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Luminescent properties of Cesium Hafnium Chloride scintillators doped with alkaline earth metals

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nbsp;High-energy-resolution scintillators are demanded for food/environmental gamma-ray monitoring systems in Fukushima or for other applications. Generally, halide scintillators have high light output due to small band-gap energy, and therefore high energy resolutions are expected [1]. However, almost all halide materials have hygroscopic nature, which makes them difficult to handle.
nbsp;In 2015, Cs₂HfCl₆ (CHC) has been reported as non-hygroscopic halide scintillator [2]. CHC has a high light output of up to 54,000 photons/MeV, and its energy resolution is estimated to be 3.3%, from full width at half maximum (FWHM), at 662 keV. In order to improve the energy resolution, we focused on its non-proportional response. In the case of LaBr₃, the non-proportional response improved by Sr²⁺-doping [3]. Therefore non-proportional response and energy resolution for CHC might be improved by doping alkaline earth metals as well. In this study, we report the effect of AE²⁺-doping (AE²⁺ is alkaline earth metals; Mg²⁺, Ca²⁺, Sr²⁺ and Ba²⁺) into Hf⁴⁺ site on scintillation properties.
nbsp;Non-doped and AE²⁺-doped CHC crystals were synthesized from 99.9%-pure (Zr-free) HfCl₄, 99.999%-pure CsCl, 99.999%-pure MgCl₂, 99.99%-pure CaCl₂, 99.998%-pure SrCl₂ and 99.99%-pure BaCl₂ from a nominal composition of Cs₂(Hf<sub>0.995</su
by the vertical Bridgman method. Crystal phases were identified by powder X-ray diffraction. Excitation/emission wavelengths were evaluated from photo- and X-ray excited radio-luminescence spectra. Light output, its non-proportionality, energy resolution and scintillation decay constant were evaluated using a ¹³⁷Cs gamma-ray source.
nbsp;Finally, we succeeded in growing non-doped and AE²⁺-doped CHC single crystals. The crystal structure of all specimens was determined as Fm-3m. No other phase was observed. Non-doped CHC showed broad emission around 400 nm under X-ray excitation. The light output and energy resolution were estimated to be 42,000 photons/MeV and 5.2% at 662 keV (FWHM), respectively. The scintillation decay constant was estimated using double exponential fitting, and fast component and slow component were determined to be 0.27 µs (4.5%) and 5.52 µs (95.5%), respectively.
nbsp;On the other hand, radio-luminescence emission spectrum of Mg:CHC was the same as for the non-doped CHC. Its light output and FWHM energy resolution were estimated to be 45,000 photons/MeV and 6.0% at 662 keV, respectively. The scintillation decay constant consisted of fast 0.69 µs (7.5%) and slow 5.99 µs (92.5%) components. In presentation, we show the results of other AE²⁺-doped CHC and discuss the relationship between their scintillation properties and co-doped elements.

References
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