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In-situ diagnostics of phase separation and segregation during growth of Cs2LiLaBr6:Ce scintillator crystals by energy-resolved neutron imaging

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Scintillators development is often limited by issues of crystal growth reproducibility especially for crystal grown by the Bridgman technique, an intrinsically "blind" technique not suited for in-situ monitoring. Recent progress in high resolution energy-resolved neutron imaging provides unique possibilities to perform in-situ measurements of process parameters, which currently can be obtained only indirectly.

Our proof-of-principle experiments demonstrate the possibility to measure the elemental distribution, shape and location of liquid/solid interface and structural defects in Cs2LiLaBr6:Ce scintillator crystals during growth of a cm-size crystal by a Bridgman process.

The concentration of several elements (most accurately for Li) is imaged with sub-mm spatial resolution during crystal growth, revealing the dynamics of elements segregation across the boundaries between the solid and liquid as well within the liquid phases. A distinct separation into two liquid phases is observed above the solid/liquid interface. In the lower liquid phase volume the concentration of Cs is increased above stoichiometric value accompanied by the decrease of Li concentration, with Li concentration increased in the upper one.

In combination with finite element modeling of thermal profiles during crystal growth these in-situ diagnostics can be used to optimize the growth parameters, such as thermal profile, growth and cooling rates, and some others in order to improve the quality and yield of resulting scintillator materials. Ultimately, optimization of growth parameters through a feedback control can be performed as information on the growth process can be obtained in real time (minutes to hours in crystal growth terms). This should allow quick path in the search for optimal growth parameters, thus greatly reducing timescale between the laboratory material discovery and upscaling to commercial/production.

References

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