

Lithium Iodide Scintillator for Advanced Neutron Instruments

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Although ⁶LiI:Eu scintillator was discovered decades ago, the potential of this material for bright emissions and/or fast timing has not been realized until recently [1]. Recently Boatner, *et al.* demonstrated 100,000 photons/neutron emission from LiI:Eu crystals [2], however such crystals are not commercially available. To benefit from such high brilliance and to take advantage of the high cross-section of 900 barns of ⁶Li for thermal neutrons, at RMD we undertook the development of ⁶LiI:Eu scintillator in a large area film form for neutron detection and imaging. These films have demonstrated brightness of up to 110,000 optical photons/neutron and spatial resolution down to 100 microns due to their microcolumnar structure. In addition to the brightness and efficiency, neutron/gamma discrimination is of critical importance, particularly for applications such as crystallography of small biological samples where signals are weak relative to background. Our efforts are now focused on achieving neutron/gamma discrimination to exceed 10⁻⁶, and perhaps to ~10⁻⁷ range. This paper will discuss our recent work on ⁶LiI:Eu film fabrication, adapting methods of improving neutron/gamma discrimination, applications in the areas of neutron crystallography, neutron radiography, and nondestructive testing.

With successful development and launch of ⁶LiI:Eu films, we are also in the process of developing ⁶LiI scintillator doped with Ce³⁺. As anticipated based on the Ce³⁺ 5d-4f transition, ⁶LiI:Ce [3] has demonstrated a primary fast decay component of 45 ns, which is orders of magnitude faster than the 1 ms decay observed in ⁶LiI:Eu. This fast timing has created the possibility to incorporate such scintillators in new neutron reflectometer designs which are expected to face instantaneous count rates up to 20 MHz or higher. We have scaled the ⁶LiI:Ce film fabrication to 10 × 10 cm² sizes and have conducted characterizations at ORNL HFIR and SNS sources.

This paper will discuss the vapor growth process for fabricating scintillators, scintillator packaging, developing stacked/layered scintillators for improving neutron/gamma discrimination, and measured scintillation and imaging performance for both ⁶LiI:Eu and ⁶LiI:Ce scintillators. Also included in the presentation are specific applications and advanced instruments where these films have been used/are planned to be used.

[1] V. V. Nagarkar, G. Velasco, J. Wang, N. Anastasi, S. Miller, A. Frost, M. Costa, M. Loyd, T. Visscher, C. Donahue, C. A. Montcalm, Y. Diawara, R. Riedel, B. Singh, Portable distortion free large solid angle coverage detector, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 1075, 2025, 170446.

[2] L.A. Boatner, E.P. Comer, G.W. Wright, J.O. Ramey, R.A. Riedel, G.E. Jellison, J.A. Kolopus, Improved Lithium Iodide neutron scintillator with Eu²⁺ activation II: Activator zoning and concentration effects in Bridgman-grown crystals NIMA 903 pp. 8-17 (2018).

[3] Lakshmi Soundara Pandian, Jun Wang, Pijush Bhattacharya, Nicholas Anastasi, Bipin Singh and Vivek Nagarkar, Fast ⁶LiI: Ce³⁺ Scintillators for High Count Rate Neutron Imaging Applications, 2025 J. Phys.: Conf. Ser. 3130 012003

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