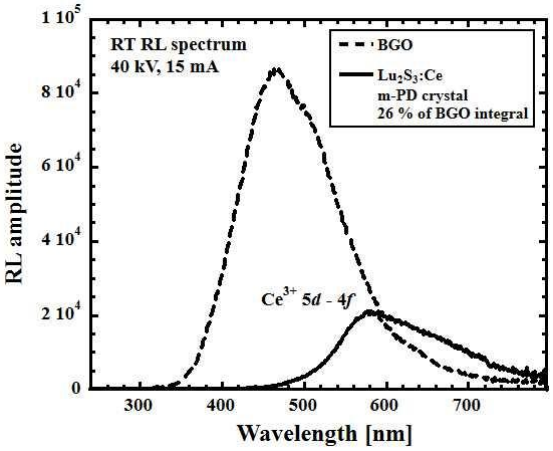
Red-Emitting Lu_2S_3:Ce Scintillator Prepared by Micro-Pulling-Down Crystal Growth

Monika Kotyková[1,2], Vojtěch Vaněček[1], Lubomír Havlák[1], Petr Golis[1], Vítězslav Jarý[1], Jan Bárta[1,2], Jakub Ježek[1]

[1]*Institute of Physics of the Czech Academy of Sciences, Prague, Czechia*
[2]*Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czechia*
Corresponding Author Email: kotykova@fzu.cz

In recent years, scintillators emitting in the red spectral region have attracted increasing attention due to the rapid development of semiconductor-based photodetectors, whose sensitivity to red photons surpasses that of conventional photomultiplier tubes. Among potential red-emitting scintillator materials, sesquisulfides represent a largely unexplored class. Recent results demonstrated the potential of sulfide-based crystalline materials: $KLuS_2:Pr^{3+}$ crystalline plates are excellent candidates for time-of-flight positron emission tomography, exhibiting an ultrafast scintillation decay time (< 1 ns) and a scintillation light yield of approx. 7000 ph/MeV (1), red-emitting Lu_2S_3:Ce, grown by the chemical vapor transport method, has been reported in Ref. (2). To the best of our knowledge, bulk sesquisulfide crystals with dimensions exceeding approx. 1 mm have not yet been reported. Sulfide materials have previously been studied mainly as novel laser media, while their scintillation properties remain insufficiently studied.



Room temperature radioluminescence spectrum of Lu_2S_3:Ce grown by micro-pulling-down method in comparison with radioluminescence spectrum of BGO.

In this contribution, we present a systematic investigation of the cerium-doped sesquisulfide Lu_2S_3. This material benefits from the high atomic number of lutetium (Z = 71) and a relatively high compound density (ρ = 6.25 g·cm^{-3}). The resulting high density and effective atomic number of Lu_2S_3:Ce (Z_{eff} = 66.8) are highly desirable properties for scintillators, as they enhance radiation detection efficiency and enable the fabrication of compact detectors compared to conventional materials with lower density and Z_{eff}.

The samples were prepared using the micro-pulling-down method, which allows rapid laboratory-scale growth of high-quality single crystals with dimensions of several millimeters. Phase purity and structural quality were verified by X-ray diffraction. Lu_2S_3:Ce exhibits a broad emission band centered at 580 nm, attributed to the allowed 5d–4f transition of Ce^{3+} ions. The integrated intensity is approximately 26 % of that of $Bi_4Ge_3O_{12}$ (BGO) single crystal. No other optically active impurities were detected. Owing to the dipole-allowed nature of the Ce^{3+} transition, the material shows a fast scintillation decay time on the order of 30 ns. Photoluminescence and scintillation characteristics of a series of micro-pulling down-grown samples will be presented. The light yield was evaluated using pulse-height spectroscopy, and the presence of possible slow decay components will be discussed.

(1) V. Jarý et al., " Efficient Ultrafast Scintillation of $KLuS_2:Pr^{3+}$ Phosphor: A Candidate for Fast-Timing Applications," *Phys. Rev. Applied* **19** (2023) 034092
(2) J. C. van't Spijker et al., "Lu2S3:Ce3+, A new red luminescing scintillator," *Nucl. Instr, and Meth. in Phys. Res. B* **134** (1998) 304-309
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