IOCN 2025 Conference — The 5th International Online Conference on Nanomaterials — 22-24 September 2025 | Online

EFFECT OF PROCESS PARAMETERS ON THE PROPERTIES OF YTTRIUM OXIDE CERAMICS

Vasilica Țucureanu[1*], Oana Brâncoveanu[1], Cosmin Romanițan[1], Iuliana Mihalache[1], Alina Matei[1*]

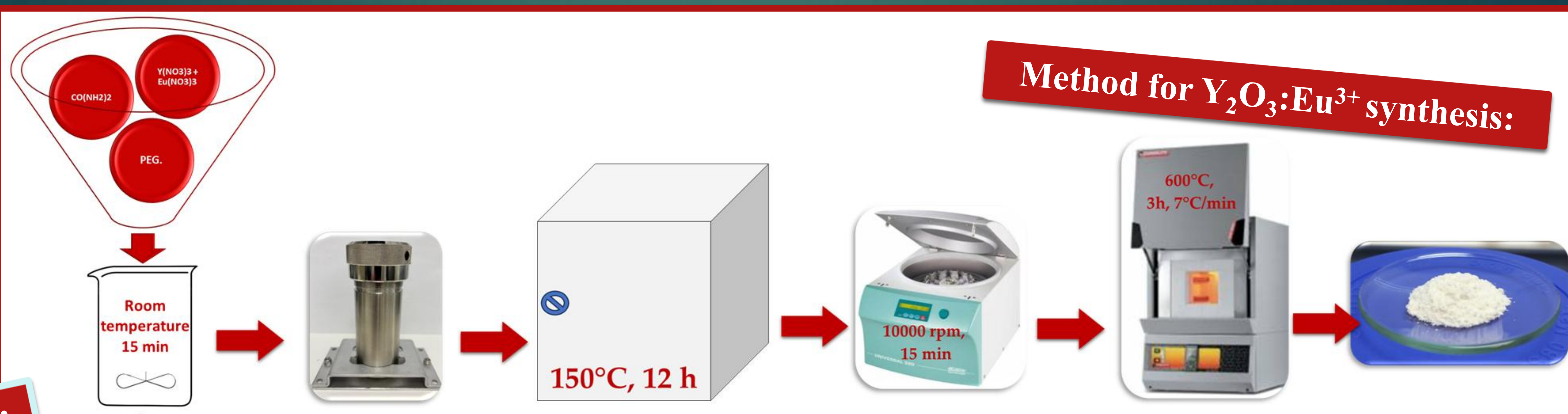
[1]National Institute for Research and Development in Microtehnologies (IMT-Bucharest), Erou Iancu Nicolae Street, 126A, 077190, Bucharest, Romania

[*]Corresponding author: e-mail: vasilica.tucureanu@imt.ro; alina.matei@imt.ro

Abstract:

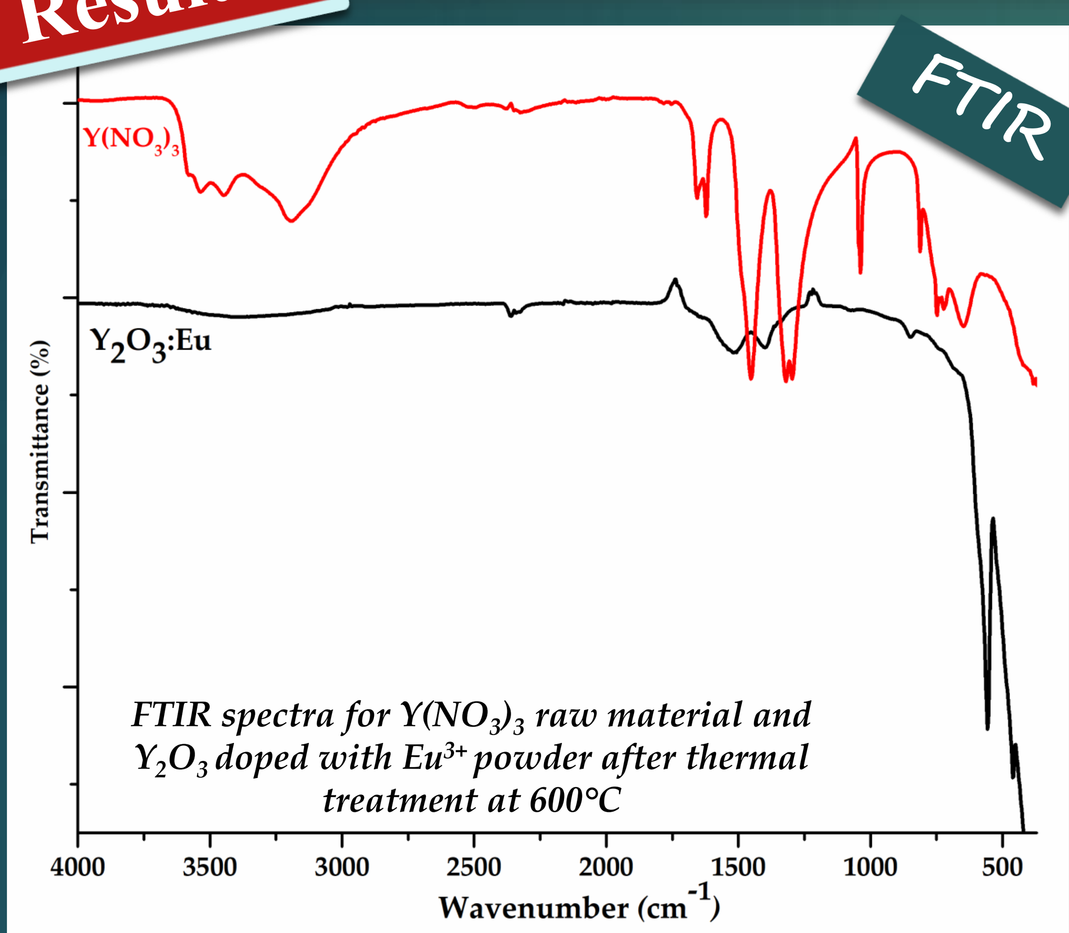
Transparent polycrystalline ceramics have been developed in response to the growing demand for new materials with multiple applications in advanced technologies. Yttrium oxide (Y_2O_3) is a ceramic material, intensively studied due to its superior qualities, which include optical clarity, biocompatibility, and chemical and thermal stability. In biotechnology, it can be used to create fluorescent labels, drug delivery systems, antimicrobial materials, lasers, and protective windows, among other. This paper aims to clarify certain methodological issues related to the synthesis of Y_2O_3 doped with rare earth ions. In this regard, a hydrothermal process involving the use of nitrates as a cation source, along with urea and polyethylene glycol was employed. The influence of the process parameters (type and concentration of raw materials, reaction time and temperature, influence of surfactant and intermediate steps, etc.) on the properties of Y_2O_3 was analyzed. Furthermore, the effectiveness of oxide doping was also evaluated. FTIR spectroscopy and X-ray diffraction were used to determine the chemical bonds, crystal structure, and purity of the material. The morphological properties influence the applicability of the oxide in the biotechnology field, so as not to raise toxicity problems in the liver or kidneys. The particles' rounded edges and spherical shape were visible under SEM microscopy. Studies on the optical properties confirmed the efficiency and applicability of the proposed method for obtaining yttrium oxide-based ceramics with potential applications in the biotechnology.

Method for $Y_2O_3:Eu^{3+}$ synthesis:



Results:

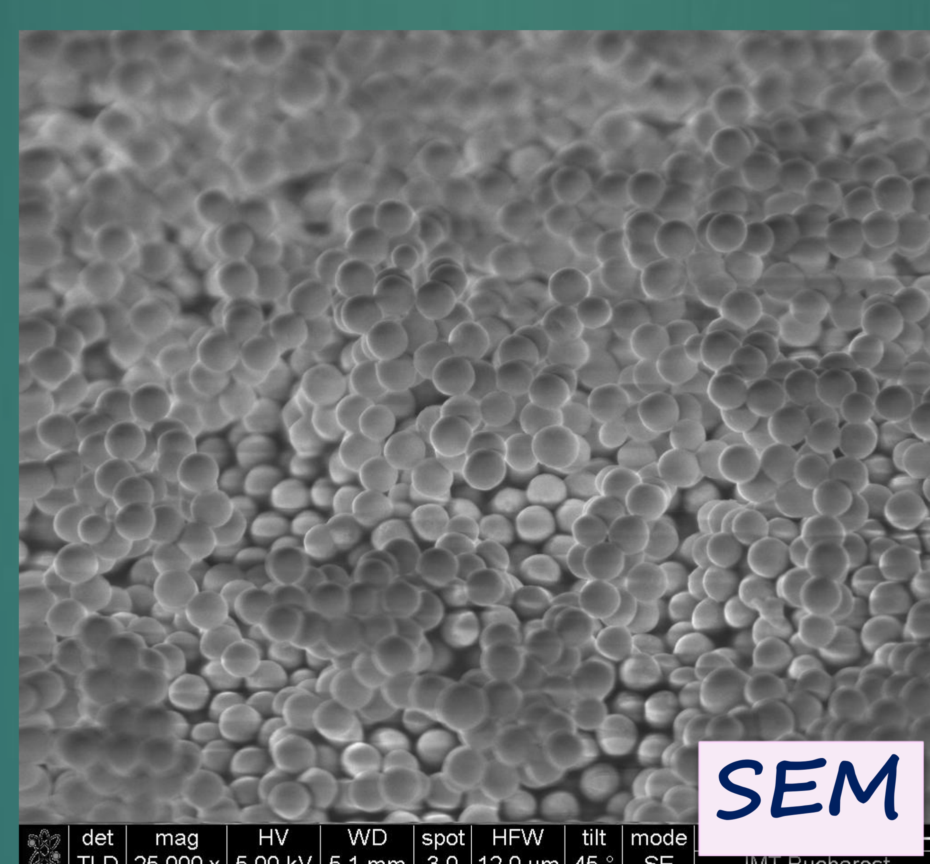
FTIR



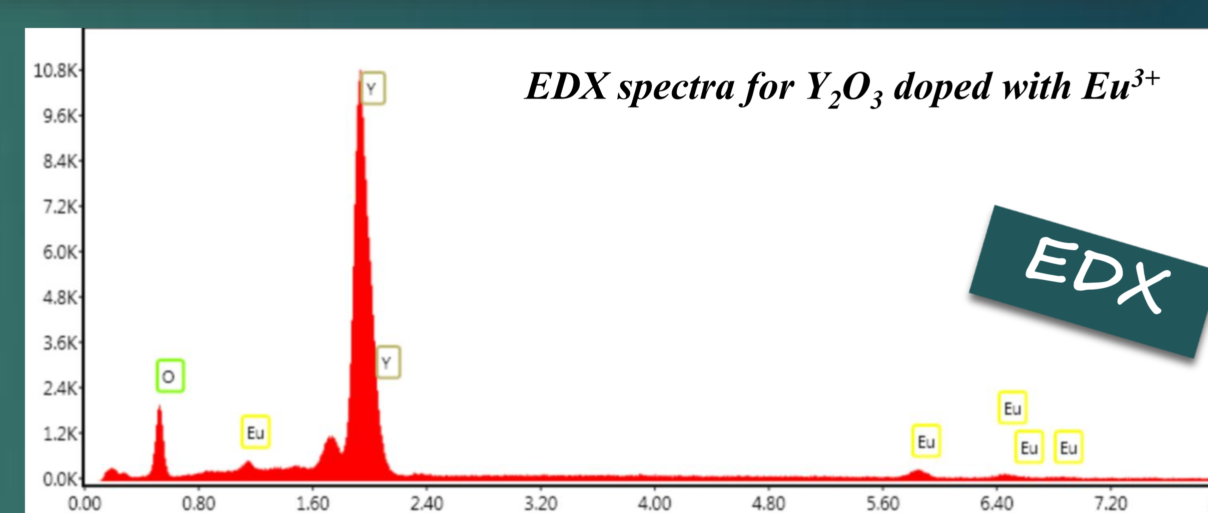
FTIR spectra for $Y(NO_3)_3$ raw material and Y_2O_3 doped with Eu^{3+} powder after thermal treatment at 600°C

SEM images for Y_2O_3 doped with Eu^{3+} sample, after thermal treatment at 600°C,

SEM

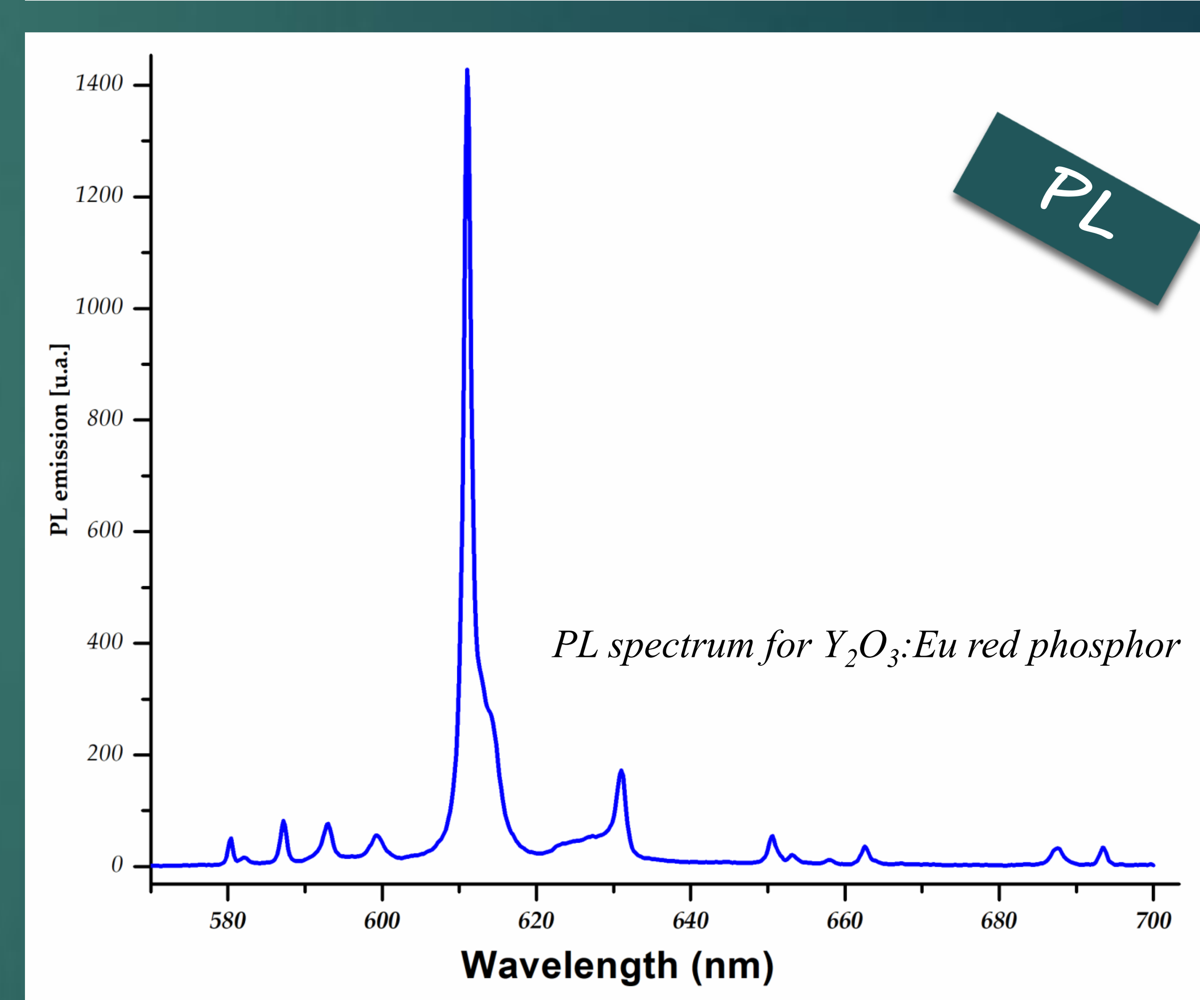


EDX



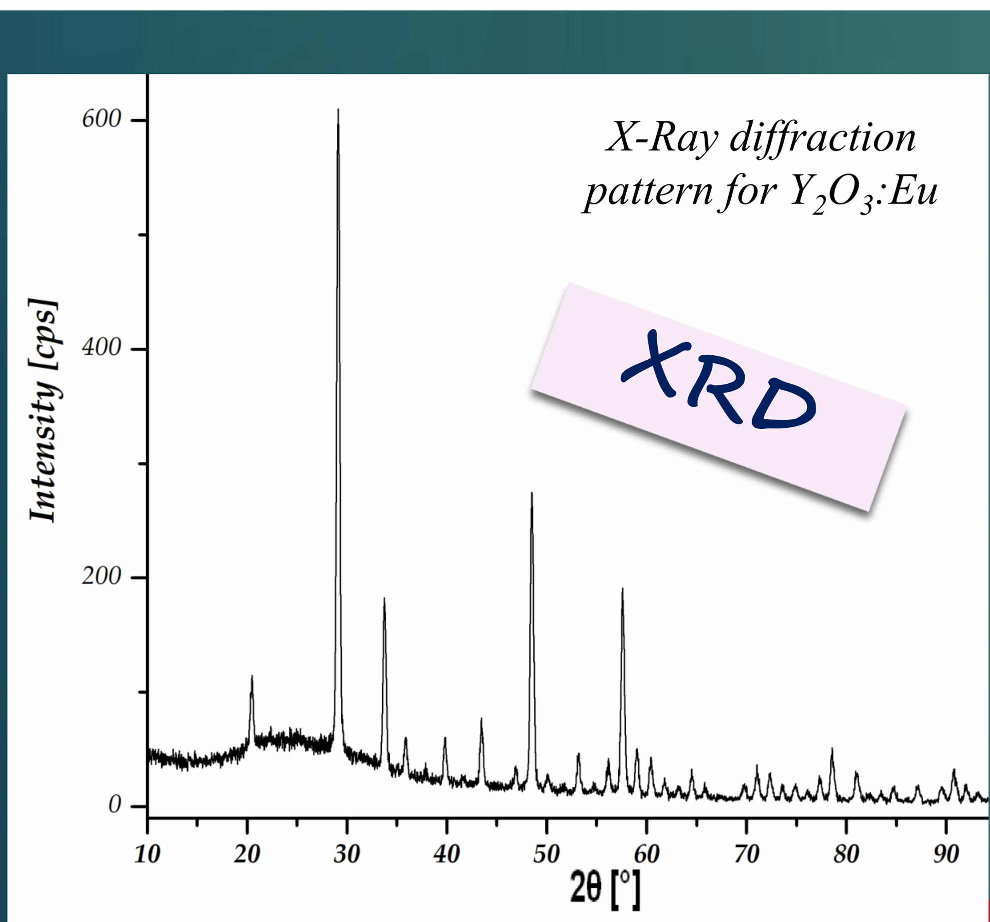
EDX spectra for Y_2O_3 doped with Eu^{3+}

PL

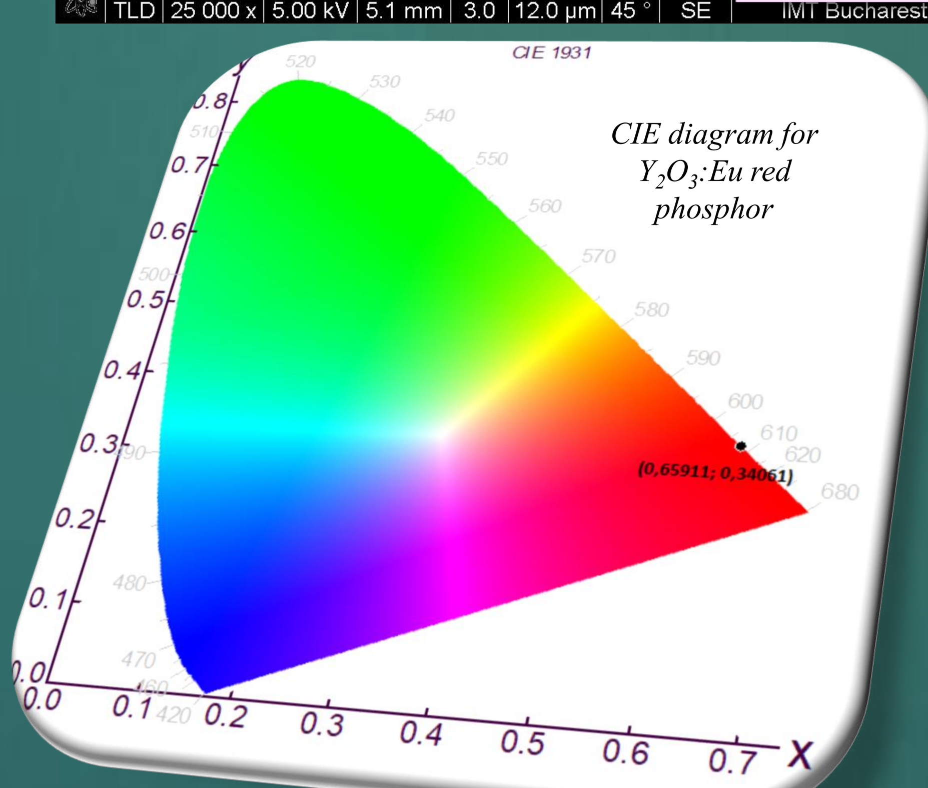


PL spectrum for Y_2O_3:Eu red phosphor

XRD



X-Ray diffraction pattern for Y_2O_3:Eu



CIE diagram for Y_2O_3:Eu red phosphor

Conclusions

- At wavenumbers below 600 cm^{-1} the IR spectrum of oxide particles is defined by absorption bands due to stretching vibrations of the Y-O and Y-O-Y bonds in cubic Y_2O_3. The lack of new bands indicates that Eu^{3+} is inserted into the cubic lattice, without producing Eu_2O_3 secondary phases, and not altering the Y_2O_3 structure.
- In the diffractogram, three main characteristic peaks were found, at 2θ values of 29.18°, 48.51° and 57.58° indexed to the (222), (440) and (622) planes. The low intensity peaks that were also indexed and attributed to a Y_2O_3 cubic crystalline structure, with a slightly deformed lattice due to the presence of the dopant.
- In the EDX spectrum, peaks attributed to oxygen (O(K) at 0.52 keV) and yttrium (Y(L) at 1.92 keV) are observed, as well as peaks corresponding to the dopant (Eu(L) at 5.84 keV and Eu(M) at 1.14 keV).
- The SEM image shows perfectly spherical particles, without surface defects, well dispersed.
- PL spectrum and CIE diagram confirm that a red phosphor is obtained by excitation with visible radiation.

Acknowledgements

This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CNCS-UEFISCDI, project number PN-IV-P2-2.1-TE-2023-0417 (BioYDetect, Contract no. 30TE/2025), within PNCDI IV. Also, this work was supported by the Core Program within the National Research Development and Innovation Plan 2022-2027, carried out with the support of MCID, project no. 2307 (µNanoEl).