Gamma-Ray Induced Radiation Damage and Phosphorescence in BaF_2: 0-20 at% Y Crystals

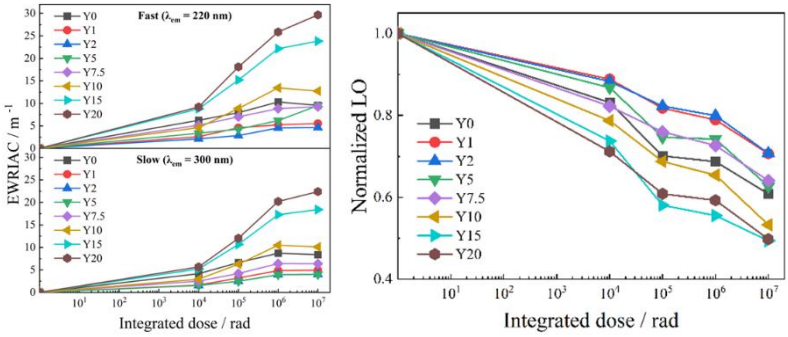
Jiawei Xu[1, 2], Xiang Li[1], Jing Zhang[1, 2], Mingxue Deng[1, 2], Xuejun Qi[1], Junfeng Chen[1, 2]

[1]*State Key Laboratory of Functional Crystals and Devices, Shanghai Institute of Ceramics, Chinese Academy of Sciences, Shanghai, China*
[2]*Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing, China*
Corresponding Author Email: jfchen@mail.sic.ac.cn

Yttrium-doped barium fluoride (BaF_2:Y) crystal is an ultrafast scintillator with efficiently suppressed slow scintillation component, demonstrating significant application potential in high energy physics calorimeters, high-repetition-rate radiation imaging, and positron annihilation lifetime spectroscopy, etc [1-2]. High-quality, large-diameter (up to 4-inch) crystals with high yttrium doping levels (up to 15 at%) have been successfully grown, establishing a solid basis for their deployment [3]. However, radiation damage in BaF_2:Y crystals remains understudied [4]. Whether such damage correlates with yttrium doping itself or impurities introduced during the preparation process remain elusive, and the relationship between radiation tolerance and yttrium concentration has yet to be established.

In this study, longitudinal transmittance (LT), light output (LO), radiation-induced phosphorene spectra and kenetics before and after gamma-ray irradiations were measured for 0–20 at% Y-doped BaF_2 crystals, exposed to doses up to 10 Mrad. Emission-weighted longitudinal transmittances (EWLTs), emission-weighted radiation-induced absorption coefficients (EWRIACs), light outputs (LOs) loss, and the origin of radiation-induced phosphorene in BaF_2:Y crystals were investigated.

The results demonstrate a complex relationship between radiation hardness and Y concentration. Y concentration up to 7.5 at% enhances radiation hardness, as evidenced by reduced RIACs and LO loss relative to pure BaF_2. At yttrium concentrations above 10 at%, both RIACs and fractional LO losses increase with Y content, reaching maxima at 20 at% Y. Besides the broad band at ~540 nm (2.3 eV), Y-doping induces additional narrow phosphorescence peaks that intensify proportionally with yttrium content.



EWRIACs (left) and normalized LOs (right) for BaF_2 crystals doped with 0–20 at % yttrium are plotted as a function of integrated dose of gamma-ray

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