IOCC 2026 Conference
The 5th International Online Conference on Crystals
15–17 June 2026 | Online
MDPI

X-ray luminescence performance of a BGO single crystal under the influence of external temperatures. Comparison with BaF_2

Theodoros Tryfonidis, Dionysios Linardatos, Vasileios Ntoupis, George Saatsakis, Ioannis Valais, Nektarios Kalyvas, George Fountos, Ioannis Kandarakis and Christos Michail

Department of Biomedical Engineering, Radiation Physics, Materials Technology and Biomedical Imaging Laboratory, University of West Attica, Athens, 12210, Greece

INTRODUCTION & AIM

- Scintillators are employed in a wide range of applications, spanning from medical imaging to radiation detectors operating under extreme temperature conditions or high radiation flux.
- In this context, systematic investigation of their luminescence response as a function of temperature and or radiation flux is of significant importance.
- In this sense, this study examined the influence of temperature on the luminescence efficiency of a bismuth germanate ($Bi_4Ge_3O_{12}$-BGO) single crystal.
- The BGO crystal under investigation has a light yield of 8.2-8.9 × 10^3 photons/MeV, a decay time of 300 ns and a timing resolution of 2500-6000 ps @ FWHM.
- Barium fluoride has a fast decay component, at around 0.6-0.87 ns and a slow one, at around 620-630 ns.
- Results were compared with a barium fluoride (BaF_2) single-crystal scintillator.

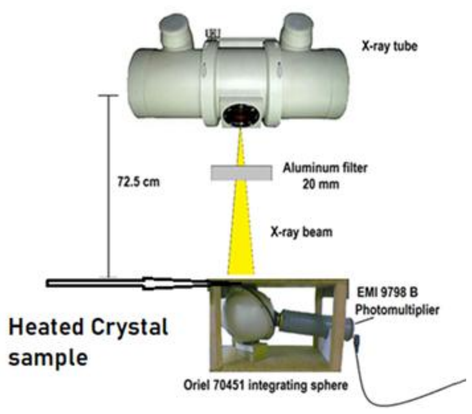

Figure 1. Luminescence efficiency apparatus.

METHOD

- The experimental setup comprised of a CPI series CMP 200 DR medical X-ray source, set to a fixed high voltage (90kVp).
- Heating was performed by using a Perel 3700-9 2000W heating gun.
- The temperature on the crystal surface was monitored using an Agilent Technologies U1253A digital multimeter, coupled to a U1185A thermocouple (J-Type) with temperature probe adapter.
- The crystal light output measurements were performed under temperatures ranging from 19 to 174 ^oC.
- The ratio of the light energy flux emitted by the examined sample, normalized by the X-ray exposure rate can be expressed as the absolute luminescence efficiency (ALE):

$$AE = \eta_A = \frac{\dot{\Psi}_\lambda}{\dot{X}} = \left(\frac{i_{elec}}{S\eta_p\alpha_s c_g}\right)\dot{X}^{-1}$$

- In equation (1) $\dot{\Psi}_\lambda$ is the light energy flux (output signal) in units of μW m^{-2}. $\dot{X}$ is the exposure rate (mR s^{-1}).
- i_{elec} is the current produced by the electrometer in pA and S denotes the surface of the crystal, excited by X-rays (mm^2).
- The peak sensitivity of the photocathode (η_p) is expressed in units of pA/W. α_s is the spectral matching between the light source to the spectral response of the optical sensor.
- The geometric light collection efficiency (c_g) has a value of 15.6. The units of the ALE is EU=(μW m^{-2})/(mR s^{-1}).

RESULTS & DISCUSSION

- The luminescence efficiency values of BGO are 2.96 EU at 21.0 ^oC and 0.37 EU at 172.4 ^oC.
- The corresponding values for BaF_2 decrease with increasing temperature, ranging from 1.56 EU at 19.5 ^oC to 0.32 EU at 174.2 ^oC.
- BGO appears with clearly higher luminescence efficiency values across the examined temperature range; however, for temperatures reaching 174 ^oC, the efficiencies of BaF_2 and BGO scintillators converge with each other, despite their initial differences.

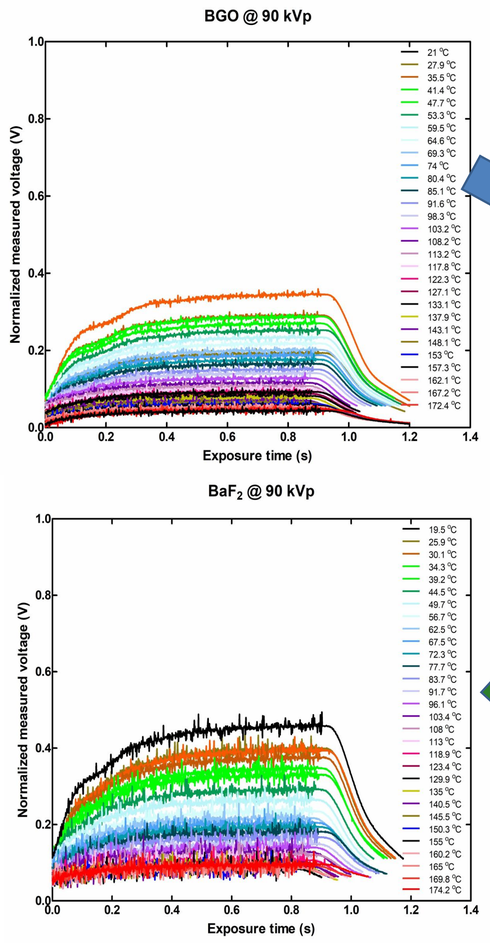

Figure 2. Voltage readings for the BGO crystal, in the examined temperature range. Fixed exposure of 1 sec and electrometer voltage scale at 1 V.

Figure 3. Voltage readings for the BaF2 crystal, in the examined temperature range. Fixed expo-sure of 1 sec and electrometer voltage scale at 300 mV.

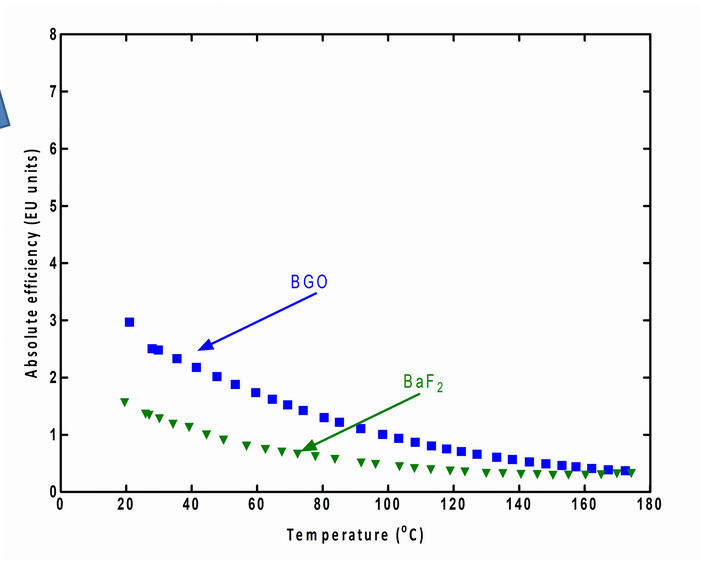

Figure 4. Comparative luminescence performance of BaF_2 and BGO samples in the temperature range 19-174 ^oC.

CONCLUSIONS

- Despite the higher luminescence efficiency values of BGO, an interesting finding of this work is that BaF_2 maintains a performance profile that is comparable to BGO, especially as temperatures approach 174°C where the differences between the two materials are minimized.
- This combination of economic accessibility and thermal stability at high temperatures renders it an good choice for harsh environments and large-scale applications where budget and durability are as critical as performance.

REFERENCES

1. BaF_2 - Barium Fluoride Scintillator Crystal | Advatech UK. Available online: https://www.advatech-uk.co.uk/baf2.html (accessed on 19 December 2024).
2. Herweg, K.; Nadig, V.; Schulz, V.; Gundacker, S. On the Prospects of BaF_2 as a Fast Scintillator for Time-of-Flight Positron Emission Tomography Systems. *IEEE Trans. Radiat. Plasma Med. Sci.* **2023**, *7*, 241–252, doi:10.1109/TRPMS.2023.3237254.
3. Morelli, D.T.; Heremans, J. Thermal Conductivity of Single-crystal Barium Fluoride. *J. Appl. Phys.* **1988**, *63*, 573–574, doi:10.1063/1.340090.
4. Gironnet, J.; Mikhailik, V.B.; Kraus, H.; de Marcillac, P.; Coron, N. Scintillation Studies of $Bi_4Ge_3O_{12}$ (BGO) down to a Temperature of 6 K. *Nucl. Instrum. Meth. Phys. Res. Sect. A* **2008**, *594*, 358–361, doi:10.1016/j.nima.2008.07.008.