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Growth Optimization and Ce Doping Engineering in CLLB/CLLBC Scintillators for Enhanced Neutron-Gamma Discrimination

Elpasolite scintillators notably $Cs_2LiLaBr_6$:Ce (CLLB) and $Cs_2LiLa(Br,Cl)_6$:Ce (CLLBC), play a critical role in neutron-gamma detection for homeland security and nuclear monitoring. In this work, high-quality CLLB crystals were grown using both the vertical Bridgman (VB) and traveling heater (THM) methods, guided by a constructed Cs_2LaBr_5-LiBr phase diagram. Focusing on performance tuning through Ce doping, detailed investigations revealed that the scintillation properties of CLLB-particularly energy resolution and neutron/gamma discrimination-are highly sensitive to the Ce concentration. Specifically, an energy resolution of approximately 3.0-3.5% at 662 keV was achieved once the effective Ce concentration exceeded 2%, with optimal neutron/gamma discrimination observed near 3% Ce doping. The effective segregation coefficient of Ce in CLLB was determined to be 1.59, and the THM process contributed to a homogenized Ce distribution, which is critical for performance control.
Further, CLLBC crystals grown via the VB method with Ce concentrations of 2-4% exhibited enhanced scintillation performance, including improved energy resolution, increased light yield and reduced decay times. Notably, the figure of merit (FOM) for pulse shape discrimination-a key metric quantifying the ability to distinguish between neutron and gamma events-increased from 1.6 to 2.0. This FOM enhancement underscores the improved pulse shape differentiation in CLLBC, which is essential for reducing misidentification in mixed radiation fields. These findings offer valuable insights into Ce doping optimization and growth methodology, paving the way for advanced neutron and gamma radiation detection technologies.

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