INFLUENCE OF X-RAY IRRADIATION ON SPECTRCOSCOPIC PROPERTIES OF TmF_3 –DOPED FLUORIDE (CaF_2 AND BaF_2) CRYSTALS

Gabriel Buse[1], Maria Poienar[1], Philippe Veber[1,2], Daniel Vizman[2], Carla Zeicu[2] and Marius Stef[2]

[1]ICAM, West University of Timisoara, Bvd. V. Parvan, No.4, Timisoara, Romania
[2]Physics Faculty, West University of Timisoara, Bvd. V. Parvan, No.4, Timisoara, Romania
e-mail: gabriel.buse@e-uvt.ro

Abstract
Rare-earth ions-doped fluorides crystals have been extensively investigated due to the possible use in various applications like medicine, energy or laser materials, optical amplifiers, quantum materials or scintillators [1]. In this regard the interaction of X-ray irradiation with fluoride crystals has significant implications for both fundamental materials science and applied radiation technologies.

Introduction
In hosts like CaF_2 (calcium fluoride) and BaF_2 (barium fluoride), some rare-earth ions (RE) are usually introduced in the trivalent state. The fluoride lattice has relatively low phonon energies, which helps reduce non radiative decay of rare earth emissions (good for luminescence). Under certain conditions (irradiation, additive coloration, etc.), some RE^{3+} can be reduced to the divalent state, RE^{2+}. This is interesting because RE^{2+} has different energy levels and thus different absorption/emission behavior. This study investigates the optical properties changes induced in various fluoride crystals—such as CaF_2, BaF_2, doped with TmF_3 under controlled X-ray exposure.

Experimental
Through spectroscopic analysis we explore the formation of color centers, and charge conversion of thulium ions. Pure and various concentration TmF_3-doped fluoride (CaF_2 and BaF_2) crystals have been grown using an in-house vertical Bridgman method [2]. Disks cleaved from the obtained single crystals have been irradiated with X-rays (Brucker D8 Advance difractometer) at room temperature at different intervals up to 4h [3].

Results and discussion
Room temperature optical absorption spectra for the non-irradiated samples demonstrate the distinct absorption features consistent with thulium ions for its divalent and trivalent states [4]. After X-rays irradiation, absorption bands modifications have been observed for the in UV-VIS domain. The magnitude of the intensity absorption bands was studied with the TmF_3 content and demonstrates a variation with time. Also the matrix type (CaF_2 or BaF_2) influence was studied. Not least, the decay optical measurements over a long period of time (days) was analyzed for the evaluation of the long-term stability properties.

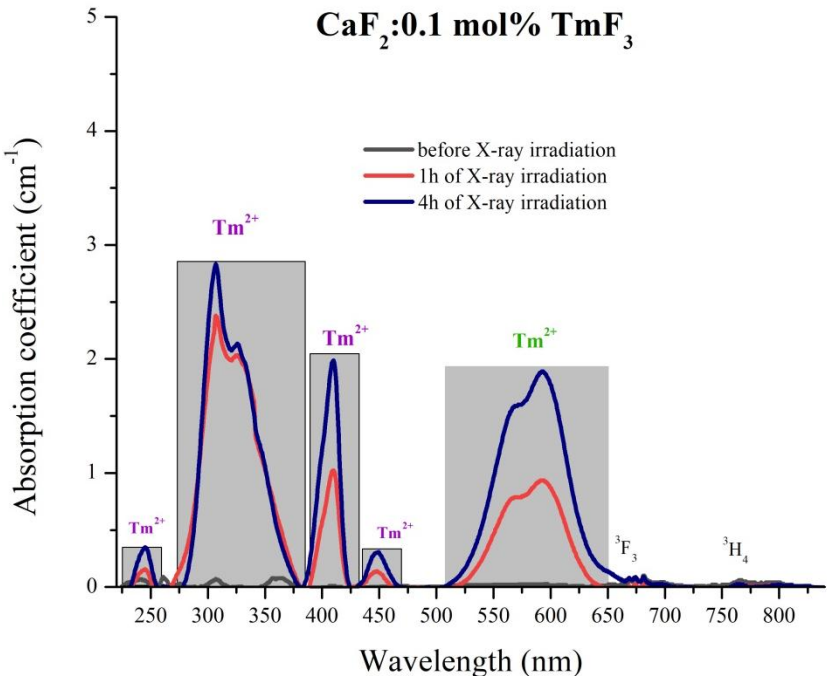

Figure 1. X-ray irradiation influence on the absorption spectra of CaF_2: 0.1mol% TmF_3.

Conclusion

The insights and results of the study demonstrate the importance of continuous research for the development of radiation-resistant optical materials, dosimetry applications, and the advancement of photonic devices operating in high-radiation environments.

Acknowledgements

This work is funded by European Commission within the framework of the Romanian National Recovery and Resilience Plan (PNRR-III-C9-2022-I8 grant) through the ESCARGOT project entitled "Enhanced Single Crystal Applications and Research in the Growth of new Optical rare earth-based compounds for sustainable and efficient Technologies" (Code 136/15.11.2022 ; CF n°760080/23.05.2023).

References

[1] D. Hahn, Opt. Photonik. 9 (2014) 45–48.
[2] D. Nicoară, I. Nicoară, Mater. Sci. Eng. 102 (1988) L1-L4.
[3] I. Nicoara et all, Phys. Stat. Sol. (c) 4, No. 3, (2007) 1234–1237.
[4] G. Buse et all, Journal of Alloys and Compounds, 1010, (2025) pp.177784.