Supplementary Information for

Manipulating trap filling of persistent phosphors upon illumination by a blue light-emitting diode

Qingqing Gao,[a] Chenlin Li,[a] Yichun Liu,[a] Jiahua Zhang,[b] Xiao-jun Wang*[c] and Feng Liu*[a]

[a]*Key Laboratory for UV-Emitting Materials and Technology of Ministry of Education, Northeast Normal University, Changchun 130024, China*

[b]*State Key Laboratory of Luminescence and Applications, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun 130033, China*

[c]*Department of Physics, Georgia Southern University, Statesboro, Georgia 30460, USA*

*Correspondence: fengliu@nenu.edu.cn (FL); xwang@georgiasouthern.edu (X.W)

Brief summary − This file contains: (1) XRD pattern of LMG:Cr; (2) illumination light path; (3) decay curves after monochromatic light illuminations; (4) UCC-PersL of LMG:Cr upon laser illuminations; (5) effect of exposure duration on thermoluminescence; (6) write/read of traps in LMG:Mn; (7) write/read of traps in LMG:Pr.

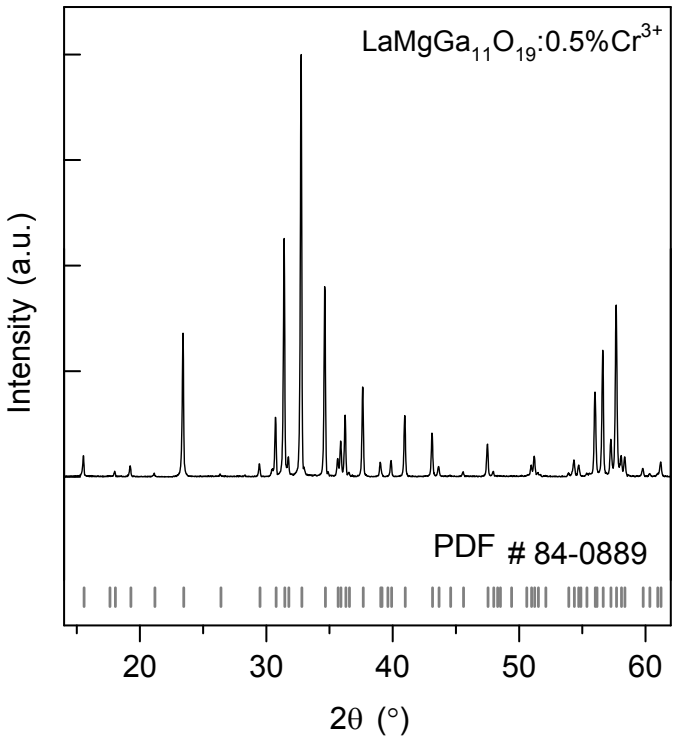

Fig. S1 X-ray diffraction (XRD) pattern of $LaMgGa_{11}O_{19}$:0.5%Cr^{3+} phosphor, showing that there is no impurity phase in the resulting phosphor. The XRD pattern was acquired on a PANalytical X'Pert Pro x-ray diffrectometer using Cu Kα1 radiation. The corresponding PDF number is also presented.

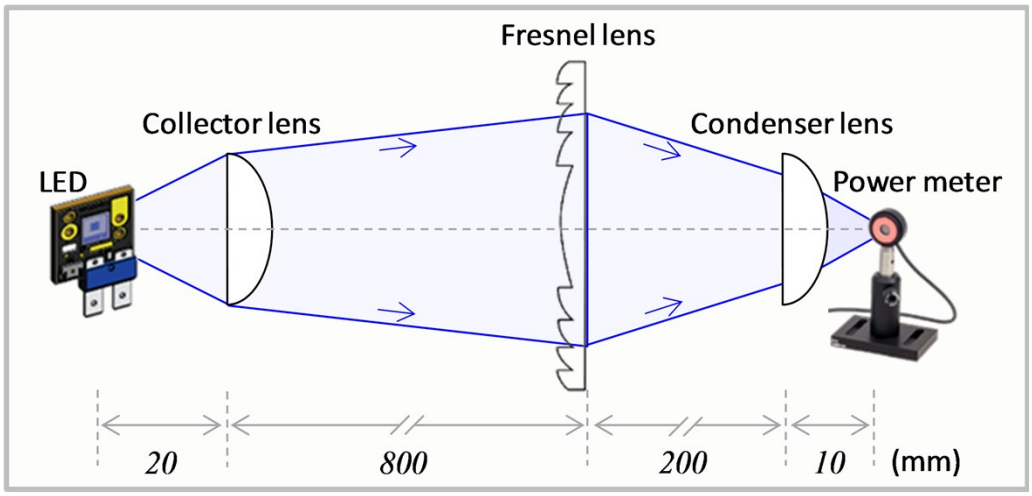

Fig. S2 Optical geometry of the blue LED illumination. Light beam of the LED is collected after transmission through a series of lens, which includes a collector lens (f = 23 mm), a Fresnel lens combination (f = 600, 2000, 300 mm) and a condenser lens (f = 42 mm). The collector lens ensures that the beam with small divergence angle is incident on the Fresnel lens. Subsequently, after passing the Fresnel lens combination and the condenser lens, a converging beam with a spot diameter of 1 cm strikes on the object.

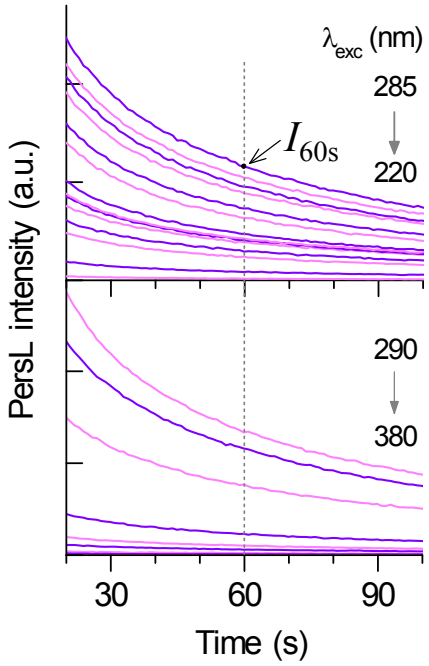

Fig. S3 Persistent luminescence (PersL) decay curves of LMG:Cr obtained by monitoring at 712 nm after illuminations for 300 s with monochromatic lights between 220–380 nm. The vertical dashed line is used to indicate the PersL intensity $\boldsymbol{I}_{60s}$ (i.e., decay intensity recorded at 60 s after the stoppage of each illumination). The $\boldsymbol{I}_{60s}$ is used to plot the PersL excitation spectrum in Fig. 2(a).

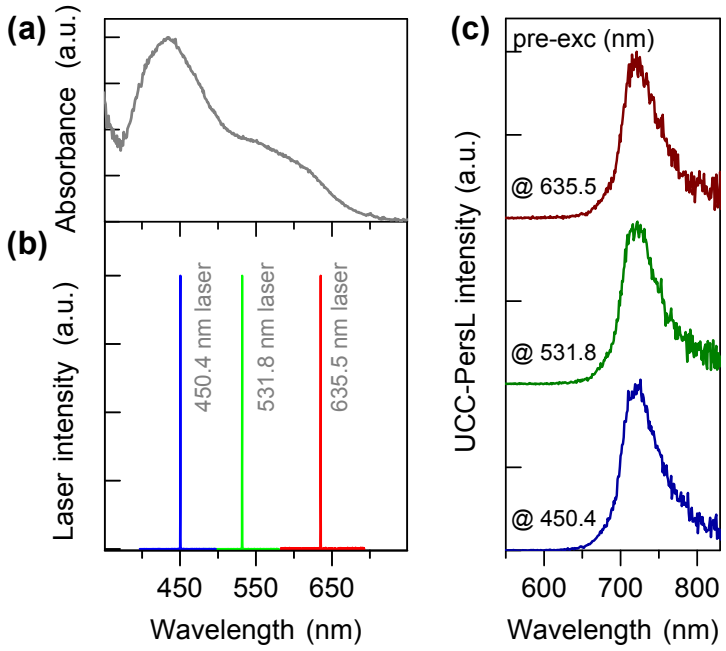

Fig. S4 UCC-PersL of LMG:Cr upon illuminations with lasers. **(a)** Diffuse reflectance absorption spectrum of the phosphor recorded over 350−750 nm. **(b)** Normalized emission spectra of the lasers, involving a blue laser (0.5 W·cm^{-2}, peaking at 450.4 nm), a green laser (0.5 W·cm^{-2}, peaking at 531.8 nm), and a blue solid-state laser (0.5 W·cm^{-2}, peaking at 635.5 nm). **(c)** UCC-PersL emission spectra of the phosphor recorded after illuminations for 60 s by the three lasers. Each spectrum is recorded with a delay time of 600 s. The measurement indicates that the UCC of LMG:Cr can be achieved upon illumination with a wide wavelength range. Accordingly, we may envisage an achievement of the UCC upon white light illumination (such as a convenient white-light flashlight).

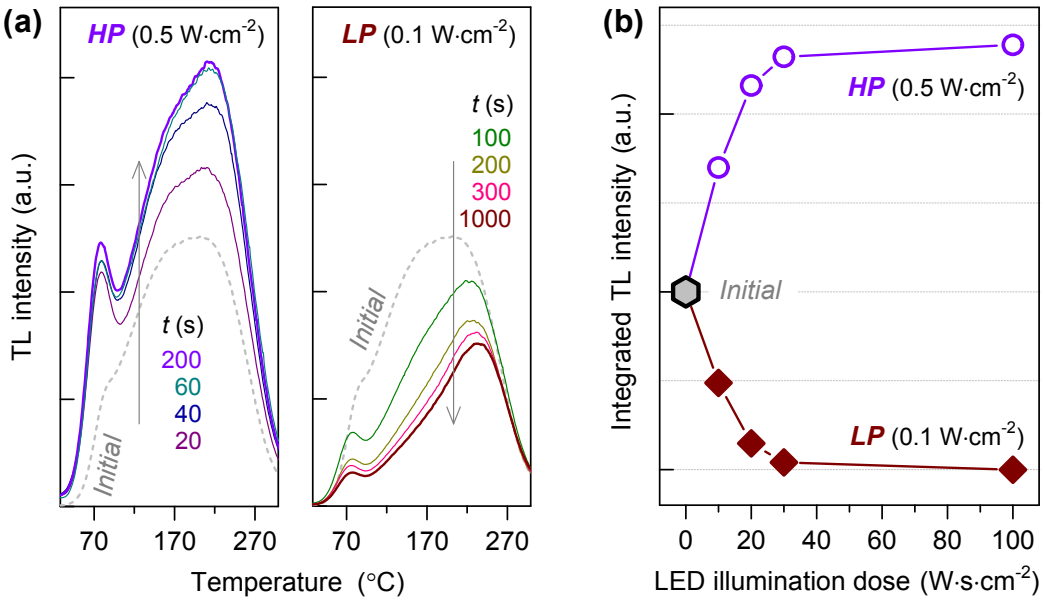

Fig. S5 **(a)** Thermoluminescence (TL) curves of LMG:Cr recorded after the blue LED illumination with different exposure durations (*t*) (see text for details). Left-hand side: TL curves recorded after high-power secondary illumination (*HP*, P=0.5 W·cm^{-2}) with *t* from 20 to 200 s. Right-hand side: TL curves recorded after low-power secondary illumination (*LP*, P=0.1 W·cm^{-2}) with *t* from 100 to 1000 s. TL curve recorded after the initial illumination (P=0.5 W·cm^{-2}) is also presented as the dashed-line curve. **(b)** Plot of the integrated TL intensity versus the secondary exposure dose, which is equal to the power density multiplied by the exposure duration. The ascending curve indicates that the phosphor is being charged by the high-power illumination. With 60 s *HP* illumination the charging appeared to become close to saturated. In contrast, upon the low-power illumination, the TL intensity decreases against the exposure duration, indicating that the phosphor is being discharged by the low-power illumination.

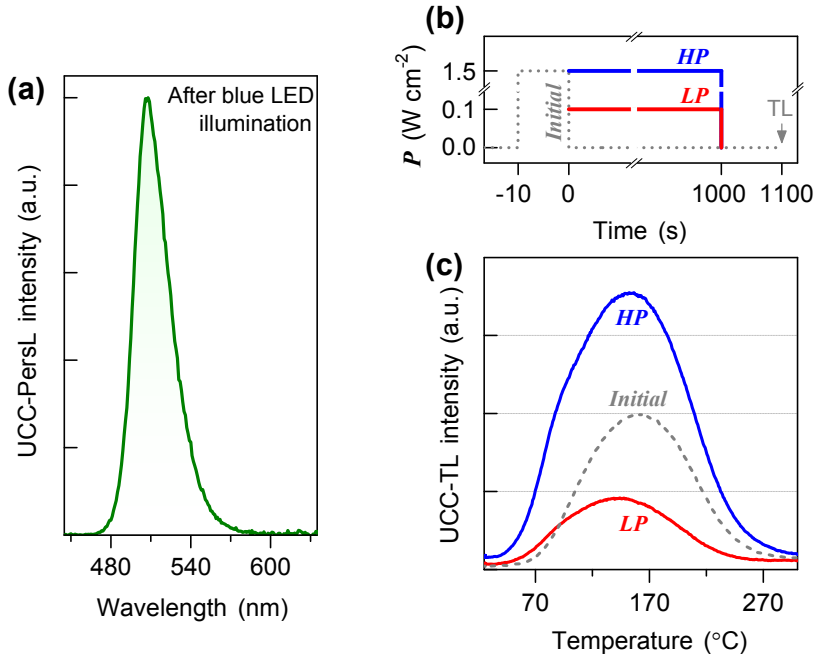

Fig. S6 Demonstration of optical write and read of traps upon the blue LED illuminations at different power densities in $LaMgGa_{11}O_{19}:0.2\%Mn^{2+}$ phosphor. **(a)** UCC-PersL emission spectrum recorded at 600 s after illumination by the blue LED. **(b)** Experiment outline, which is similar with the one in Fig. 4a. **(c)** TL curves obtained after illuminations with different illumination modes, indicating that the phosphor can be charged under the high-power mode (*HP*) and discharged under the low power mode (*LP*).

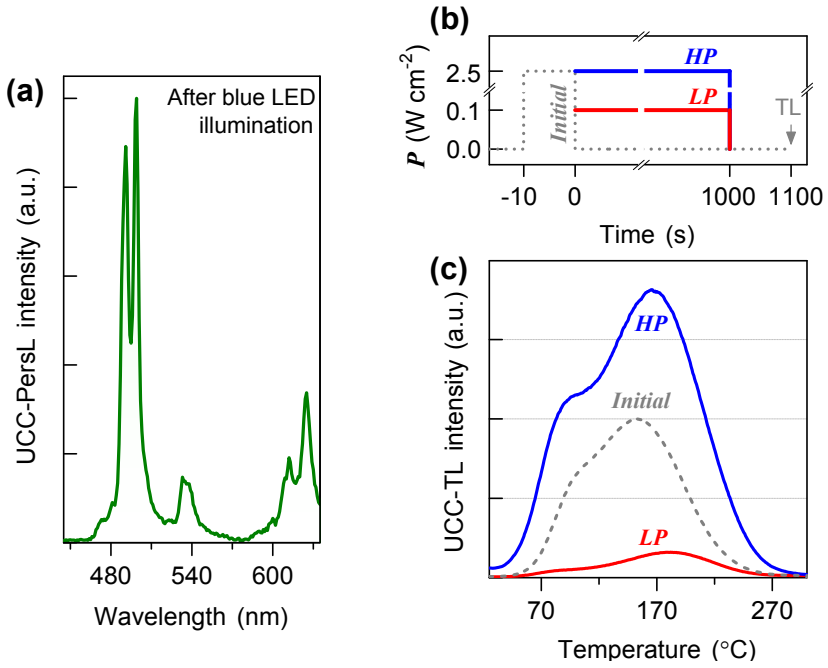

Fig. S7 Demonstration of optical write and read of traps upon the blue LED illuminations at different power densities in $LaMgGa_{11}O_{19}$:0.5%Pr^{3+} phosphor. **(a)** UCC-PersL emission spectrum recorded at 600 s after illumination by the blue LED. **(b)** Experiment outline, which is similar with the one in Fig. 4a. **(c)** TL curves obtained after illuminations with different illumination modes, indicating that the phosphor can be charged under the high-power mode (*HP*) and discharged under the low power mode (*LP*).