 52) and good energy resolution make it possible to apply in various nuclear technologies (PET, SPECT etc.). We have tested two samples of Ce:GFAG (both with dimension of 10x10x5 mm) in gamma-ray spectrometry with light readout through the photomultiplier (PMT) and the avalanche photodiode (APD). The parameters such as light output, energy resolution, non-proportionality, light pulses and timing resolution were measured.
The measurements of energy resolution obtained with Hamamatsu R-6231-100 PMT irradiated with 137Cs source gives the results of about 7 %, whereas for new samples of GAGG it was reported as about 6% [3]. The decay time measurements of Ce:GFAG gives the results significantly better that that of Ce:GAGG [3]: the fast component is at the level of 60 ns (54% intensity of the pulse) the medium one at about 120 ns (35% of the pulse). The third, slow component of the light pulse has a decay time of about 500 ns with only 10% intensity. A comparative discussion of GFAG performance in potential PET detectors to that of LSO, LFS, GSO and GAGG summarizes the study.

References:

[1] N. Cherepy et al Proceedings of SPIE 7079X, September 04, 2008

[2] K. Kamada et al., Journal of Physics D, Applied Physics 44 (2011) 505104

[3] P. Sibczynski et al. Nuclear Instruments and Methods in Physics Research A 772 (2015) 112

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Session Classification: Poster Session 3

Track Classification: P5_characterization