Growth and characterization of $Gd_3(Sc,Al,Ga)_5O_{12}$:Ce and $Gd_3Sc_2(Al,Ga)_3O_{12}$:Ce,Mg multicomponent garnet crystals

The luminescence and scintillation characteristics of $Gd_3(Al,Sc,Ga)_5O_{12}$:Ce and $Gd_3Sc_2(Al,Ga)_3O_{12}$:Ce,Mg multicomponent garnet crystals grown by μ-PD method are presented. $Gd_3Sc_2Al_2GaO_{12}$:Ce shows high RL yield 340% of BGO, LY of 24,000 ph/MeV and energy resolution of 9.5% at 662 keV γ rays. $Gd_3Sc_2AlGa_2O_{12}$:Ce shows faster scintillation decay time of 12 ns (12%). The acceleration of decay time and simultaneous decrease of its LY value are obtained for the Mg^{2+} -codoped $Gd_3Sc_2(Al,Ga)_3O_{12}$:Ce,Mg samples.

$Gd_3Al_2Ga_3O_{12}$:Ce (GAGG:Ce) single crystal, prepared by the μ-PD down method, was discovered in 2011 and the first Czochralski - grown GAGG:Ce single crystal was reported one year later with high light yield (LY) of 46,000 ph/MeV [1]. Recently, an extremely high LY with fast scintillation decay time of about 90 - 120 ns were obtained for advanced GAGG:Ce crystals [2]. In this work, we investigate luminescence and scintillation properties of $Gd_3(Al,Sc,Ga)_5O_{12}$:Ce and Mg-codoped $Gd_3Sc_2(Al,Ga)_3O_{12}$:Ce multicomponent garnet crystals grown by the micro-pulling-down method.

An example of as-grown GSAGG:Ce crystal is shown in Fig.1. The starting materials used were an 4N(99.99%) purity powders. An Ir crucible was used in the atmosphere of Ar + 2%O2 to prevent evaporation of gallium oxide.

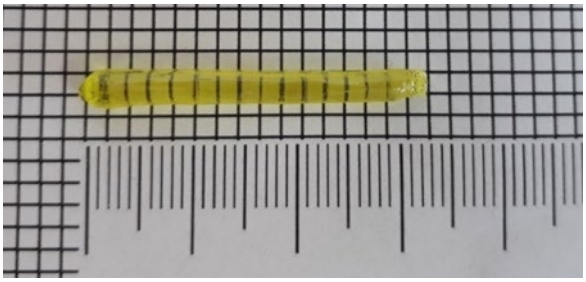

Fig. 1 As-grown GSAGG:Ce crystal

The RL spectra of GSAGG:Ce crystals at RT in comparison with a BGO crystal are presented in Figs. 2. The integral scintillation efficiencies for the studied samples relative to a BGO (100%) reference

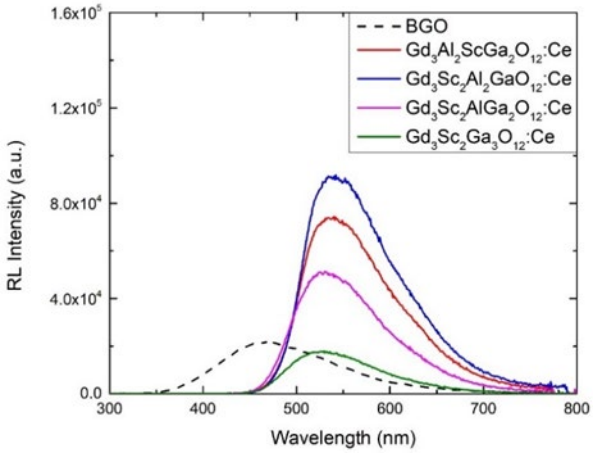

Fig.2 RL spectra of GSAG:Ce crystal ref. with BGO.

The LY(ph/MeV) and energy resolution (ΔE/E) are collected under excitation with a ^{137}Cs source by coupling the crystals to an R6231 PMT. $Gd_3Sc_2Al_2GaO_{12}$:Ce shows highest LY value of 23,970 ph/MeV, LY value gradually decreased with increasing Ga/Al ratio.

PL decay of GSAGG:Ce samples measured at RT under excitation in the 4f → 5d1 absorption of Ce^{3+}. The shortening of PL decay time with the increasing Ga/Al ratio in the same trend with the decrease of RL yield and LY value. This can be explained by a larger thermal ionization from the 5d1 excited states to the conduction band.

References

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