Abstract

This research focuses on the scintillation properties of three types of crystals: pure and doped gallium oxide (β-Ga_2O_3), Ga-based spinels ($MgGa_2O_4$ and $ZnGa_2O_4$), and mixed (Zn,Be)Se crystals with Be compositions from 2% to 20%.

The study includes pulse height spectra, scintillation time profiles, and radio- and thermoluminescence measurements. For β-Ga_2O_3, the pure crystals achieved the highest scintillation yield (~9000 ph/MeV) and the best energy resolution (10.6%) with free electron concentrations of 10^{16} cm^{-3}. Higher free carrier concentrations led to decreased light yield due to Auger quenching. $MgGa_2O_4$ and $ZnGa_2O_4$ crystals were also found to scintillate under gamma irradiation, with yields up to 2500 ph/MeV. Mixed (Zn,Be)Se crystals initially showed low scintillation efficiency, but zinc vapor annealing increased the yield to 7700 ph/MeV for Be concentration of 2%. A new method for analyzing scintillation decay curves was developed, involving recording both the sample and apparatus responses, which were deconvolved and fitted with multi-exponential decay functions. This revealed that the fastest mean decay times were observed for samples with lower scintillation yields. Thus, a balance is needed to achieve both fast and efficient scintillation in β-Ga_2O_3, $MgGa_2O_4$, $ZnGa_2O_4$ and (Zn,Be)Se crystals, which is to be found by adjusting selected parameters prior to the crystal growth. Radioluminescence spectra revealed typical bands for all the studied materials, with some negative thermal quenching. Thermoluminescence measurements detected glow peaks in crystals across all categories, which were analyzed quantitatively. Additionally, the temperature dependence of relative light yield was examined, showing significant variation with temperature. For instance, β-Ga_2O_3 exhibited only 40% of its light yield at room temperature as compared to liquid N_2.

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