Possible ways to suppress an afterglow in CsI:Tl and NaI:Tl scintillators

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We have reviewed a four possible ways haw to suppress a millisecond afterglow (AG) in scintillation materials on a base of CsI:Tl and NaI:Tl crystals. Our analysis is ground on a supposition that nature of afterglow closely connected with the impurities which form traps with short lifetimes at room temperature.

First way is obvious and connected with additional purification of salt or melt. Indeed it is well known that crystal growth from pure salt (for instance so called "low background CsI") can provide a low level of AG in CsI:Tl crystal. Furthermore there are a lot of patents which show a possibility to suppress AG by melt purification before crystal growth.

Second way consists in changing of trap lifetime. As an example we considered a CsI:Tl,BO_2 material with very low AG level. Unstable traps in this crystal are transformed partly into color centers stable up to 400K. We believe that the same situation is characterized for CsI:Tl,Eu crystal. Introducing of Eu^{2+} ions into CsI lattice results in formation of precipitates consisting of three $Eu^{2+}V_C^-$ dipoles or mixed Eu-Ba complex. A mixed complex consisting of two $Eu^{2+}V_C^-$ dipoles and $Ba^{2+}V_C^-$ one has an increased thermal stability up to 300K instead 215K for $Ba^{2+}V_C^-$ dipole (trap of hole of V_F-type).

Third way consists in using quenched centers which can form a complex with activator and predominantly with traps. Such approach is realized for NaI:Tl crystal doped by O_2^- or NO_2^- ions and for CsI:Tl doped by NO_2^-. For instance in NaI:Tl crystal doped by O_2^- or NO_2^- ions the light yield is decreased less than 10 % but AG level up to ten times.

Fourth way is based on optical bleaching of unstable color centers. This approach is realized for NaI:Tl crystal only. For optical bleaching of F-centers (630 nm absorption band) the luminescence of ZnSe:Te crystal is used. Powder of ZnSe:Te plays a role of side or top reflector and emits a light with λ_{em} = 640 nm and decay time of τ = 100 μs. In this case the light yield depends strongly on light collection coefficient (construction of housing). Optimization of scintillator optical system allows suppressing the millisecond AG level significantly without appreciable decreasing of light yield.