New Hybrid Scintillator Based on the $Lu_{1.5}Gd_{1.5}Al_{1.5}Ga_{3.5}O_{12}$ Single Crystalline Films and $Gd_3Al_{2.5-2}Ga_{2.5-3}O_{12}$ Crystals for Simultaneous Registration of α-Particles and γ-Quanta

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This work presents the results of creation of hybrid film-crystal scintillators based on the Ce^{3+} doped $Lu_{1.5}Gd_{1.5}Al_{1.5-2}Ga_{3.5-3}O_{12}$ single crystalline films (SCF), grown by liquid phase epitaxy (LPE) onto substrates prepared from undoped and Ce^{3+} doped $Gd_3Al_{2.5}Ga_{2.5}O_{12}$ (GAGG) single crystal (SC) from the super-cooling melt solution based on the $PbO\text{-}B_2O_3$ flux. We have found that the SCFs of the $Lu_{1.5}Gd_{1.5}Al_{1.5-2}Ga_{3.5-3}O_{12}$ mixed garnets can be grown onto GAGG substrates with a misfit of about 0.88-1.31%. We have also determined the segregation coefficients of Gd, Lu, Ga cations and Ce^{3+} impurity at LPE grown of these SCFs onto GAGG substrates.

We have shown that the best scintillation properties are observed in $Lu_{1.5}Gd_{1.5}Al_{1.5}Ga_{3.5}O_{12}$:Ce SCF. The light yield (LY) of these SCFs under α– particles excitation by Pu^{239} source (5.15 MeV) is comparable with the LY of reference YAG:Ce SCF. This SCF scintillator possesses also relatively fast scintillation response with $t_{1/e}$=105 ns and $t_{1/20}$=1078 ns. Such scintillation response is significantly faster in the 0-500 ns range than in the GAGG:Ce SC substrate. For this reasons the epitaxial structures based on the $Lu_{1.5}Gd_{1.5}Al_{1.5}Ga_{3.5}O_{12}$:Ce SCFs, grown onto GAGG:Ce SC substrates, can be used as hybrid scintillators for simultaneous registration of the components of mixed ionizing fluxes, specifically α– particles and γ– quanta, respectively. The separation of the signals from SCF and SC components of hybrid scintillator can be realized by the way of registration of the difference in the scintillation decay kinetics of SCF and substrate scintillators. Namely, the separation of the response from SCF and substrate can be achieved at large (>2) ratio K= $t_{1/e}$ (SCF) / $t_{1/e}$ (substrate). Taking into account that the scintillation decay times of $Gd_3Al_{2-2.5}Ga_{3-2.5}O_{12}$:Ce substrates are within $t_{1/e}$=248-418 ns and $t_{1/20}$=837-1543 ns ranges, the K ratio is equal to 4 and 2.36 for hybrid scintillators based on the $Lu_{1.5}Gd_{1.5}Al_{1.5}Ga_{3.5}O_{12}$:Ce SCF, grown onto $Gd_3Al_{2.5}Ga_{2.5}O_{12}$:Ce and $Gd_3Al_2Ga_3O_{12}$:Ce substrates, respectively.

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