Development of novel red-emitting scintillators through crystal field engineering

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Radiation such as X-rays and gamma rays is widely used in modern society, including medical diagnostics, cancer radiotherapy and nuclear energy applications. Scintillator materials, which convert such high-energy radiation into optical photons, play a central role in radiation detection. In recent years, there has been growing demand for red-to-near-infrared (NIR) scintillators for radiation dosimetry in harsh environments, such as inside nuclear reactors. Emission in the NIR region (800–900 nm) is particularly advantageous due to low transmission loss in optical fibers.

In this study, we focus on chemically stable oxide scintillators doped with transition metal ions. Luminescence originating from d–d transitions of transition metal ions is strongly influenced by the crystal field at the occupied lattice sites, allowing systematic wavelength control based on Tanabe–Sugano diagrams [1]. In particular, previous studies have reported that Cr^{3+}-doped $AlTaO_4$ and Cr^{3+}-doped $GaTaO_4$ exhibit broadband emission originating from the $^4T_2$–$^4A_2$ transition over 800 nm, suggesting their potential as red-to-NIR-emitting scintillators [2, 3].

Motivated by these findings, we grew Cr^{3+}-doped $(Al,Ga)TaO_4$ crystals using the laser floating-zone method and systematically evaluated their crystal structures and optical properties. Fig. 1 shows the photoluminescence emission spectra of $(Cr_{0.01}Al_{0.99})TaO_4$ and $(Cr_{0.01}Ga_{0.99})TaO_4$, in which broad emission attributed to the $^4T_2$–$^4A_2$ transition was clearly observed, with peak wavelengths at 846 nm and 815 nm, respectively. In this presentation, the relationship between crystal structure and optical properties is discussed in more detail.

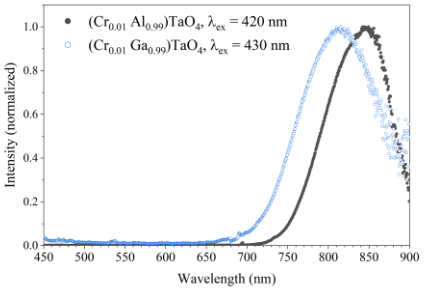

Figure 1 Photoluminescence emission spectra of $(Cr_{0.01}Al_{0.99})TaO_4$ and $(Cr_{0.01}Ga_{0.99})TaO_4$

This work was partially supported by the Iketani Science and Technology Foundation (ISTF) and GIMRT Program of the Institute for Materials Research, Tohoku University (Proposal No. 202603-RDKYA-0059).

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