Development of Oxyfluoride Glasses for X-ray Imaging Applications

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Keywords: Scintillators; Oxyfluoride glass; X-ray detectors

ABSTRACT

We have synthesized Tb-doped oxyfluoride glasses by the conventional melt quenching method, and the potential for X-ray imaging applications was evaluated. The synthesized glass showed green emission under X-ray irradiation, which was suitable for the wavelength sensitivity of Si-photodiode. Although the lifetimes of Tb-doped glasses had a few milliseconds, Tb-doped oxyfluoride glasses were considered usable as integration-type detectors.

1 Introduction

X-ray imaging applications have been applied for many fields including medical diagnosis [1], security [2], industrial inspection [3]. As the detectors for these applications, the scintillation detectors are often used, which consists of scintillators and photodetectors. The scintillators immediately convert the absorbed energy of ionizing radiation into many low energy photons, and the emitted photons are detected by the photodetector. The required properties of scintillators were a high effective atomic number, a high light yield and a suitable emission wavelength for the spectral sensitivity of photodetectors.

To date, the single crystals were mostly used as the material forms of commercial scintillators because of their optical qualities. Recently, K. Shinozaki *et al*. have reported the scintillation properties of oxyfluoride glasses such as AEF_2-Al_2O_3-B_2O_3 (*AE* = Mg, Ca, Sr, Ba), and these glasses showed high quantum yields and scintillation light yields [4], [5]. In addition, glasses have a lot of advantages such as low cost and easy productivities in comparison with single crystals. However, there are only a few reports on scintillation properties of oxyfluoride glasses. In this study, we have synthesized Tb-doped SrF_2-Al_2O_3-B_2O_3 glasses and investigated optical and X-ray induced scintillation properties.

2 Experiment

$x$$TbF_3$-(30-$x$)$SrF_2-20Al_2O_3-50B_2O_3$ glasses were synthesized by the conventional melt quenching method. The raw powders of TbF_3, SrF_2, Al_2O_3, and B_2O_3 were used. The detailed synthesis process was written in our past report [6]. The surfaces of synthesized glass were polished using a polishing machine.

As the optical properties, the diffuse transmittance spectrum was measured by a spectrometer (Shimadzu, SolidSpec-3700). The X-ray induced scintillation spectrum and decay curve were evaluated using our original setups [7], [8].

3 Results and Discussion

Fig. 1 shows X-ray induced scintillation and diffuse transmittance spectra of a 1.0% Tb-doped oxyfluoride glass. Under X-ray irradiation, some sharp emission lines were confirmed in the range of 350–650 nm, which would be originated from the 4f-4f transitions of Tb^{3+} ions [9]. As the increasing Tb concentrations, the emission intensities in the 400–450 nm region decreased, which would be attributed mainly to the cross-relaxation energy transfer between the Tb^{3+} ions. As the result of transmittance spectrum, the Tb-doped glass exhibits highly transparent (~90%) in the emission wavelength range. Fig. 2 shows the integrated scintillation intensity of the prepared oxyfluoride glasses in the integrated ranges of 350–650 nm. When the Tb concentration was 10%, the integrated intensity was the highest among the prepared oxyfluoride glasses.

X-ray induced decay curve of a 1.0% Tb-doped oxyfluoride glass is shown in Fig.3. The decay curve was approximated by a sum of two exponential decay functions. The obtained faster and slower lifetimes were 0.6 and 2.6 ms, respectively. The results were typical for

the 4f-4f transitions of Tb^{3+} ions [10].

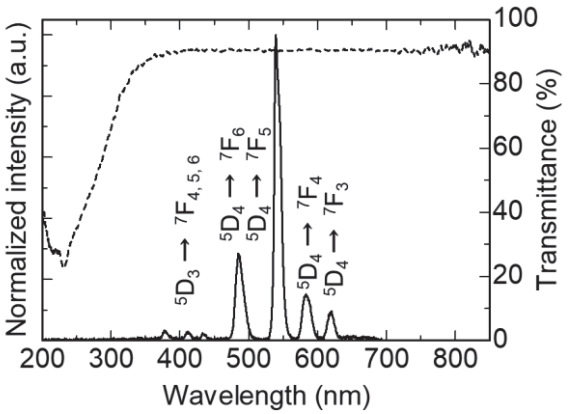

Fig. 1 X-ray induced scintillation (solid line) and diffuse-transmittance (dotted line) spectra of a 1.0% Tb-doped oxyfluoride glass.

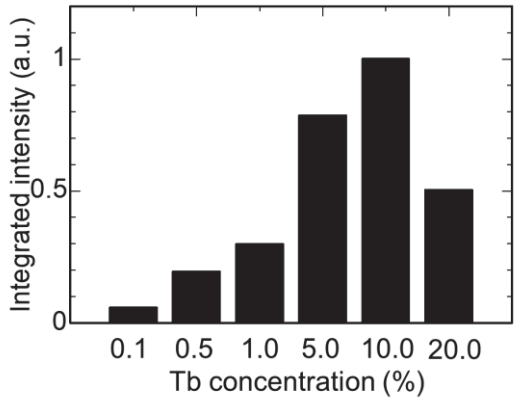

Fig. 2 X-ray induced scintillation intensity of a 0.1–20% Tb-doped oxyfluoride glass in the integrated range of 350–650 nm.

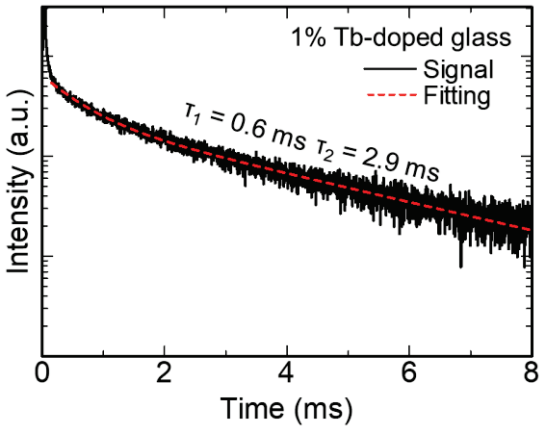

Fig. 3 X-ray induced decay curve of a 1.0% Tb-doped oxyfluoride glass.

4 Conclusions

We have synthesized Tb-doped oxyfluoride glasses by the conventional melt quenching method, and their optical and scintillation properties were investigated. In the 1.0% Tb-doped oxyfluoride glass, the transmittance was 90% in the spectral range of 300–850 nm. Under X-ray irradiation, the glass showed some sharp emission peaks around 350–650 nm originated from the 4f-4f transitions of Tb^{3+} ions. The emission wavelength was suitable for the wavelength sensitivity of Si-photodiode. In this conference, we will report the results of radiation-induced scintillation properties and X-ray imaging tests in detail.

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