

Improvement of Scintillation Light Yield in Ce:CaHfO₃ Single Crystal through Be-substitution

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Scintillation detectors are classified into photon-counting and integrated types. At present, Tl:CsI, Pr:Gd₂O₂S, and CdWO₄ are widely used in the integrated-type detectors. However, these materials suffer from chemical stability, optical transparency, and the content of Cd, a toxic element. Therefore, there is a demand for a scintillator with a large effective atomic number (Z_{eff}), high density, and properties that address the issues mentioned above. The present study focuses on Ce:CaHfO₃ single crystal (SC) with a large Z_{eff} (65.2), high density (6.95 g/cm³), and high chemical stability. In recent years, our research group has revealed that doping alkaline-earth metals to CaHfO₃ SC can enhance the scintillation light yield (LY) [1-4]. Leveraging this insight, this study aims to develop a novel heavy-element scintillator by partially substituting Be for Ca sites in Ce:CaHfO₃ SC, with the goal of achieving the LY surpassing that of CdWO₄ (15,800 photons/MeV).

Fig. 1 (left) shows the scintillation spectra of Ce:CaHfO₃ (unsubstituted) and Ce:Ca_{99%}Be_{1%}HfO₃ (Be-substituted) samples. The broad emission bands are observed, and the spectral shapes are similar to those of Ce³⁺-doped materials [1,2]. Therefore, the emission origin would be due to the 5d–4f transitions of Ce³⁺. Fig. 1 (right) shows pulse height spectra. Using commercially available Bi₄Ge₃O₁₂ as a reference and calculating the LY values, the LY values for the unsubstituted and Be-substituted samples are 12,700 and 16,600 photons/MeV, respectively. Based on these results, we have successfully developed a scintillator that outperforms the LY of CdWO₄ by substituting Be for Ca sites. On-site, the factors contributing to the increased LY are discussed based on the photoluminescence and the other scintillation properties.

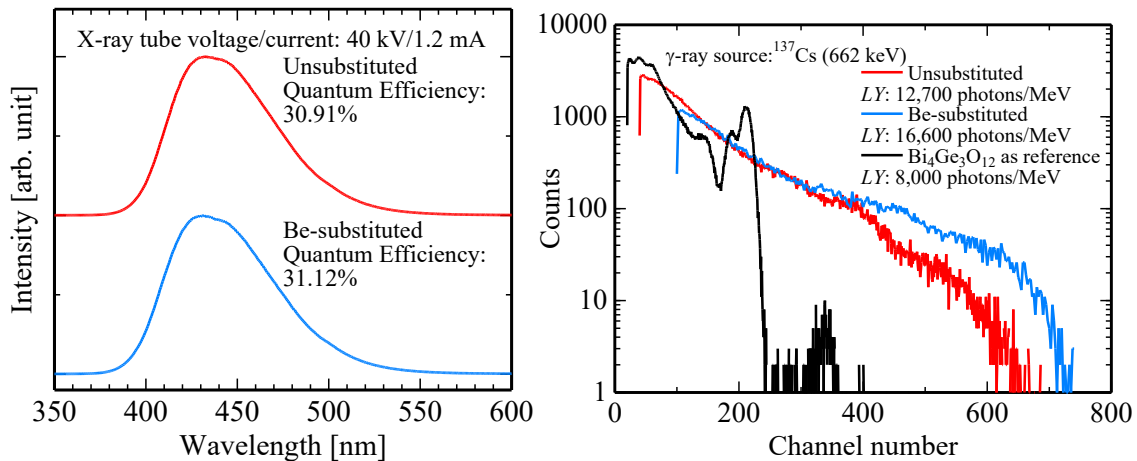


Fig. 1 (left) Scintillation spectra. (right) Pulse height spectra and calculated LY values.

References

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