Properties of Li-doped Perovskite scintillator grown by a room temperature solvent evaporation crystallization method

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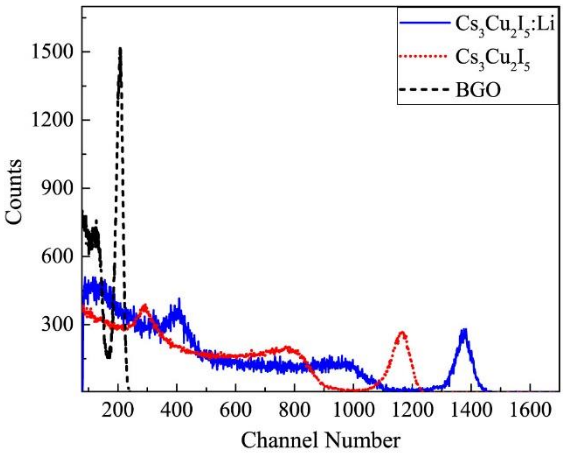
Lead-free metal halide perovskites, such as $Cs_3Cu_2I_5$, have attracted significant attention as environmental friendly alternatives to lead-based perovskites due to their excellent scintillation properties and promising applications in radiation detection. Elemental doping is a widely used strategy to tailor the structural, optical and scintillation properties of halide perovskites [1,2]. In this study, Li-doped $Cs_3Cu_2I_5$ single crystals were successfully synthesized at room temperature using a solvent evaporation method. The structural, compositional, optical and scintillation properties of the doped single crystal were systematically investigated. Li doping did not alter the crystal structure, phase, or the positions of the emission and excitation peaks. However, an increase in photoluminescence (PL) decay time was observed with Li doping, and a similar trend was observed in scintillation decay as well. Notably, Li doping led to improved scintillation performance, with the energy resolution at 662 keV improving from 5.8 % to 5.0 % and a 15 % improvement in light output. This improvement in both light output and energy resolution indicates a positive effect of Li incorporation on scintillation performance. These results align with those reported by Xiang et al. [3], reinforcing the role of trap state modulation by Li doping. In the undoped crystal, numerous deep-level defects likely exist within the bandgap, promoting non-radiative recombination. With Li doping, the shallow Li-related energy levels are introduced, which temporarily localize the excited electrons before they recombine radiatively through the STE state. This reduction in deep trap-mediated recombination pathways leads to enhanced radiative efficiency. Therefore, the observed improvement in scintillation performance for Li-doped $Cs_3Cu_2I_5$ may be attributed to the suppressed non-radiative transitions, demonstrating the effectiveness of doping strategies in optimizing halide perovskite scintillators. The impact of Li doping on the α/γ ratio and α-γ discrimination was also evaluated, revealing enhancements in both the α/γ ratio and in figure of merit (FoM). These results demonstrate the potential of low-cost, solution-grown Li-doped $Cs_3Cu_2I_5$ single crystals as efficient and versatile scintillators for the detection of different kinds of radiation and discrimination applications.



Pulse height spectra of Li-doped $Cs_3Cu_2I_5$, undoped $Cs_3Cu_2I_5$, and reference BGO scintillator for ^{137}Cs γ-ray source.

1. N. Shakti, et al. AIP Advances 8.1 (2018).
2. Z. Fang, et al. Advanced Science 5.12 (2018).
3. P. Xiang, et al. Journal of Materials Chemistry C 10.41 (2022).