

Crystal growth and optimization of post-annealing condition of intrinsic scintillator YNbO₄

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Rare-earth niobate crystals have recently been studied as novel intrinsic scintillators with high light outputs due to the charge transfer luminescence between Nb⁵⁺ and coordinated O²⁻. Nb⁵⁺ is easily reduced to Nb⁴⁺ during crystal growth; thus, post-annealing is important for exhibiting high light output. In previous reports, YNbO₄ was grown using the Czochralski method, and the post-annealed YNbO₄ single crystal showed a light output of 14,300 photons/MeV [1]. In this study, we grew YNbO₄ to fabricate single-crystalline specimens and tested post-annealing conditions to maximize the light output of YNbO₄.

YNbO₄ was first synthesized from the starting powders of Y₂O₃ and Nb₂O₅, and the synthesized YNbO₄ ceramics were melted in an Ir crucible in Ar atmosphere. The YNbO₄ melt was then slowly cooled to room temperature over 24h. Single crystals of YNbO₄ were obtained from a solidified melt. YNbO₄ was post-annealed in air and O₂ atmospheres to reduce the oxygen defects. Finally, the optical and scintillation properties of the as-grown YNbO₄ and post-annealed YNbO₄ were evaluated.

The YNbO₄ specimen was successfully fabricated by cleaving the solidified YNbO₄ melt, as shown in Fig. 1. The as-grown crystal was dark black in color and exhibited weak blue emission under UV irradiation. By measuring the transmittance spectra, the dark color was revealed to be due to oxygen defects. Post-annealing was performed in air and O₂ atmospheres, and the optimal condition was found to be O₂-annealing at 1200°C (12 h).



Figure 1. (Left) As-grown and (Right) Air-annealed YNbO₄ crystal.

The pulse-height spectrum of O₂-annealed YNbO₄ was measured under 662-keV gamma-ray irradiation from a ¹³⁷Cs source. The channel number of the photoabsorption peak was compared with that of the Bi₄Ge₃O₁₂ reference, and the light output of O₂-annealed YNbO₄ was calculated to be ~25,000 photons/MeV. This light output is one of the highest values among intrinsic scintillators. The energy resolution of O₂-annealed YNbO₄ was estimated to be ~11.4% (FWHM at 662 keV). In this presentation, the anisotropic scintillation properties for the dark matter search will also be discussed.

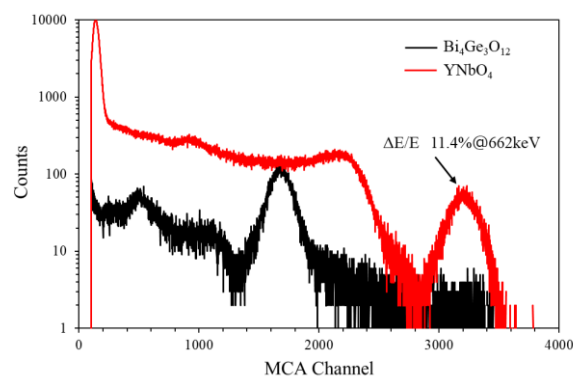


Figure 2. Pulse height spectra of O₂-annealed YNbO₄ and reference Bi₄Ge₃O₁₂ crystal.

1. Y. Zhou et al., “High-density Nb:YTaO₄ single crystals for X-ray scintillation,” *CrystEngComm*, **27**, 81–89 (2024)