Phase transition under control: Toward application-oriented luminescence thermometry and thermally activated emission

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Streszczenie

Phase-transition-based luminescent thermometers are characterized by two inherent limitations: a narrow thermal operating range and the presence of a hysteresis loop in the thermometric parameter. In this work, we demonstrate that controlling the particle size of $LaGaO_3$:Eu^{3+} phosphors enables significant enhancement of thermometric performance. Specifically, a reduction in grain size dispersion leads to an increase in relative thermal sensitivity and significantly narrows the hysteresis loop. As a result of this approach, the relative sensitivity was increased to 18.2 % K^{-1} for $LaGaO_3$:Eu^{3+} synthesized via the solid-state method, compared to 3.0 % K^{-1} for the counterpart prepared using the Pechini method. Furthermore, we show that the intentional incorporation of Al^{3+} and Sc^{3+} co-dopant ions allows for continuous tuning of the structural phase transition temperature from 165 K for 15 % Al^{3+} to 491 K for 2 % Sc^{3+}, without significantly affecting the low-temperature spectroscopic properties of Eu^{3+} ions. This ability to shift the phase transition temperature in $LaGaO_3$ offers a practical route to modulate the thermal response range of the luminescent thermometer, enabling its adaptation to specific application requirements. The empirical relationship established in this study between the phase transition temperature and the ionic radius mismatch parameter provides a predictive tool for the rational design of phase-transition-based phosphors with tailored thermometric performance. The ability to systematically tune the phase transition temperature via ionic radius mismatch, together with enhanced thermometric performance resulting from reduced grain size dispersion, establishes a coherent strategy for the rational design of high-sensitivity, low-hysteresis thermal sensors. These results lay the groundwork for the development of application-specific luminescent thermometers with tailored operating ranges and improved reliability.

Słowa kluczowe

Luminescence thermometry, Phase transition, Ratiometric approach, Relative thermal sensitivity

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