



HAL
open science

YAG :Ce³⁺/4⁺ aerogels : efficiency, timing, diffusion and self-absorption

Pavlo Mai, Yannis Cheref, Raphael Marie-Luce, Frederic Lerouge, Sylvie Pierre, Benoit Sabot, Frederic Chaput, Christophe Dujardin

► To cite this version:

Pavlo Mai, Yannis Cheref, Raphael Marie-Luce, Frederic Lerouge, Sylvie Pierre, et al.. YAG :Ce³⁺/4⁺ aerogels : efficiency, timing, diffusion and self-absorption. 17th International Conference on Scintillating Materials and their Applications (SCINT 2024), University of Milano, Jul 2024, Milano, Italy. p52. cea-04958709

HAL Id: cea-04958709

<https://cea.hal.science/cea-04958709v1>

Submitted on 20 Feb 2025

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

T-NA2 YAG:Ce^{3+/4+} aerogels: efficiency, timing, diffusion and self-absorption

Pavlo Mai¹, Yannis Cheref^{1,2}, Raphael Marie-Luce², Frederic Lerouge², Sylvie Pierre³, Benoit Sabot³, Frederic Chaput² and Christophe Dujardin^{1,4}

¹Universite Claude Bernard Lyon1, CNRS, ILM UMR5306, Villeurbanne, France

²Laboratoire de Chimie, Ecole Normale Supérieure de Lyon, Université Claude Bernard Lyon1, CNRS UMR 5182, Lyon, France

³Université Paris-Saclay, CEA, LIST, Laboratoire National Henri Becquerel, Palaiseau, France

⁴Institut Universitaire de France (IUF), Paris, France

Corresponding Author Email: pavlo.mai@univ-lyon1.fr

Detection of radionuclides that decay directly to the ground state in the atmosphere requires to detect the beta or alpha radiation directly, which is very challenging due to their short mean free path in air at normal pressure. This suggests that the highest detection efficiency is obtained when the radionuclide is incorporated in the sensing part of the detector, which is applied with different gas radionuclides in ionisation chambers (gas-gas mixing) and for liquid solution in the liquid scintillation counting (LSC) technique (gas-liquid mixing). We hereby introduce the concept of gas-solid mixing to design an efficient detector, wherein the radioactive gas is introduced into a highly porous transparent inorganic scintillator. In this frame we have prepared YAG:Ce aerogels from sol-gel nanoparticle dispersion.

Post-synthesis thermal treatment (sintering/calcination) at several temperatures was applied to the aerogels demonstrating a significant impact on the cerium oxidation state and transparency (figure 1). The focus of this work is also the investigation of the aerogel optical properties after being altered by sub-calcination/sintering temperature treatments in H₂ or air ambient gases. This low-temperature (400°C) treatment has managed to significantly change the ratio of Ce^{3+/4+} population in the sample, thus introducing a novel, easy and reversible approach to change scintillating properties of YAG:Ce aerogel.

In this presentation, the effect of the thermal treatment on the transparency, diffusion, self-absorption, photoluminescence and scintillation efficiency and timing will be discussed in the frame of their use as sensor in the Triple to Double Ratio method, the standard technique used for liquid scintillation and the metrology of radionuclides.

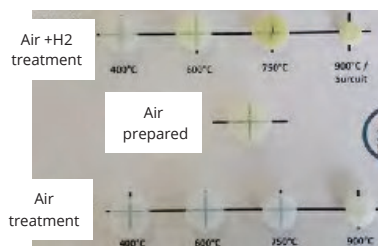


Figure 1: YAG:Ce aerogels under various thermal treatments

Acknowledgement

The authors acknowledge support from the European Community through the grant n° 899293, HORIZON 2020 – SPARTE.

T-NA3 Fast timing with highly loaded cesium lead halide perovskite nanocomposites

Eva Mihoková^{1,2}, Jan Král^{1,2}, Vojtěch Zablouil^{2,3}, Fiammetta Pagano^{3,4}, Kateřina Děcká^{1,2}, Etienne Auffray³, Václav Čuba²

¹Institute of Physics, Czech Academy of Sciences, Prague, 162 00, Czech Republic

²FNSPE Czech Technical University in Prague, 115 19, Czech Republic

³European Organization for Nuclear Research (CERN), Meyrin, 1211, Switzerland

⁴Department of Physics, University of Milano-Bicocca, Milano, 20 126, Italy (now at I3M, Valencia)

Corresponding Author Email: mihokova@fzu.cz

In recent years cesium lead halide perovskite nanocrystals have attracted attention in many application fields, among which that of radiation detection. Thanks to quantum confinement effect they feature ultrafast scintillation decays [1]. Therefore, they have been identified as promising fast emitters in scintillating metamaterials intended to build up novel detectors requiring fast timing [2]. Such detectors are particularly needed in the time-of-flight (TOF) techniques in medical imaging as well as high energy physics. However, the practical usage of nanocrystals requires dealing with two major issues. Poor chemical stability can be overcome by their incorporation in a suitable, e.g. polymer, matrix to form nanocomposite. Low stopping power calls for fabrication of nanocomposites with the highest possible nanocrystalline loading keeping their reasonable level of transparency.

In this work we study synthesis, structural and optical characteristics including the timing performance of cesium lead bromide and cesium lead bromo-chloride nanocrystals embedded in the polystyrene matrix. We focus on synthesis routes for nanocomposites with high nanocrystalline loading up to 40%. However, with higher loading favourable luminescent properties of nanocrystals can be compromised by their agglomeration leading to reduced transparency and consequently the reduced light extraction from prepared nanocomposites. To limit this effect, we use advanced polymerization techniques and copolymerizable ligands. The level of nanoparticle agglomeration is studied by confocal microscopy. We also study scintillation characteristics of prepared nanocomposites, especially scintillation decays. We assess the nanocomposite time resolution using a setup described in [3]. Prepared nanocomposites feature significantly better time resolution with respect to the currently used standalone conventional scintillators, such as LYSO:Ce crystal.

1. K. Děcká, J. Král, F. Hájek, P. Průša, V. Babin, E. Mihoková, V. Čuba "Scintillation response enhancement in nanocrystalline lead halide perovskite thin films on scintillating wafers," *Nanomaterials*, 12, 14 (2021).

2. G. Konstantinou, P. Lecoq, J.M. Benloch, A.J. Gonzalez "Metascintillators for ultrafast gamma detectors" A review of current state and future perspectives," *IEEE Trans. Radiat. Plasma Med. Sci.*, 6, 510 (2021).

3. F. Pagano, N. Kratochwil, M. Salomoni, I. Frank, S. Gundacker, M. Pizzichemi, M. Paganoni, E. Auffray "A new method to characterize low stopping power and ultra-fast scintillators using pulsed X-rays," *Front. Phys.*, 10, 1 (2022).

This work was carried out in the frame of crystal clear collaboration. Financial support of projects: GAČR 23-05 615, SenDiSo, Reg.No. CZ.02.01.01/00/22_008/0004596 and European Pathfinder project Unicorn (GA: 101098649) is gratefully acknowledged.