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In-situ diagnostics of crystal growth by energy-resolved neutron imaging

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There is usually a long delay between the discovery of novel single crystal materials and their use in practical applications. The new materials are often characterized with a small synthesized grain, while many applications require relatively large crystals (e.g. large enough to absorb gamma photons in case of gamma detectors). Introduction of new single crystal materials is often limited by the difficulties related to crystal growth. Optimization of single crystal growth techniques can benefit from the recent progress in high-resolution energy-resolved neutron imaging, which provides unique possibilities to perform in-situ measurements of process parameters, which currently can be obtained only indirectly.

This paper presents the results of recent experiments demonstrating the possibility to measure the elemental distribution, shape and location of liquid/solid interface and structural defects in several single crystal materials developed for gamma detection. The concentration of several elements is imaged with sub-mm spatial resolution during crystal growth, revealing the dynamics of elemental segregation across the boundaries between the solid and liquid phases as well within the liquid phases.

Our results indicate that the optimization of growth parameters can be performed through a feedback control as information on the growth process can be obtained in real time (minutes to hours in crystal growth terms). This should enable a 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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