A novel red-emitting $K_5La(MoO_4)_4:Eu^{3+}$ phosphor with a high quantum efficiency for w-LEDs and visualization of latent fingerprints

新型高量子效率红色荧光粉$K_5La(MoO_4)_4:Eu^{3+}$在白光LED和潜指纹显影领域的应用

Daomiao He(何道淼),Yifang Lin, Wenhao Li(李文浩), Huayu Sun(孙华宇),
Jiaxin Yan(颜佳馨),Renkang Qin(秦仁康),Dan Zhang(张丹,指导老师),
College of Science, Northwest A&F University, Yangling, Shaanxi 712100, PR China

Introduction

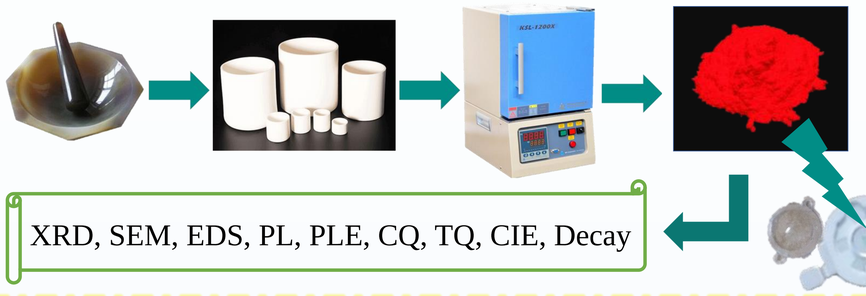
A series of KLMO:Eu^{3+} phosphors were synthesized and studied for the first time. In this work, the lattice structure, luminescence characteristics of KLMO:Eu^{3+} phosphors, and their applications in w-LEDs and LFP were studied and analyzed in detail. Besides, the KLMO:0.80Eu^{3+} phosphor was surface-functionalized with oleic acid (OA) (KLMO:0.80Eu^{3+}@OA) to apply in LFP development.

As is well known, the 4f→4f transitions of Eu^{3+} ions make Eu^{3+}-activated phosphors able to emit intense red light under ultraviolet (UV) light excitation.

For example, $Li_3Y_3BaSr(MoO_4)_8:Eu^{3+}$, SrAO4 (A = Mo and W):Eu^{3+} , and Bi_2-xMoO_6:xEu^{3+} phosphors have been reported to well perform in w-LED fabrication. However, $K_5La(MoO_4)_4:Eu^{3+}$ (KLMO:Eu^{3+}) phosphors have not previously been synthesized and reported.

Experimental

$$2.5K_2O_3+0.5(1-x)La_2O_3+4MoO_3+0.5xEu_2O_3 \xrightarrow{600℃\times 3h} K_5La(1-x)Eu(MoO_4)_4$$



Eu^{3+}-doped KLMO (*x* = 0.05, 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.80, and 1.00 mol*)* were synthesized by solid-state reaction. Raw materials were Eu2O3 /La2O3.).K2CO3 (99.99%), La2O3 (99.99%), MoO3 (99.99%), and Eu2O3 (99.99%).

XRD, SEM, EDS, PL, PLE, CQ, TQ, CIE, Decay

EL, CIE, CCT, CRI

Results and Discussion

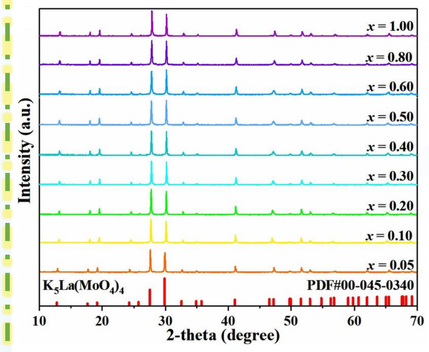


Fig.1 XRD patterns of the KLMO :0.80Eu^{3+} samples.

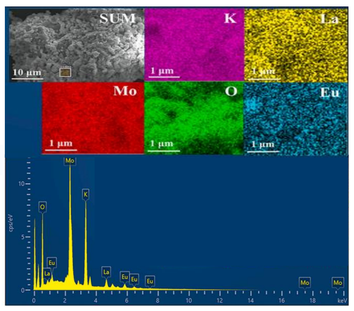


Fig.2 The EDS spectrum and mapping of the KLMO :0.80Eu^{3+} phosphor.

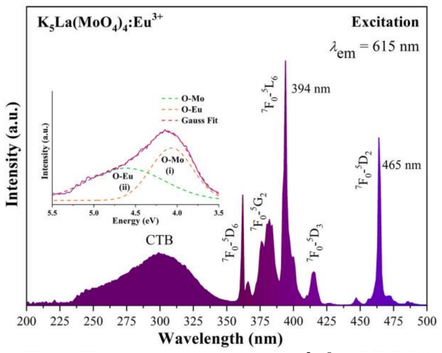


Fig.3 Excitation spectrum of the KLMO :0.80Eu^{3+} (λ_{em} = 615 nm).

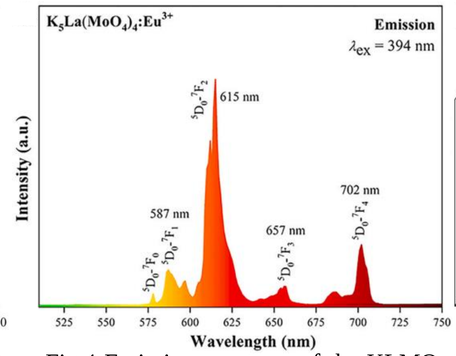


Fig.4 Emission spectrum of the KLMO :0.80Eu^{3+} (λ_{ex} = 394 nm).

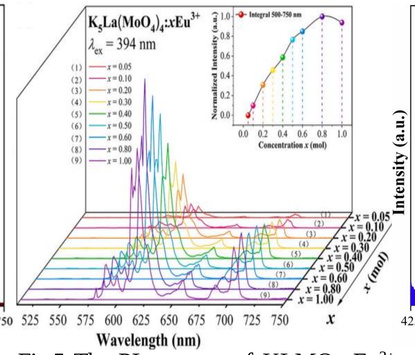


Fig.5 The PL spectra of KLMO:*x*Eu^{3+} (*x* = 5-100 mol%) phosphors with different concentration of Eu^{3+} ions.

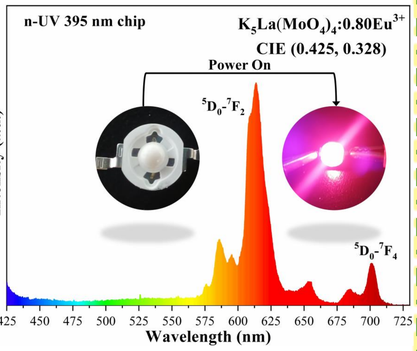


Fig.6 The EL spectrum of the red LED

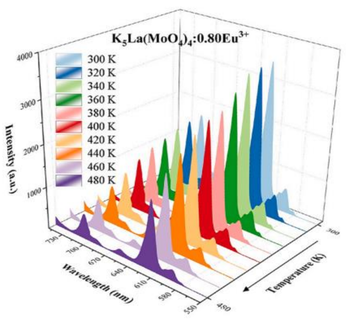


Fig.7 Three-dimensional PL spectra of KLMO:0.80Eu^{3+} phosphor at different temperatures.

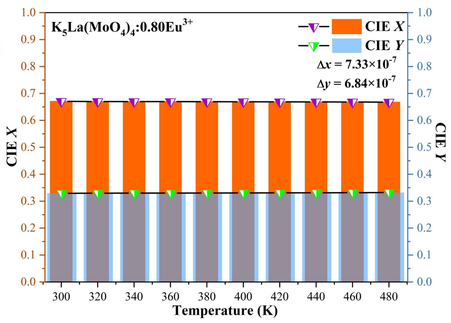


Fig.8 The temperature-dependent chromaticity coordinates of the KLMO:0.80Eu^{3+}

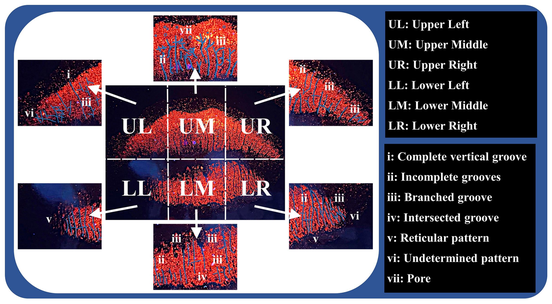


Fig.9 Identification of different lip print features.

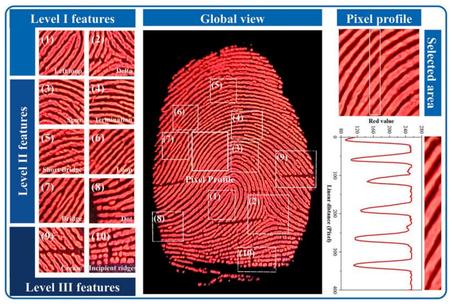


Fig.10 Global view, microscopic pictures and the pixel profile stained by KLMO:0.80Eu^{3+}.

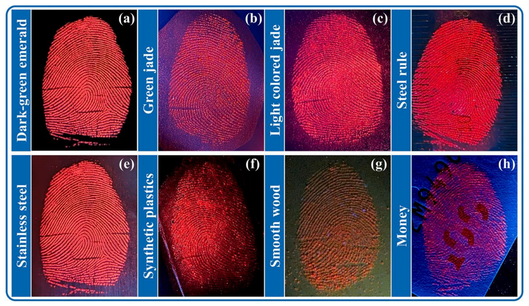


Fig.11 Staining of LFPs left on the surfaces of different objects by KLMO:0.80Eu^{3+}@OA phosphor.

Conclusions

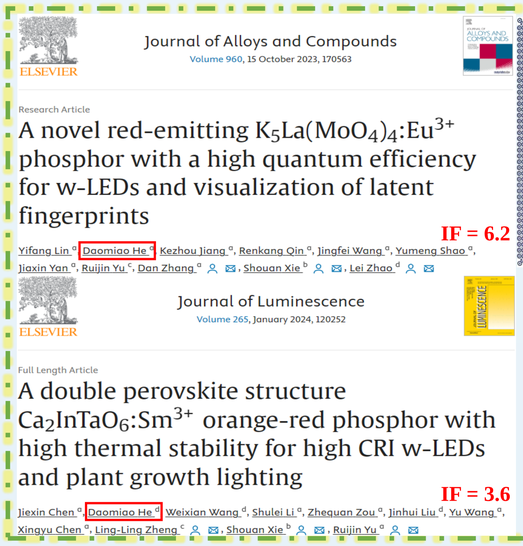
- In summary, the novel molybdate KLMO:*x*Eu^{3+} (x = 5–100 mol%) phosphors and KLMO:0.80Eu^{3+}@OA phosphor were successfully synthesized in this work.
- KLMO:0.80Eu^{3+} phosphor has a high IQE of 84.5%. The CIE chromaticity coordinates, high R_a, and low CCT of the w-LED fabricated with KLMO:0.80Eu^{3+} are determined as (0.342, 0.345), 5117 K, and 89, respectively. These results indicate the potential of the phosphor in the w-LED application.
- The fingerprints stained by KLMO:0.80Eu^{3+} phosphor shows higher accuracy in revealing Level I-III fingerprint features, and they can be well exhibited on the surface of different substances with high contrast.

Acknowledgements

- The work is supported by the Undergraduate Innovation Fund of Northwest A&F University, China (202010712093).

- For more details, please contact with *472249912@qq.com.*

Achievements



Journal of Alloys and Compounds
Volume 960, 15 October 2023, 170563
Research Article
A novel red-emitting $K_5La(MoO_4)_4:Eu^{3+}$ phosphor with a high quantum efficiency for w-LEDs and visualization of latent fingerprints
IF = 6.2
Yifang Lin, Daomiao He, Kezhou Jiang, Renkang Qin, Jingfei Wang, Yumeng Shao, Jiaxin Yan, Ruijin Yu, Dan Zhang, Shouan Xie, Lei Zhao

Journal of Luminescence
Volume 265, January 2024, 120252
Full Length Article
A double perovskite structure $Ca_2InTaO_6:Sm^{3+}$ orange-red phosphor with high thermal stability for high CRI w-LEDs and plant growth lighting
IF = 3.6
Jiexin Chen, Daomiao He, Weixian Wang, Shulei Li, Zhequan Zou, Jinhui Liu, Yu Wang, Xingyu Chen, Ling-Ling Zheng, Shouan Xie, Ruijin Yu

互联网+大学生创新创业大赛陕西省赛区 省级 金奖
全国大学生生命科学竞赛（创新创业类）国家级 一等奖

[1] Y. Lin, D. He(何道淼), K. Jiang, R. Qin (秦仁康), J. Wang, Y. Shao, J. Yan (颜佳馨), R. Yu, D. Zhang, S. Xie, L. Zhao, A novel red-emitting $K_5La(MoO_4)_4:Eu^{3+}$ phosphor with a high quantum efficiency for w-LEDs and visualization of latent fingerprints, J Alloy Compd, 960 (2023). IF = 6.2, 中科院二区TOP

[2] J. Chen, D. He(何道淼), W. Wang, S. Li, Z. Zou, J. Liu, Y. Wang, X. Chen, L.-L. Zheng, S. Xie, R. Yu, A double perovskite structure $Ca_2InTaO_6:Sm^{3+}$ orange-red phosphor with high thermal stability for high CRI w-LEDs and plant growth lighting, Journal of Luminescence, 265 (2024). IF = 3.6, 中科院二区