

Radiation hardness of Cs₃Cu₂I₅ single crystal Perovskite scintillator

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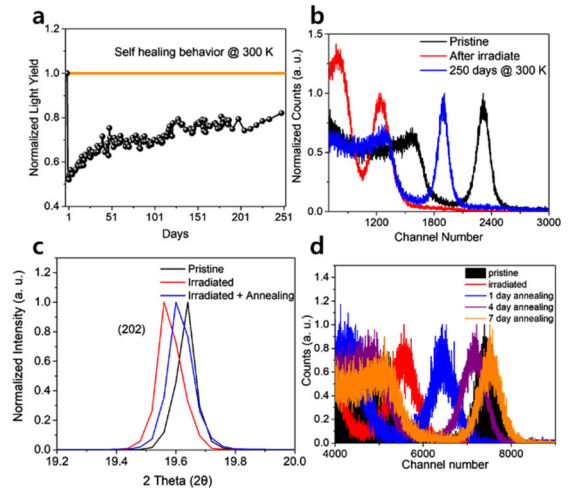
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Zero-dimensional (0D) perovskite scintillators have recently attracted significant attention for radiation detection owing to their high light yield and fast decay characteristics. Among them, Cs₃Cu₂I₅ (CCI) has emerged as a promising candidate. However, its radiation tolerance under high-dose gamma irradiation has not been systematically investigated. In this study, we evaluate the radiation resistance of single-crystal CCI scintillators and clarify the underlying degradation mechanisms.

High-quality CCI single crystals were synthesized via the slow vacuum evaporation technique and exhibited excellent crystallinity, as confirmed by X-ray diffraction. The as-grown CCI scintillator achieved an energy resolution of 5.2% at 662 keV (Cs-137), demonstrating its suitability for gamma-ray spectroscopy. To assess radiation tolerance, the samples were exposed to gamma-ray irradiation at a dose rate of 15 kGy/h, with cumulative doses up to 300 kGy. Scintillation performance was evaluated before and after irradiation using spectroscopy, optical transmittance, and photoluminescence analyses.

A significant reduction in light output was observed after the initial irradiation step, decreasing to approximately 55% of the initial value at 20 kGy. Notably, further irradiation up to 300 kGy caused no substantial additional degradation, indicating a saturation-like behavior in radiation-induced damage. Elemental analysis confirmed that the overall stoichiometry of the CCI crystals remained unchanged after irradiation, while X-ray photoelectron spectroscopy revealed the formation of iodine interstitial defects.

In addition, it was experimentally confirmed that the performance degradation induced by radiation can be recovered through thermal effects, either thermal energy of ambient air or by externally applied thermal treatment. The saturation behavior of radiation-induced attenuation and the thermally recoverable performance of the detector, demonstrates that the CCI single-crystal detector is well optimized for operation in extreme radiation environments.



Recovery behavior of CCI (a) recovery under ambient conditions of an irradiated CCI crystal, (b) pulse height spectra before/after irradiation and after recovery, (c) HR-XRD before/after irradiation and recovery, and (d) pulse height spectra before/after irradiation and thermal annealing.

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