Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Supporting Information

Strategy for developing thermal-quenching-resistant emitting and super-long persistent luminescence in $BaGa_2O_4:Bi^{3+}$

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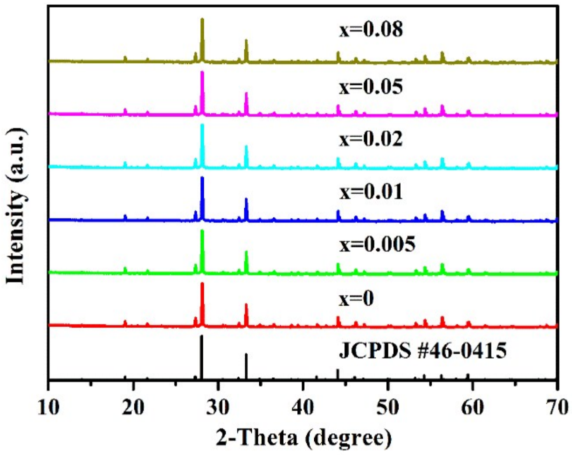

Fig. S1 XRD patterns of the standard of $BaGa_2O_4$ (JPCDS #46-0415) and the as-prepared phosphors $BaGa_2O_4$:xBi^{3+} (x=0 - 0.08)

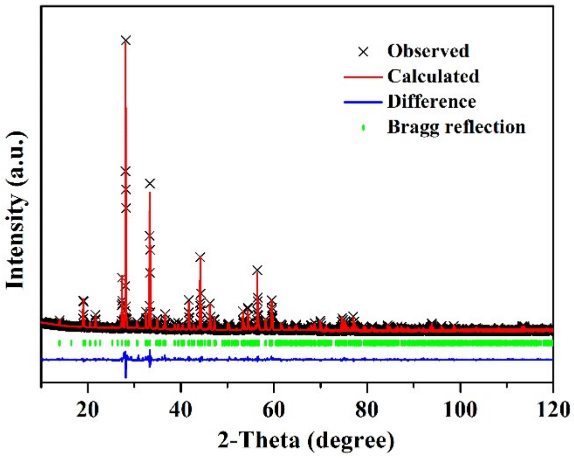

Fig. S2 Observed (×) and calculated (red solid line) powder XRD patterns of $BaGa_2O_4$:$0.02Bi^{3+}$, Bragg reflection (green sticks) and the profile difference between the observed and calculated data (blue solid line).

Table S1 Rietveld refinement and lattice parameters of $BaGa_2O_4$:0.02Bi^{3+}.

Formula	$BaGa_2O_4$:0.02Bi^{3+}
Space group	P-63(173)
a = b (Å)	18.62491
c (Å)	8.65935
α = β	90
γ	120
Units, Z	24
V (Å^3)	2601.383
R_p (%)	7.99
R_{wp} (%)	9.88
χ^2	4.42

Table S2 Selected bond distances in $BaGa_2O_4$:0.02Bi^{3+}.

Bonds	Distance (Å)	Bonds	Distance (Å)	Bonds	Distance (Å)
Ba4-O1	2.74158	Ba5-O1	2.83335	Ba6-O9	2.66738
Ba4-O1	2.74161	Ba5-O1	2.83338	Ba6-O9	3.12189
Ba4-O1	2.74260	Ba5-O1	2.83433	Ba6-O10	2.47119
Ba4-O6	3.16973	Ba5-O6	2.6779	Ba6-O10	3.41692
Ba4-O6	3.17073	Ba5-O6	2.67909	Ba6-O11	2.40504
Ba4-O6	3.17076	Ba5-O6	2.67912	Ba6-O13	2.94394
Ba4-O11	3.25453	Ba5-O14	3.19338	Ba6-O13	2.96016
Ba4-O11	3.25476	Ba5-O14	3.1929	Ba6-O13	3.12487
Ba4-O11	3.25622	Ba5-O14	3.19159	Average	2.88892
Average	3.05583	Average	2.90167		
Ba1-O2	3.33522	Ba2-O3	3.49542	Ba3-O2	2.70680
Ba1-O4	2.81659	Ba2-O3	2.41326	Ba3-O4	2.96709
Ba1-O5	3.38447	Ba2-O3	3.49542	Ba3-O5	2.52204
Ba1-O7	1.40747	Ba2-O3	2.41326	Ba3-O8	3.24502
Ba1-O8	2.70262	Ba2-O3	3.49542	Ba3-O12	2.09729
Ba1-O12	2.37434	Ba2-O3	2.41326	Ba3-O16	2.41183
Ba1-O14	2.63733	Average	2.95434	Average	2.65835
Ba1-O15	3.25179				
Ba1-O16	3.52457				
Average	2.82604				

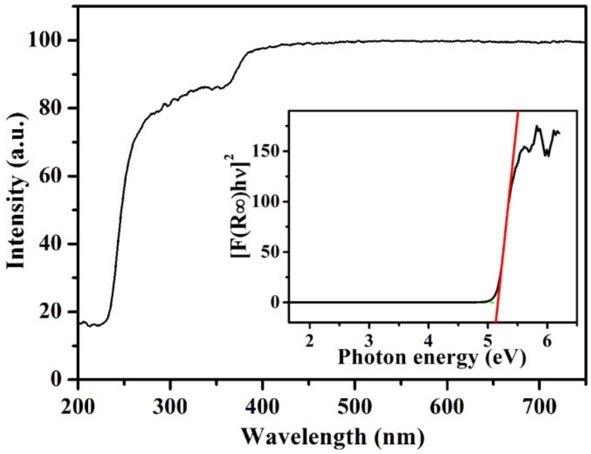

Fig. S3 UV−vis diffuse reflectance spectrum of $BaGa_2O_4$ host, the inset represents the band gap calculated using the Kubelka−Munk theoretic equation.

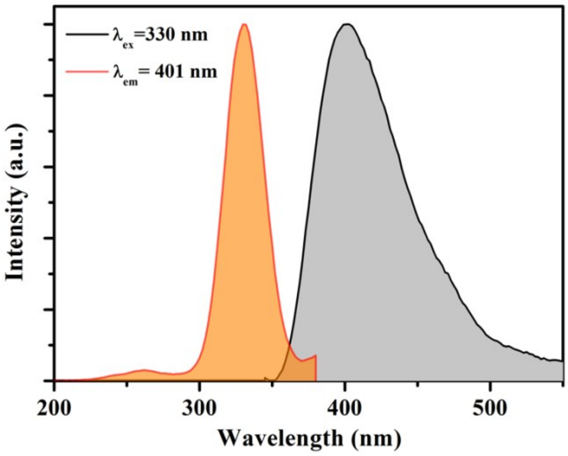

Fig. S4 PLE and PL spectra of $BaGa_2O_4$ host, λ_{ex} = 330 nm and λ_{em} = 401 nm.

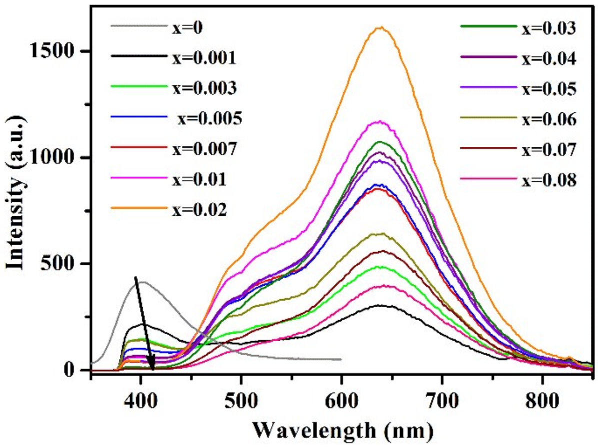

Fig. S5 PL spectra of $BaGa_2O_4$:xBi^{3+}(x = 0-0.08), λ_{ex} = 325 nm.

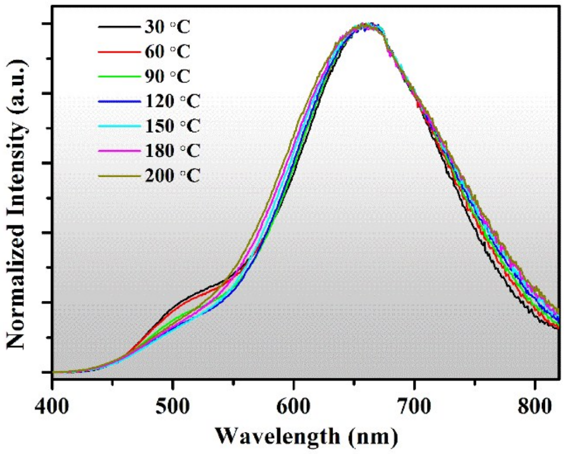

Fig. S6 Normalized temperature dependent PL spectra of $BaGa_2O_4$:$0.02Bi^{3+}$, λ_{ex} = 325 nm.

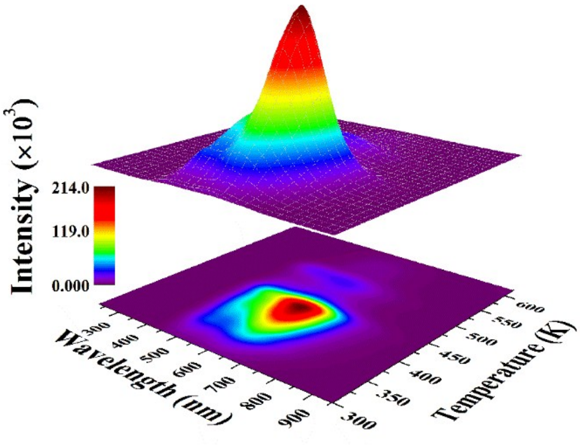

Fig. S7 Three-dimensional (3D) TL spectrum of $BaGa_2O_4$:0.02Bi^{3+}. The samples were pre-irradiated by a 254 nm UV lamp for 5 min.

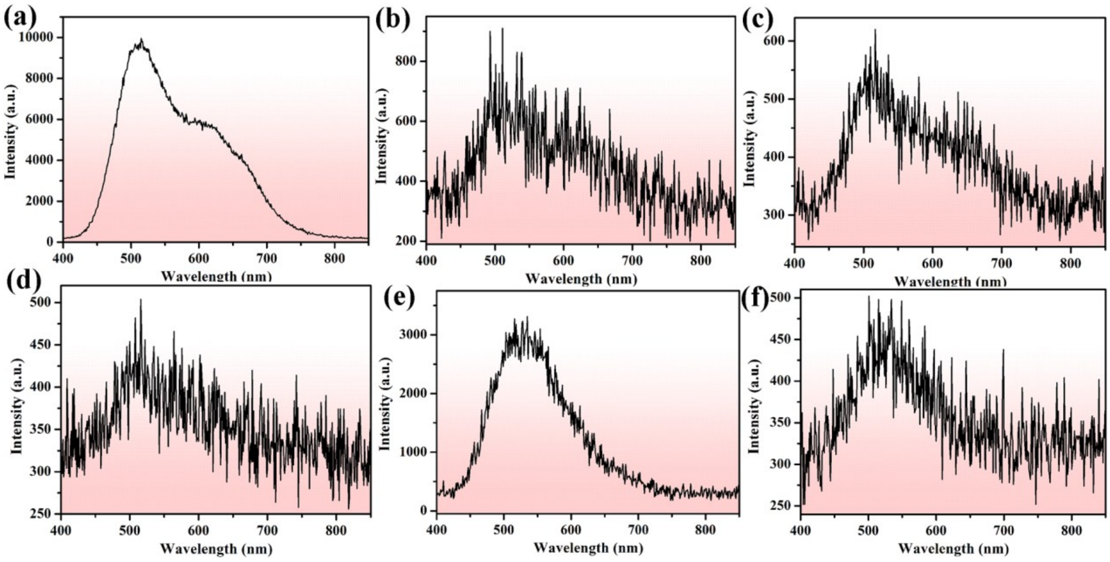

Fig. S8 Uncorrected LPL spectra of $BaGa_2O_4$:0.02Bi^{3+}. The spectra recorded at 1 day (a), 7 day (b), 14 day (c) and 25 day (d) after the stoppage of the 254 nm irradiation for 5 min. The spectra recorded at 5 min (e) and 1 h (f) after the stoppage of the 365 nm irradiation for 5 min.

Two types of spectra can be obtained simultaneously in the process of spectral monitoring by HORIBA Jobin Yvon Fluorolog-3 spectrofluorometer, that are the raw (uncorrected) spectrum and corrected spectrum. Since the signal collected by the instrument is different from the real signal, thus, the raw spectrum is generally corrected. And the corrected spectrum is much more real. Some spectra such as Fig. S9 b-f are too weak to corrected, thus, we provide the raw spectra which only serves to illustrate the intensity changes of the initial spectral signals. To show the difference between the raw spectrum and corrected spectrum, Fig. S10 displays the comparative data of the two.

Note: We employed some methods to improve the PL and LPL properties. In terms of synthetic methods, in a reasonable range, reducing the amount of Ga and increasing the heating and cooling cycles (1300 and 1400ºC as mentioned in the experimental section) could help to improve the PL and LPL properties. As introducing Zn^{2+} could help to improve PL or LPL properties in some certain situation, we attempted to use cations (2%, 5%) of Zn to substitute Ba, but no obvious luminescence improvement was detected. Moreover, we also attempted to use other monovalent cations such as Li^+, Na^+ K^+ and Rb^+ (0.5%, 1%, 3%) as charge compensator previously, but no obvious luminescence improvement was detected.

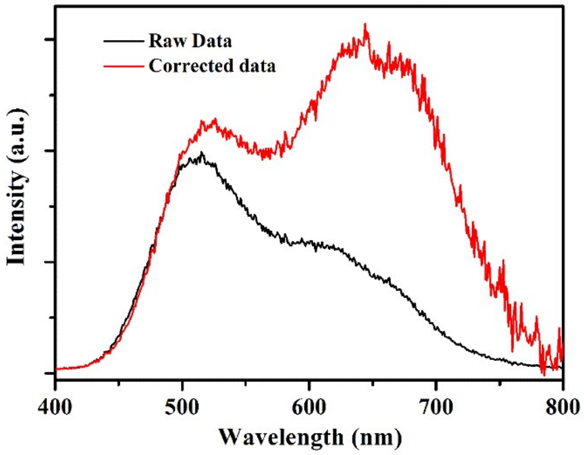

Fig. S9 Raw and corrected LPL spectra of $BaGa_2O_4$:0.02Bi^{3+} recorded at 1 day after the stoppage of the 254 nm irradiation for 5 min.

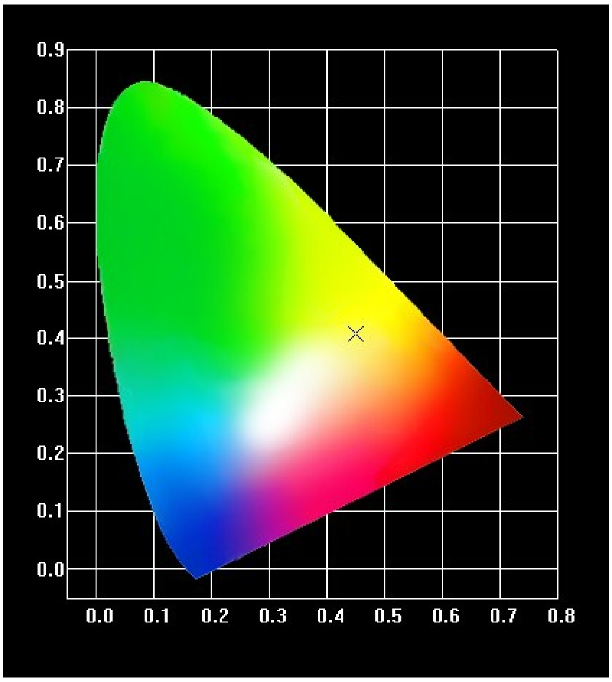

Fig. S10 Commission International de l'Eclairage (CIE) coordinates of the fabricated WLED.

Table S3 Color parameter, photometric parameter and electrical parameter of the WLEDs device.

Parameter	Value	Parameter	Value
R1	91.18	R12	76.18
R2	92.68	R13	90.67
R3	93.57	R14	96.59
R4	90.13	R15	94.00
R5	89.03	VF	7.284 V
R6	86.17	IF	350.00 mA
R7	96.14	P	2549 mW
R8	94.58	Δλd	177.3 nm
R9	87.65	R	27.0%
R10	82.00	G	69.2%
R11	84.41	B	3.8%