

**Title:**

Engineered Nanostructuring in Lu<sub>2</sub>O<sub>3</sub>:Eu for Enhanced Scintillation Efficiency: From Core-Shell Design to Benchmarked Performance

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**Abstract:**

Nanostructuring in inorganic scintillators offers a potent route to control energy transfer pathways, yet its impact on overall scintillation efficiency is often counterbalanced by surface-induced losses. Here, we demonstrate a breakthrough via a sol-gel fabrication of core-shell Lu<sub>2</sub>O<sub>3</sub>:Eu nanoparticles, where an optically inert, epitaxial shell precisely passivates the active core. Spectroscopic and scintillation characterization reveals a dramatic suppression of surface quenching channels, resulting in a 40% increase in radioluminescence output compared to unpassivated counterparts. Combined with Monte Carlo simulations of energy deposition, we provide a comprehensive model that decouples the contributions of improved energy transfer from reduced surface recombination. The fabricated screens show superior spatial resolution in X-ray imaging tests, validating this engineered nanostructuring approach as a general strategy for optimizing the performance of nanocrystalline scintillators.

**Keywords:**

Nanostructuring, core-shell nanoparticles, Lu<sub>2</sub>O<sub>3</sub>:Eu, scintillation efficiency, surface passivation, radioluminescence, X-ray imaging, Monte Carlo simulation, energy transfer, nanocrystalline scintillators.