# Supporting Information

# A Novel Green-Emitting Phosphor $NaLa_9Ge_6O_{26}$:$x$$Tb^{3+}$ with Anti-Thermal Quenching for WLEDs

Zhenwei Jia[1], Yijie Ren[1], Mengdi Yue[1], Jiaqi Wang[1], Jing Meng[1], Li Wu[1*], Yongfa Kong[1] and Jingjun Xu[1]

[1] *Key Laboratory of Weak-Light Nonlinear Photonics, Ministry of Education, School of Physics, Nankai University, Tianjin 300071, China.*

[*] *E-mail: lwu@nankai.edu.cn*

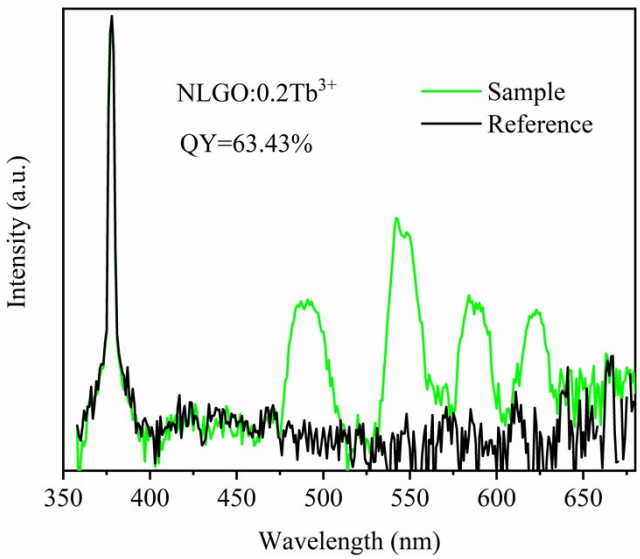


Fig. S1. PLQY of NLGO:0.2$Tb^{3+}$.

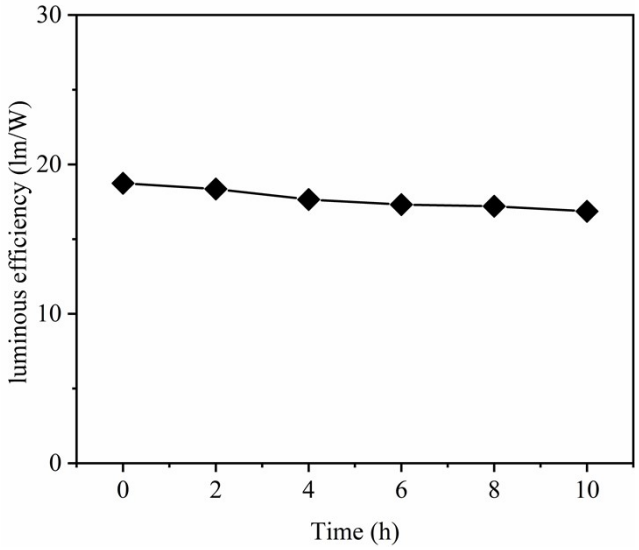


Fig. S2. Luminous efficiency of the device operated from 0 to 10 h.

Table S1. Lattice parameters and agreement factors for NLGO:0.2$Tb^{3+}$ refined by Rietveld method.

| Formula | NLGO | NLGO:0.2$Tb^{3+}$ |
|---|---|---|
| Crystal system | Hexagonal | Hexagonal |
| Space group | P63/m | P63/m |
| a=b (Å) | 9.883(2) | 9.832(4) |
| c (Å) | 7.267(3) | 7.124(13) |
| Z | 1 | 1 |
| Volume ($Å^3$) | 614.7 | 596.4(4) |
| $R_p$ | / | 8.76 |
| $R_{exp}$ | / | 5.92 |
| GOF | / | 2.06 |

Table S2. Atomic positions and occupancies for NLGO:0.2$Tb^{3+}$ refined by Rietveld method.

| | Np | *x* | *y* | *z* | Occupancy |
|---|---|---|---|---|---|
| La1 | 12 | 0.3333 | 0.6667 | 0.0003 | 0.75 |
| Na1 | 12 | 0.3333 | 0.6667 | 0.0003 | 0.25 |
| La2 | 6 | 0.2500(5) | 0.000(3) | 0.2500 | 0.819(3) |

| | | | | | |
|---|---|---|---|---|---|
| Tb | | | | | 0.181(3) |
| Ge1 | 6 | 0.3700(16) | 0.3800(15) | 0.2500 | 1.0 |
| O1 | 6 | 0.0000(4) | 0.4000(7) | 0.2500 | 1.0 |
| O2 | 6 | 0.0000(2) | 0.3000(2) | 0.7500 | 1.0 |
| O3 | 12 | 0.3000(8) | 0.3000(2) | 0.5000(9) | 1.0 |
| O4 | 2 | 0.0000 | 0.0000 | 0.2500 | 1.0 |

Table S3. QY of $Tb^{3+}$ ions in NLGO and other compounds.

| Compound | QY | Refs |
|---|---|---|
| $SrMg_{1.06}Al_{9.94}O_{17}:Tb^{3+},Ce^{3+}$ | 55.14% | 1 |
| $Lu_2(MoO_4)_3:Tb^{3+}$ | 43.79% | 2 |
| $Ca_2ZrSi_4O_{12}:Tb^{3+},Ce^{3+}$ | 59.20% | 3 |
| $NLGO:Tb^{3+}$ | 63.43% | This work |

Table S4. The CCT, $R_a$, CIE chromaticity coordinates, and luminous efficiency under different currents (25-300 mA) for the fabricated WLED.

| Current (mA) | CIE (x,y) | CCT | $R_a$ | lm/W |
|---|---|---|---|---|
| 25 | (0.3381, 0.3209) | 5209 | 84.7 | 26.27 |
| 50 | (0.3383, 0.3210) | 5196 | 84.6 | 25.44 |
| 75 | (0.3381, 0.3207) | 5203 | 84.5 | 24.58 |
| 100 | (0.3381, 0.3204) | 5206 | 84.6 | 23.74 |
| 125 | (0.3380, 0.3203) | 5209 | 84.6 | 22.96 |
| 150 | (0.3380, 0.3203) | 5211 | 84.6 | 22.1 |
| 175 | (0.3379, 0.3202) | 5216 | 84.7 | 21.55 |
| 200 | (0.3379, 0.3210) | 5216 | 84.6 | 20.82 |
| 225 | (0.3379, 0.3202) | 5213 | 84.7 | 20.37 |
| 250 | (0.3380, 0.3201) | 5209 | 84.7 | 19.68 |
| 275 | (0.3379, 0.3202) | 5213 | 84.8 | 19.15 |
| 300 | (0.3379, 0.3202) | 5216 | 84.9 | 18.8 |

## Notes and references

1. C. Shan, Q. Wang, P. Xue, L. Tian, Enhancement of luminescence, thermal stability and quantum efficiency with $Ce^{3+}$ co-doped $SrMg_{1.06}Al_{9.94}O_{17}:Tb^{3+}$ phosphor, *Heliyon*, 2023, **9**(3), e14492

2. N. Huang, G. Lu, B. Bai, H. Zhao, W. Yao, C. Cao, Y. Li, A. Xie, Preparation, crystal structure, and photoluminescence properties of $Tb^{3+}$ activated $Lu_2(MoO_4)_3$ green-emitting phosphors, *J. Lumin*. 2024, **269**, 120475.

3. Y. Gao, R.H. Cong, T. Yang, Color-tunable emissions realized by $Tb^{3+}$ to $Eu^{3+}$ energy transfer in $ZnGdB_5O_{10}$ under near-UV excitation, *Dalton Trans*. 2023, **52**(35), 12332.