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Ce valence state in the Ce-doped $Sr_3YB_2O_9$ for Scintilator application

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Ce doped $Sr_3YB_3O_9$ crystal was investigated for neutron scintillators application with rapid decay time. Transparent crystal was grown by Floating Zone method. Ce content of the grown crystal was very low (0.1 at%). Valence state of Ce in the crystal was mainly trivalent. Absorption edge is 290 nm in wavelength, and emission bands at 415 nm corresponding to 5*d*-4*f* transition of Ce were observed under 365 nm excitation. The decay time for the 415nm emission was 12ns and light yield strength excited by α-ray was ~300 photon/neutron. These results indicate that the studied crystal can be promising scintillator crystal.

1 Introduction

The energy released by neutron irradiating from the boron in the $Sr_3YB_3O_9$ (SYB) crystal, it can be converted into visible light by introducing a suitable emission center of rare earth elements. Short decay time is necessary for developing scintillator systems with high temporal and spatial resolutions [1]. Ce^{3+} provides short decay time of 5*d*–4*f* luminescence. In this study, the basic optical properties and the Ce valence state in the Ce:SYB crystal were investigated.

2 Experiment

Samples were grown by the floating zone (FZ) method under dry-air atomosphere. Ce content in the grown crystal was measured by electron probe microanalysis (EPMA).

X-ray absorption near edge structure (XANES) spectra for the Ce *LIII* edge (5.73 keV) were measured in the fluorescent mode by using a Si(111) double-crystal monochromater, a Ni-coated mirror for eliminating the higher-order harmonic component, and a 19-channel solid-state detector at the beam line 12C of the Photon Factory (PF), Institute of Materials Structure Science (IMSS), High Energy Acceleration Organization (KEK). The PF synchrotron operates with stored energy of 2.5 GeV and electron current of 450 mA. CeO_2 chemical reagent and a synthesized monazite were used to measure the standard XANES for Ce^{4+} and Ce^{3+}, respectively. Ce^{3+} abundance in the sample was estimated by referring to the standard XANES spectra with using REX2000.

Optical measurements such as transmission spectrum, excitation-emission-intensity analysis, excitation and emission spectra, decay kinetics excited by a nanosecond hydrogen-filled pulse flashlamp, and emission spectrum excited by an α-source (241Am, 5.5 MeV [2]) were also measured.

3 Results and Discussion

Ce doped $Sr_3YB_3O_9$ crystal was successfully grown by the floating zone (FZ) method. EPMA showed that the Ce content in the grown crystal was about 0.1at%. Ce *LIII* XANES spectra indicated that the Ce in the prepared sintering Ce:SYB raw powder was mainly quadrivalent (approximately 90%) and that in the grown Ce:SYB crystal was mainly trivalent (approximately 80%); this suggests that melt growth is necessary for substituting the trivalent Ce into the SYB crystal structure. The maximum intensity of Ce^{3+} luminescence corresponding to 5*d*–4*f* transition was observed at 415 nm when the excitation wavelength was 365 nm. The decay time of the photoluminescence is short (12.27±0.45 ns). The light yield strength excited by an α-source was approximately 6% of that from the Li-glass. These results indicate that the Ce:SYB crystal is a promising scintillator crystal. It is necessary to increase Ce concentration (light yield strength) in SYB for further development.

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Research Achievements

1. Oral presentation in the 5th Asian Conference on Crystal Growth and Crystal Technology, Singapore
2. R. Simura *et al.*, Journal of Crystal Growth 362 (2013) 296–299

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