Thermally stable novel double perovskite orange-red emitting Sr_2InTaO_6: Sm^{3+} phosphors with high CRI for WLEDs

一种具有双钙钛矿结构的新型高热稳定性橙红色发光Sr_2InTaO_6:Sm^{3+}荧光粉用于高显色WLED的研究

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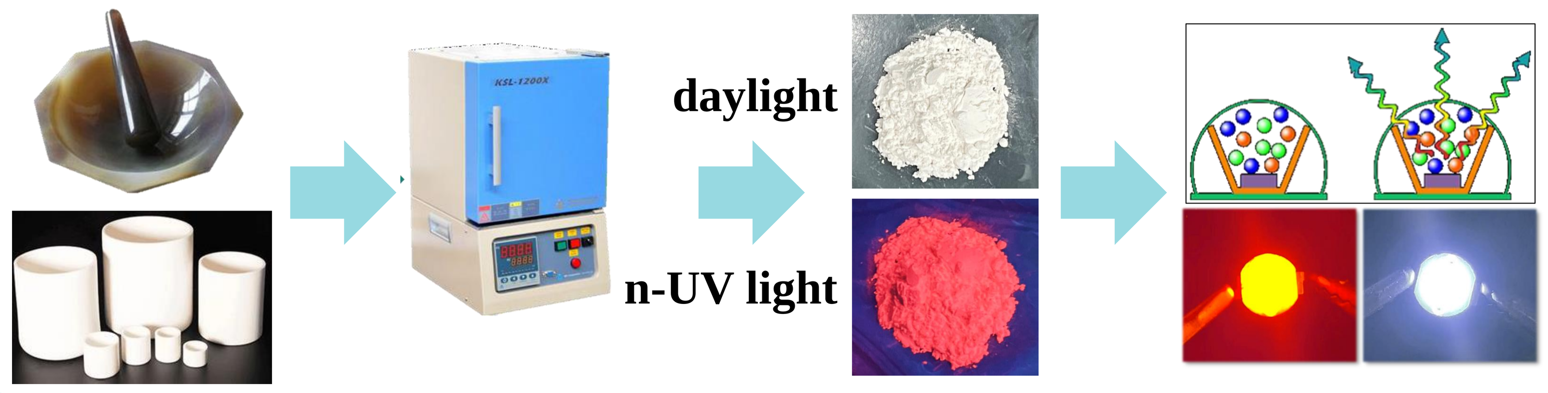
Introduction

- **The current research concentrates on pc-WLEDs** (phosphor-converted white light-emitting diodes).
- Nevertheless, the made w-LEDs in traditional way have bad wishes in red that **the color rendering index (R_a) is poor and the correlated color temperature (CCT) is high.**
- Three-color WLEDs made **by combining green, red, and blue phosphors** with ultraviolet (UV) LED chips can **solve these problems.**
- Sm^{3+} ions are suitable activators for producing **orange-red emissions** in various inorganic host.
- Sr_2InTaO_6 is a compound belonging to **the double perovskite class with high color purity, good thermal stability, and broad application.**

Experimental



The synthetic raw materials for Sr_2InTaO_6:Sm^{3+} phosphor were weighed $SrCO_3$, In_2O_3, Ta_2O_5, and Sm_2O_3 mixed in a mortar, and ground thoroughly. The mixed compounds were first sintered at 600 ℃ for 6 h, followed by secondary grinding and sintering at 1300 ℃ for 6 h, waiting for the temperature to drop to room temperature to obtain the target phosphors.

Phase purity

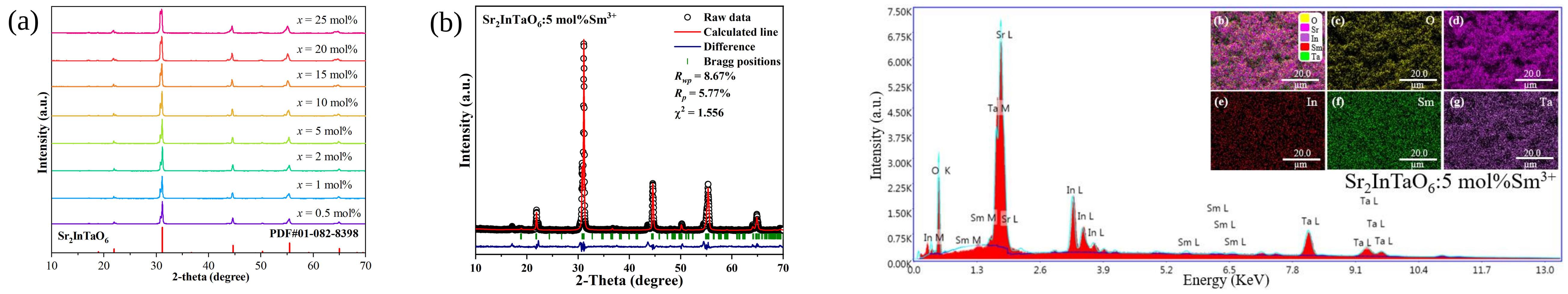


Fig. 1. (a) The XRD patterns of Sr_2InTaO_6:xSm^{3+} and Sr_2InTaO_6 standard PDF card. (b) Rietveld refinements of the Sr_2InTaO_6:5 mol%Sm^{3+} phosphor.

Fig. 2. (a–g) EDS spectra of Sr_2InTaO_6:5 mol%Sm^{3+} and elemental mapping of O, Sr, In, Sm, and Ta.

Optical properties

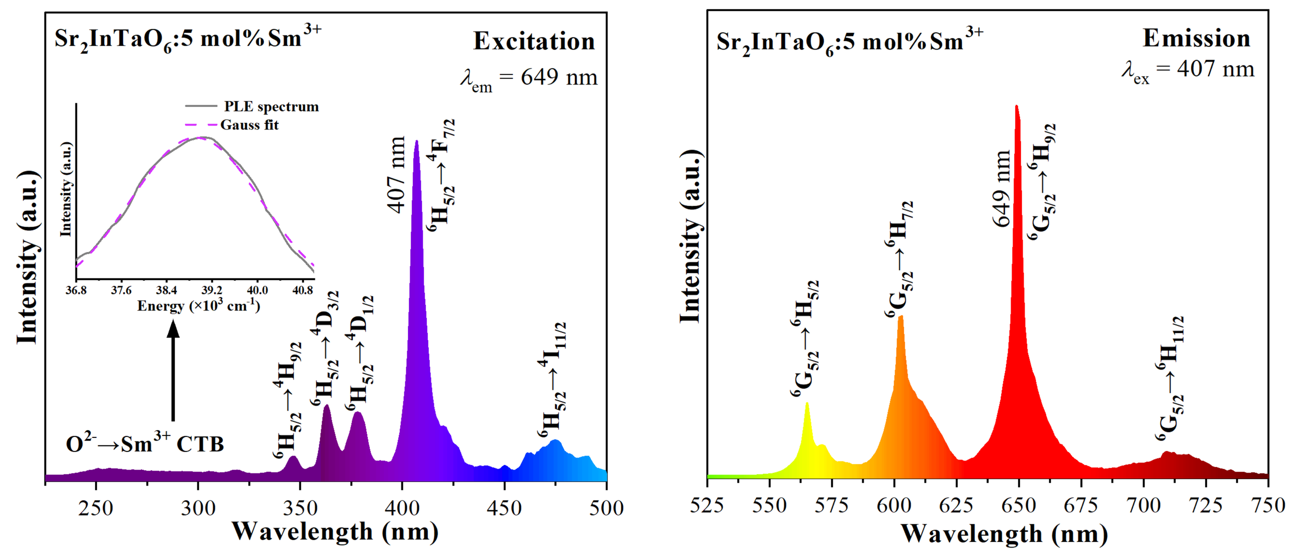


Fig. 3. Excitation spectrum of Sr_2InTaO_6:5 mol%Sm^{3+} (λ_{em} = 649 nm, inset: Gauss fit result of CTB).

Fig. 4. Emission spectrum of Sr_2InTaO_6:5 mol%Sm^{3+} (λ_{ex} = 407 nm).

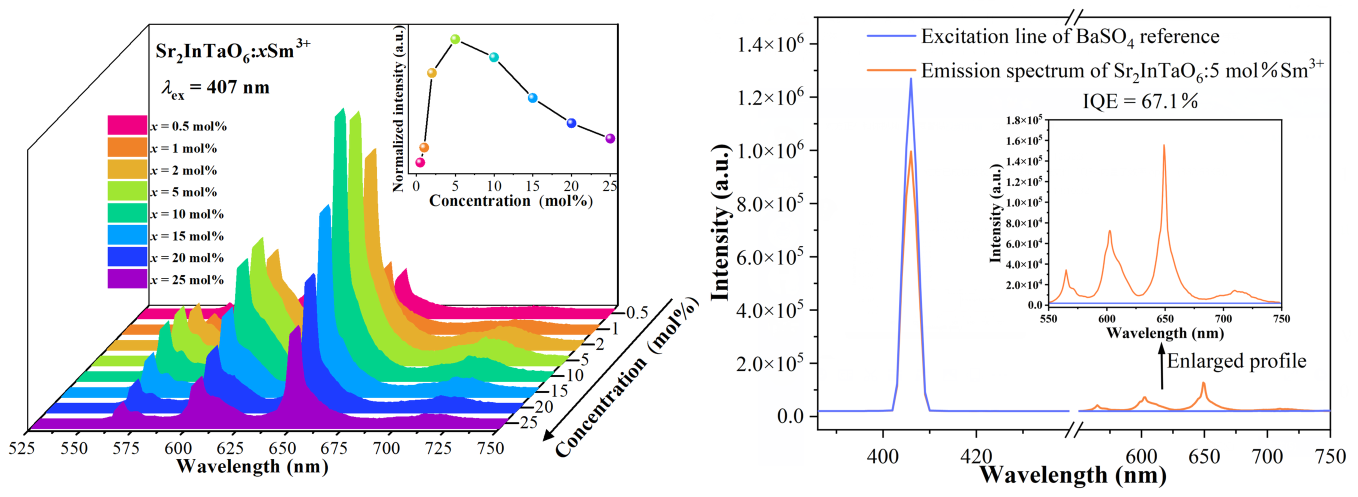


Fig. 5. Variation of Sr_2InTaO_6:xSm^{3+} fluorescence intensity with concentrations.

Fig. 6. Excitation line of $BaSO_4$ based and emission spectrum of Sr_2InTaO_6:5 mol%Sm^{3+} collected with an integrating sphere. (Inset: magnification of emission spectrum from 550 to 750 nm).

Thermal stability

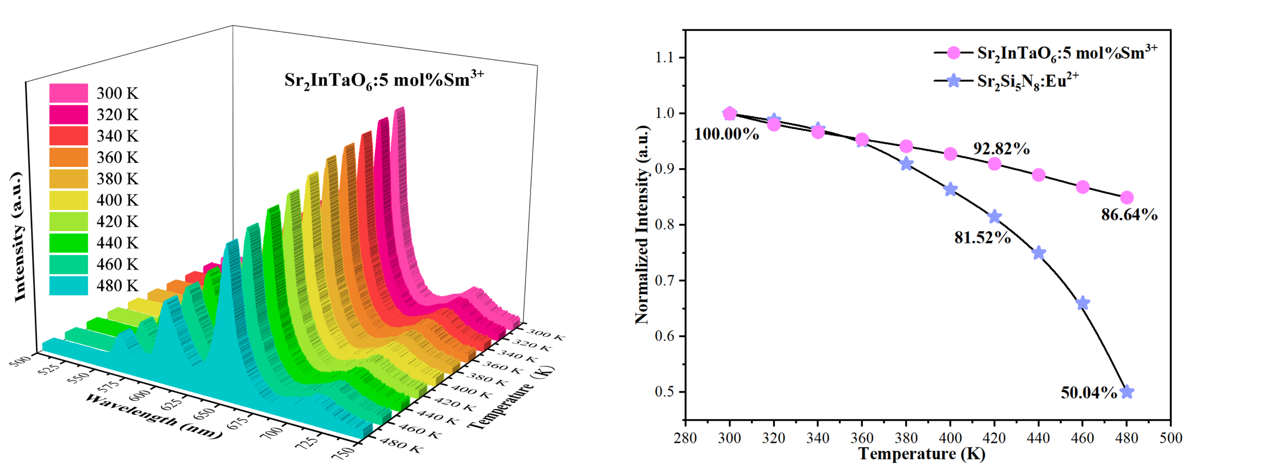


Fig. 7. (a) PL spectrum of Sr_2InTaO_6:5 mol%Sm^{3+} at 300–480 K. (b) Integral diagram of luminous intensity of Sr_2InTaO_6:5 mol%Sm^{3+} compared with that of commercially available red phosphor $Sr_2Si_5N_8$:Eu^{2+}.

Color stability

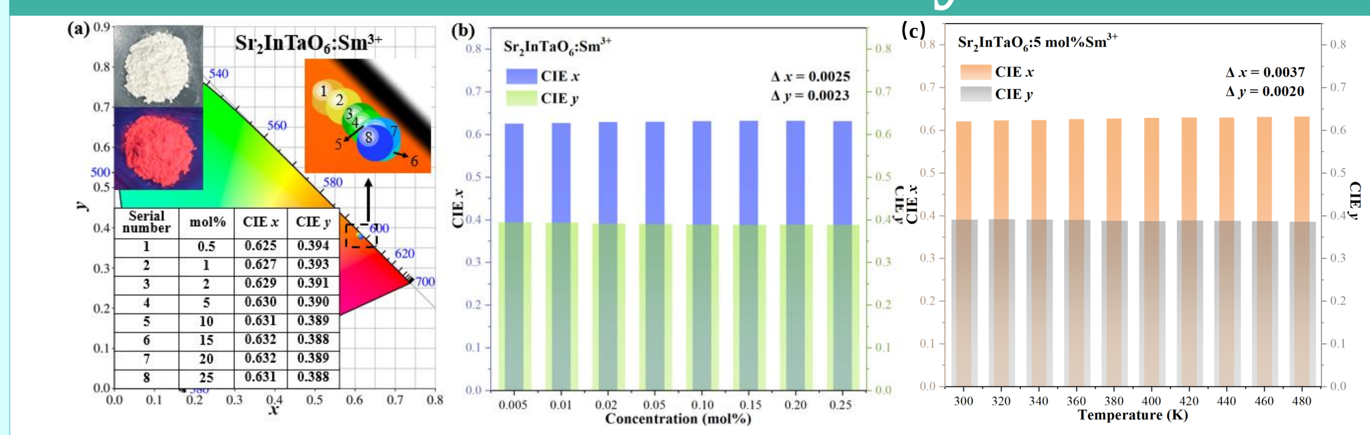


Fig. 8. (a) Coordinate diagram of Sr_2InTaO_6:xSm^{3+} phosphors (0.5 mol% ≤ x ≤ 25 mol%). The middle inset shows a picture of the Sr_2InTaO_6:5 mol%Sm^{3+} phosphor. (b) The standard deviation of the x and y of the Sr_2InTaO_6:xSm^{3+} phosphors (0.5 mol% ≤ x ≤ 25 mol%). (c) Relationship between CIE x, CIE y, and different temperatures (300–480 K) of Sr_2InTaO_6:5 mol%Sm^{3+}.

WLED

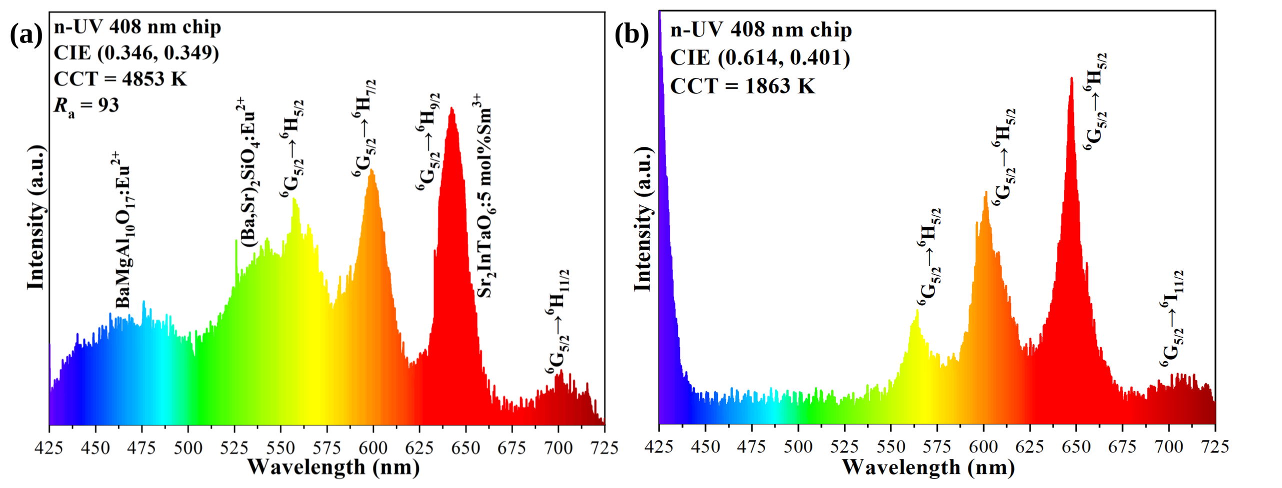


Fig. 9. (a) Electroluminescence (EL) spectrum of the WLED with a three-color method-based NUV chip. (b) EL spectrum of an orange-red LED based on a NUV chip.

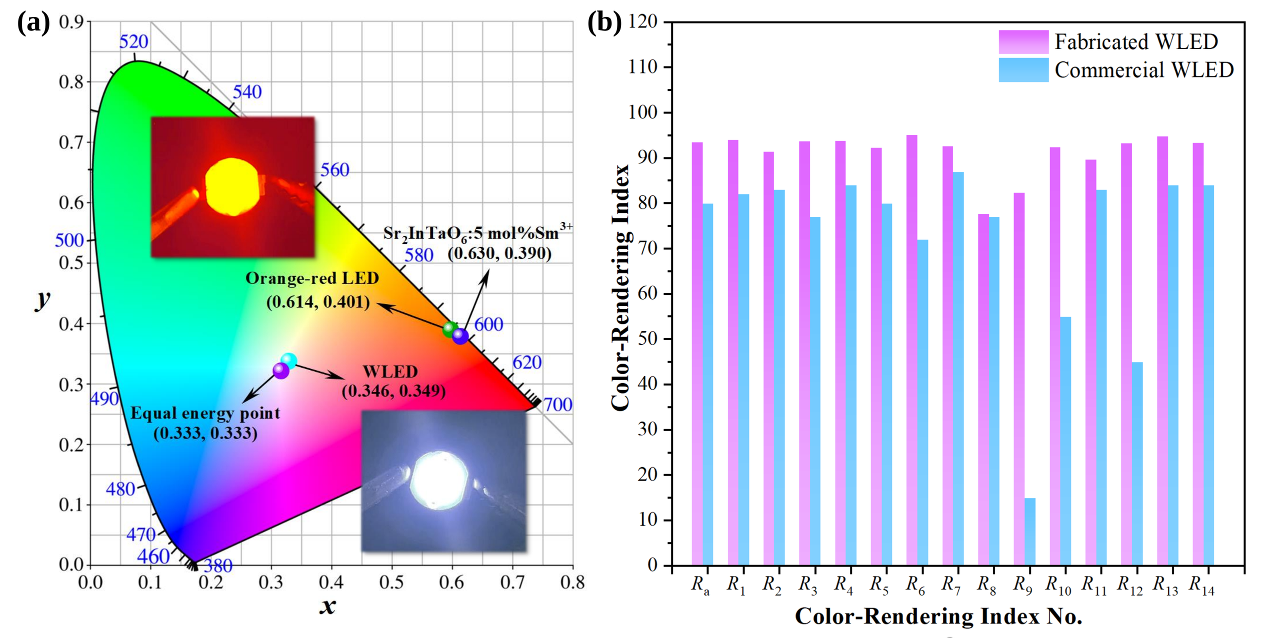


Fig. 10. (a) Coordinate diagram of Sr_2InTaO_6:5 mol%Sm^{3+} phosphor and the prepared LEDs. (b) Histogram of the CRI of the fabricated WLED compared with that of the commercial WLED.

Conclusions

1. We **successfully synthesized Sr_2InTaO_6:xSm^{3+} phosphor** by a high-temperature. Under n-UV excitation of 407 nm, the Sr_2InTaO_6:Sm^{3+} phosphors emit strong orange-red light at 649 nm.
2. The Sr_2InTaO_6:5 mol%Sm^{3+} phosphor has **a good IQE of 67.1%.**
3. The Sr_2InTaO_6:Sm^{3+} phosphors have a thermal quenching behavior and **excellent thermal stability.**
4. A WLED with **suitable CCT (4853 K) and high R_a (93), and CIE (0.346, 0.349)** was prepared. These indicate that Sr_2InTaO_6:Sm^{3+} phosphors can be **effectively used in WLEDs.**

Achievements

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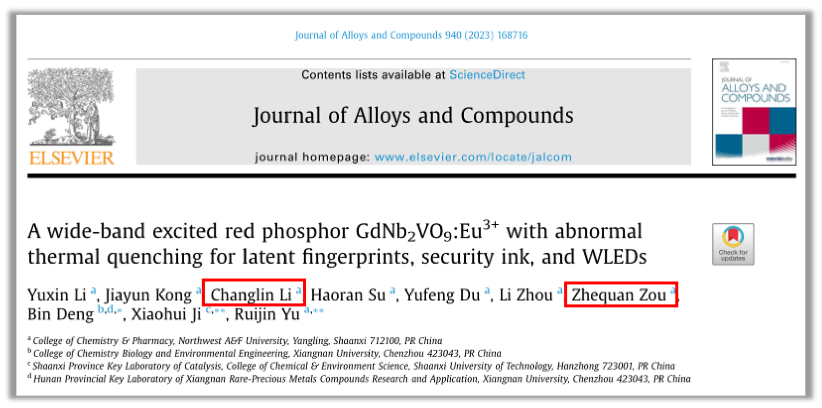

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