Monovalent ion doping effect on the scintillation properties of $BaCl_2$ single crystals for eutectic type thermal neutron detector

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[Introduction] Demand for thermal neutron detectors is rising, especially for lithium-ion battery inspection and nuclear power plant dosimetry. While ^{3}He gas detectors were standard due to their stability, recent resource depletion has created a significant supply-demand imbalance. To address this, ^{6}Li-containing solid scintillators, leveraging the ^{6}Li(n, α) reaction, are being developed. Eutectic scintillators, combining a ^{6}Li neutron capture phases with scintillator phases, are particularly promising as ^{3}He alternatives due to their high and flexible ^{6}Li content. $BaCl_2$ is considered a promising candidate for a scintillator phase owing to its low hygroscopicity and a refractive index comparable to that of LiCl, which serves as the neutron capture phase. Previous studies have reported the use of Eu:LiCl/$BaCl_2$[1], and Tb:$BaCl_2$/NaCl/KCl[2] for X-ray detection. In reference [2], it was suggested that the luminescence properties of the $BaCl_2$ phase may have been enhanced by the trace incorporation of NaCl or KCl, which were blended with $BaCl_2$ to form a eutectic composite.[3] The deliberate doping of trace amounts of monovalent cations such as Na^+ or K^+ into $BaCl_2$ and the subsequent analysis of its scintillation behavior are pivotal for optimizing the performance of the scintillator phase in eutectic-type thermal neutron detectors. Accordingly, the present study aimed to grow $BaCl_2$ crystals doped with Na, K, Tb, and Eu, characterize their scintillation properties, and assess their potential for practical implementation as a scintillator phase.

[Results] In the initial stage of this study, the effects of co-doping with monovalent cations on $BaCl_2$, which constitutes the scintillator phase, were systematically investigated. $BaCl_2$:K1% single crystal was grown by the VB method. The results of X-ray radioluminescence measurements demonstrated that the incorporation of monovalent potassium suppressed the self-trapped exciton (STE) emission near 300 nm, while enhancing the emission around 410 nm, which is associated with defects and impurities in $BaCl_2$.[4] The scintillation pulse height spectra were measured under ^{137}Cs gamma-ray irradiation, revealing that $BaCl_2$:K1% exhibited a light output three times greater than that of undoped $BaCl_2$. The results of detailed crystal growth procedures and other scintillation properties will be presented in the conference.

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[3] Yui Takizawa et al., Journal of Crystal Growth 580 (2022) 126467

[4] K. Onodera et al., Radiation Physics and Chemistry 78 (2009) 1031–1033