The Role of Host Material in the Design of Ratiometric Optical Density Meters Based on Cr^{3+} Luminescence in $Y_3Al_{5-x}Ga_xO_{12}:Cr^{3+}$

Autorzy

Julia Jaśkielewicz

Maja Szymczak

Justyna Zeler

Łukasz Marciniak

Rok wydania

2025

Czasopismo

Advanced Optical Materials

Numer woluminu

13

Strony

2402039/1-2402039/11

DOI

10.1002/adom.202402039

Kolekcja

Naukowa

Język

Angielski

Typ publikacji

Artykuł

Streszczenie

The skillful combination of luminescent thermometry and optical heating has enabled the development of luminescent optical density meters. However, developing such sensing materials with predefined sensing performance requires an understanding of which material parameters play a dominant role in the optical response of the system. In this study, a systematic investigation is conducted on the influence of host material composition and crystal field strength affecting the Cr^{3+} ions on the sensing performance of the ratiometric optical density meter based on the $^2E \rightarrow {}^4A_2$ to $^4T_2 \rightarrow {}^4A_2$ luminescence intensity ratio (LIR) in $Y_3Al_{5-x}Ga_xO_{12}:Cr^{3+}$. As shown, the LIR reveals thermal variation according to the Boltzmann distribution in these materials over the 160 to 500 K range. However, at higher temperatures, monotonic changes in LIR are still observed. This has enabled the development of optical density meters with high sensitivity, operating over a wide range of power densities (<5500 W cm^{-2}). The maximum sensitivity is found for $Y_3Al_3Ga_2O_{12}:Cr^{3+}$, reaching 0.086% W^{-1} cm^2 at 2 W cm^{-2}, which is the highest value reported to date among all ratiometric Cr^{3+}-based optical density meters. It is demonstrated that a strong crystal field favorably influences the thermal sensitivity of the analyzed systems, thereby achieving high sensitivity in the low optical power density range (<1000 W cm^{-2}). However, it also limits the operating range of the sensing material. Conversely, to extend the operating range of the optical density meter, materials with intermediate or low crystal field strengths are preferred.

Słowa kluczowe

Cr3+, luminescent sensors, optical density meter, ratiometric

Adres publiczny

http://dx.doi.org/10.1002/adom.202402039