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Effect of Co-doping on Pulse Shape Discrimination Properties of Gd_3Ga_3Al_2O_12:Ce Scintillators

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Gadolinium gallium aluminum garnet ($Gd_3Ga_3Al_2O_{12}$, also called GGAG) doped with Cerium (Ce) has shown the best combination of the scintillation characteristics exhibiting high density (6.7 g/cm^3), effective atomic number (55), light yield of 54,000 ph/MeV and fast decay time of 55 ns **[1]**. The efficient and fast emission at 550 nm makes these scintillators very useful in the fabrication of compact detectors based on silicon photo-sensors. Single crystals of CsI:Tl, also having 550 nm emission, are conventionally used with different photo-sensors for various detection applications. Therefore, the comparison of both the crystals has been studied in details by many researchers. However the pulse shape discrimination properties of GGAG scintillators have not been explored in much detail.

The scintillation decay time of CsI:Tl detector, for gamma excitation, consists of two component having 700 ns and 3500 ns time with relative contribution of 57% and 43% respectively. Therefore, the average time for gamma radiation is calculated to be 1200 ns. The alpha radiation causes the acceleration of decay time in comparison with gamma excitation. The average time for alpha radiation is calculated to be 600 ns only. However, this trend was found to be opposite in case of GGAG scintillators where alpha radiation slows down the decay time to 284 ns (average) in comparison with average decay time of 108 ns with gamma excitation. Thus, the quenching mechanism by the higher ionization density which successfully explains the dependence of decay in CsI:Tl crystals on the mode of excitation does not explain the behavior of scintillation kinetics in GGAG:Ce crystals. Various co-doping in garnet scintillators have shown the strong affect on the scintillation properties **[2]**. The dependence of decay times on gamma and alpha radiations was studied in different co-doped GGAG crystals. The pulse shape discrimination capabilities were also observed to be dependent on the presence of co-doping, growth ambient and after growth annealing treatment. The results indicate the role of defect centers on charged particles discrimination characteristics of GGAG scintillators.

References

1. Kamada K. *et al.,* Journal of Crystal Growth 352, 2012, p. 88–90.
2. Tyagi M. *et al.,* Journal of Physics D 46, 2013, p. 475302.

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