Author's Accepted Manuscript

www.elsevier.com/locate/jcrysgro

Effects of Increasing Size and Changing Europium Activator Concentration in $KCaI_3$ Scintillator Crystals

Adam C. Lindsey, Mariya Zhuravleva, Yuntao Wu, Luis Stand, Matthew Loyd, Sasmit Gokhale, Merry Koschan, Charles L. Melcher

PII: S0022-0248(16)30274-3
DOI: http://dx.doi.org/10.1016/j.jcrysgro.2016.05.045
Reference: CRYS23381

To appear in: *Journal of Crystal Growth*

Received date: 13 January 2016
Revised date: 14 May 2016
Accepted date: 27 May 2016

Cite this article as: Adam C. Lindsey, Mariya Zhuravleva, Yuntao Wu, Luis Stand, Matthew Loyd, Sasmit Gokhale, Merry Koschan and Charles L. Melcher Effects of Increasing Size and Changing Europium Activator Concentration in $KCaI_3$ Scintillator Crystals, *Journal of Crystal Growth*, http://dx.doi.org/10.1016/j.jcrysgro.2016.05.045

Effects of Increasing Size and Changing Europium Activator Concentration in $KCaI_3$ Scintillator Crystals

Adam C. Lindsey*, Mariya Zhuravleva, Yuntao Wu, Luis Stand, Matthew Loyd, Sasmit Gokhale, Merry Koschan, Charles L. Melcher

Scintillation Materials Research Center – Materials Science and Engineering Department - The University of Tennessee - Knoxville TN, USA

*Corresponding author Tel: 423 943 9508. AColemanLindsey@gmail.com

Abstract

$KCaI_3$:Eu crystals have been identified as very promising for use in spectroscopic detector applications related to nuclear nonproliferation and domestic security efforts. Initial studies have shown for small crystals a few mm^3 in size with 3% europium dopant concentration, a high light yield of > 70,000 ph/MeV and energy resolution of ≈ 3% at 662 keV is attainable which is comparable with the highest performance scintillators discovered. In this work, single crystals of $KCaI_3$ with a range of Eu^{2+} doping between 0 and 5 at% substituting for Ca^{2+} were grown at 22 mm diameter and their performance for gamma-ray spectroscopy studied. Comparisons among crystals approximately Ø22 mm x 22 mm (8.4 cm^3 or ≈ 0.5 in^3) provide a more accurate understanding of how scintillation performance changes with Eu doping and increased crystal size. $KCaI_3$ in the undoped form is shown to be a highly efficient intrinsic scintillator with a defect-related emission at 404 nm which coexists with the Eu^{2+} 5d-4f emission in low dopant concentrations and is completely re-absorbed in more heavily doped crystals. For larger crystals, effects from self-absorption due to Eu activation become more evident by a near doubling of decay time for 0.5 in^3 crystals as the activator is increased from 0.5 to 5.0 at% Eu. Comparisons of pulse-height spectra obtained for Ø22 mm x 22 mm cylinders with varying Eu concentration suggests best performance is achieved using lower Eu additions closer to 0.5-1.0 at%. Using a modified crystal packaging featuring an offset reflector geometry, 0.5 in^3 crystals of $KCaI_3$:Eu can attain under 4% energy resolution at 662 keV.

Keywords

Bridgman technique, Single crystal growth, Halides, Scintillator materials, Reflector geometry

Introduction

Much effort has been focused on increasing spectroscopic radiation detection capabilities through development of new semiconductor and scintillator materials with improved characteristics over old technology, with the latter category providing more cost effective options. At this point SrI_2:Eu and $LaBr_3$:Ce have garnered the most attention as next generation scintillators for gamma-ray detection. However, due to perhaps poor crystal yield during growth, these commercialized scintillators have failed thus far to produce a method of synthesis of large volumes which provides a competitive price required to replace CsI:Tl, and NaI:Tl. New ternary compounds with similar performance have been discovered and are in various stages of development which aim to provide similar capability as well as a cost reduction,