

Photoluminescence and Scintillation Properties of Tb-doped Sr₃TaGa₃Si₂O₁₄ Single Crystals

Ryosei Takahashi¹, Kai Okazaki¹, Daisuke Nakauchi¹, Kenichi Watanabe², Takumi Kato¹,
Noriaki Kawaguchi¹, Takayuki Yanagida¹

¹Nara Institute of Science and Technology (NAIST), Ikoma, Nara, Japan

²Kyushu university, Nishi, Fukuoka, Japan

Corresponding Author Email: takahashi.ryosei.tn7@naist.ac.jp

Scintillators are phosphors that promptly show emission with low-energy (a few eV) when irradiated with high-energy ionizing radiation. They have been incorporated into radiation detectors and applied in many fields such as medical imaging, security, and well logging.

When scintillators are used in integrated-type detectors for X-measurements, they are generally required to satisfy high scintillation intensity, large effective atomic number (Z_{eff}), and emission wavelength within the sensitivity range of Si-photodiodes commonly used in X-ray detectors. Tb-doped Gd₂O₂S (Tb:GOS) ceramics have been used as scintillators for X-ray detectors such as flat-panel detectors. They have a large Z_{eff} (61) and a high scintillation intensity. In addition, the emission wavelengths are within the sensitivity wavelength ranges of conventional Si-photodiodes. However, the X-ray spatial resolution of Tb:GOS is limited by optical scattering due to grain boundaries and large particles of the ceramics. Although GOS has a high melting temperature (2265 °C [1]), growth of its bulk single crystals is challenging due to sulfur-volatilization resulting from thermal decomposition at elevated temperatures. Consequently, there is a demand for alternative scintillators with a large Z_{eff} , high scintillation intensity, and excellent optical transparency. Sr₃TaGa₃Si₂O₁₄ (STGS) was chosen as a promising scintillator for X-ray detectors owing to its relatively large Z_{eff} (50) and the ease to grow its large crystal [2]. In this study, Tb³⁺ was chosen as the dopant, inspired by the good performance of Tb:GOS scintillator. Tb-doped phosphors have been known to show emissions at 350–650 nm, which is covered by the sensitivity range of Si-photodiodes. In this study, Tb-doped STGS (Tb:STGS) single crystals with 2, 5, 7, and 10 at% Tb-concentrations (for Sr) were grown by the floating zone method, and their photoluminescence (PL) and scintillation properties were investigated.

Figure 1 illustrates the scintillation spectra of the Tb:STGS samples under X-ray irradiations. All the samples displayed several emission bands at a range of 350–650 nm. They were attributed to 4f–4f transitions of Tb³⁺ [3]. This presentation reports the detailed PL and scintillation properties of the Tb:STGS samples.

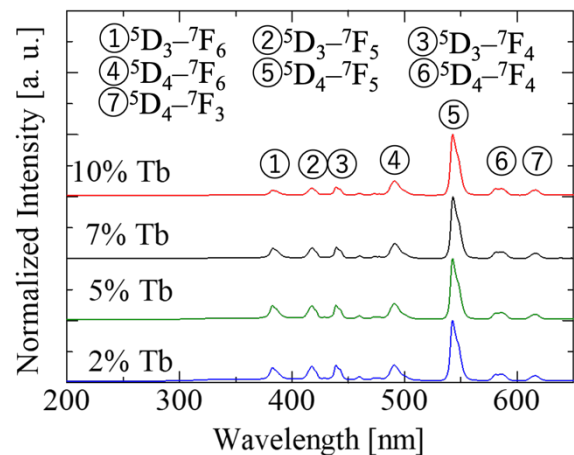


Fig. 1. Scintillation spectra of Tb:STGS samples under X-ray irradiations.

References

1. H. Xu et al., “Synthesis and photoluminescence of Gd₂O₂S:Tb³⁺ nanoaggregates via one-pot solvothermal method”, *Adv. Mater. Rapid Commun.* **11**, 703 (2017).
2. Z. Wang et al., “Study on the growth and characterization of Sr₃TaGa₃Si₂O₁₄ single crystals”, *J. Alloys. Compd.*, **30**, 287 (2004).
3. J. Sun et al., “Luminescent properties of LiBaPO₄:RE (RE = Eu²⁺, Tb³⁺, Sm³⁺) phosphors for white light-emitting diodes”, *J. Appl. Phys.*, **111**, 013101 (2012).