La:Lu_2O_3 single crystal scintillators

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Lutetium oxide (Lu_2O_3) due to its remarkably high density (9.5 g/cm^3) and Z_{eff} of 68 is potentially excellent scintillating matrix with a low attenuation length. A wide band gap of 5.8 eV and the cubic crystal structure makes Lu_2O_3 matrix suitable for the incorporation of different rare-earth dopants in large concentrations [1,2]. For instance, La:Lu_2O_3 ceramics demonstrate promosing scintillation parameters – a fast decay (530, 1230 ns) and rise (600 ps) times, a light output of up to 15000 ph/MeV and an energy resolution of 5.3% at 662 keV, a very good proportionality of the light yield [3].

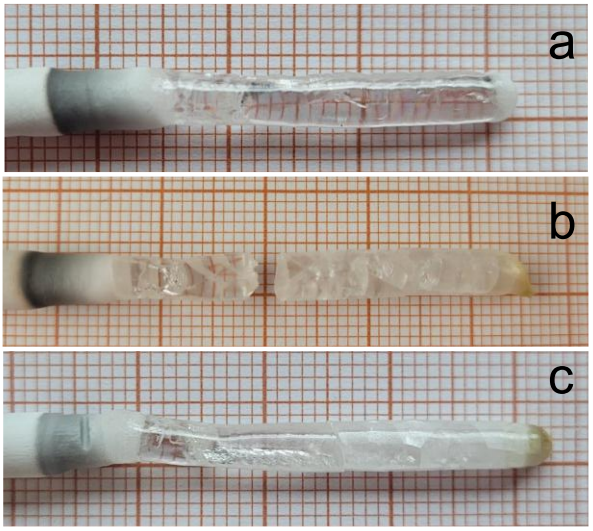

Figure 1. La-doped Lu_2O_3 single crystals with La content of 3 mol.% (a), 5 mol.% (b) and 7 mol% (c) grown by the OFZ.

Meanwhile, scintillation parameters of Lu_2O_3-based single crystals remain poorly studied, while potentially they should offer superior characteristics compared to ceramic samples due to higher structural uniformity. The main challenge associated with Lu_2O_3-based single crystals is extremely high-melting temperature above 2500 ºC. The crucible-free Floating Zone (OFZ) method excluding any interaction between the melt and crucible materials during the growth process emerges as an optimal approach for crystal growth of Lu_2O_3-based compounds.

In this work, a series of La:Lu_2O_3 single crystals with the various La^{3+} dopant contents were grown by the OFZ method (figure 1). While ingots contain some cracks, samples for characterization were fabricated from crack-free parts of the crystals. Structural, luminescent (optical excitation/emission photoluminescence and radioluminescence), and scintillation properties (light yield, non-proportionality, energy and time resolution, and decay time) were studied.

1. M. Guzik, "Structural Investigations of Lu_2O_3 as Single Crystal and Polycrystalline Transparent Ceramic," *Crystal Growth & Design*, **14**, 3327 (2014).
2. E. Zych, "Low-temperature luminescence of Lu_2O_3:Eu ceramics upon excitation with synchrotron radiation in the vicinity of band gap energy," *Chemistry of Materials*, **18**, 2194 (2006).
3. J. Glodo, "La Doped Lu_2O_3 Scintillator," *Optical Materials: X*, **26**, 100405 (2025).