Supporting Information

Title: Narrowband ultraviolet-B persistent luminescence from $(Y,Gd)_3Ga_5O_{12}:Bi^{3+}$ phosphors for optical tagging application

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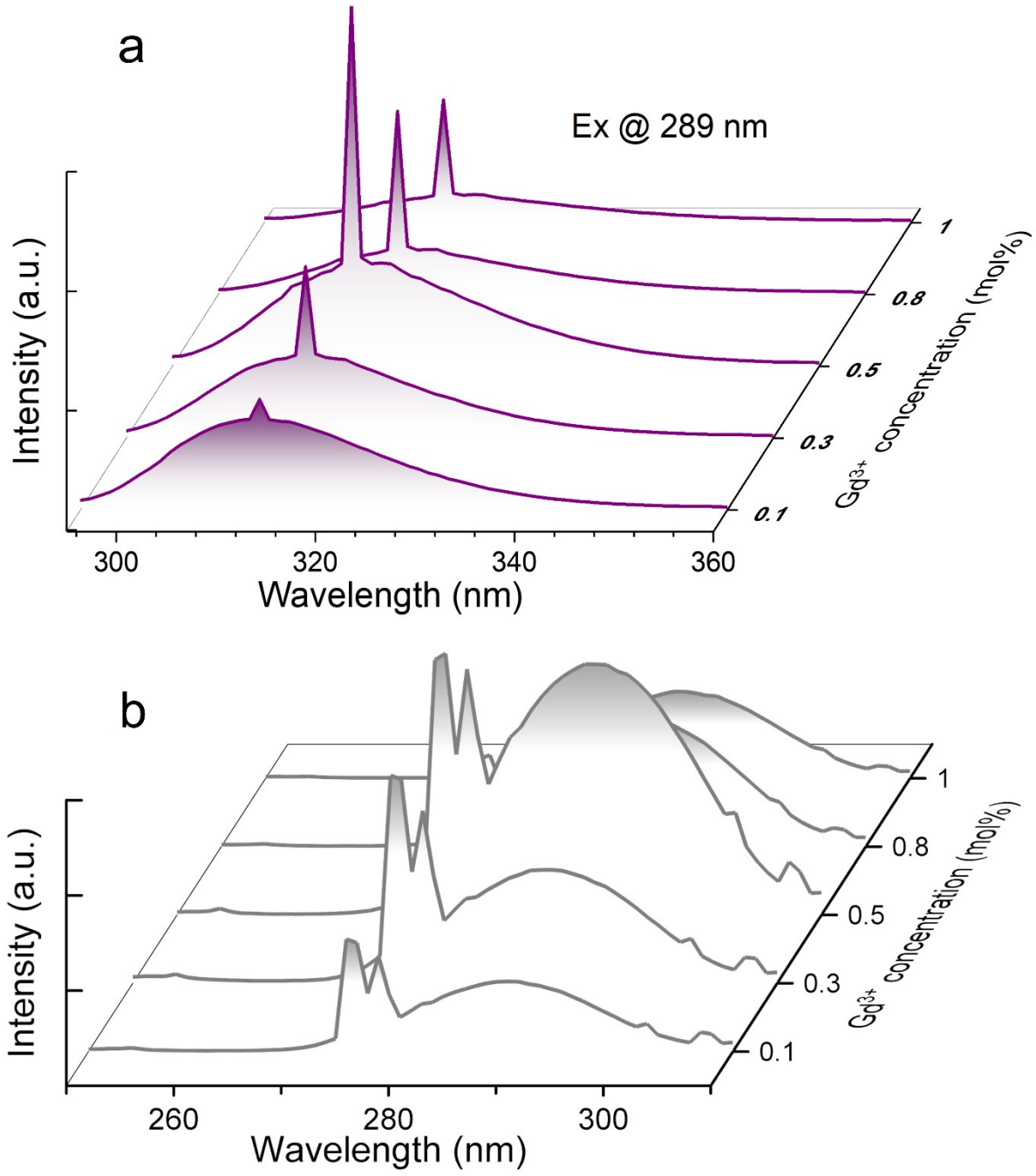
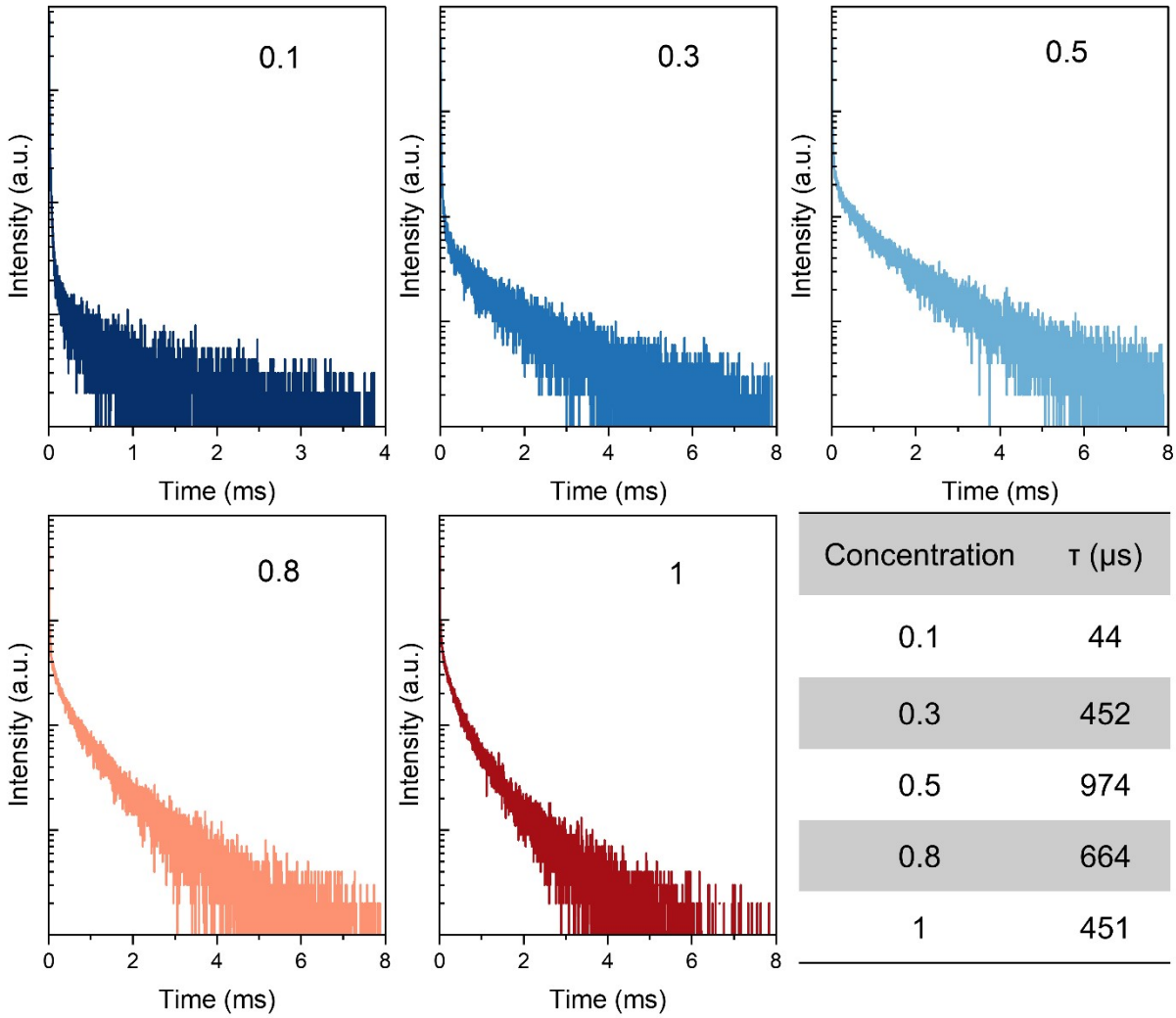


Fig. S1. Photoluminescence emission and excitation spectra of $Y_{3-x}Gd_xGa_5O_{12}$:0.3%Bi^{3+} (x= 0.1, 0.3, 0.5, 0.8 and 1) phosphors. The emission spectra are acquired upon 289 nm excitation and the excitation spectra are obtained by monitoring at 313 nm emission.



Concentration	τ (μs)
0.1	44
0.3	452
0.5	974
0.8	664
1	451

Fig. S2. Decay curves of $Y_{3-x}Gd_xGa_5O_{12}$:0.3%Bi^{3+} (x= 0.1, 0.3, 0.5, 0.8 and 1) phosphors monitored at 313 nm emission.

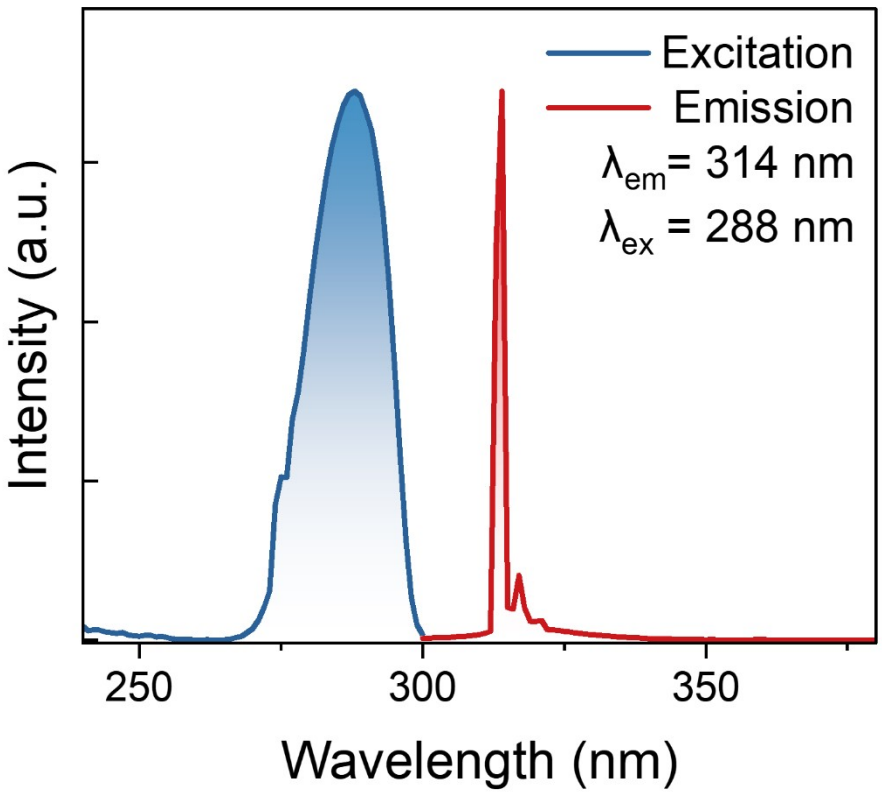


Fig. S3. Photoluminescence excitation and emission spectra of YGGG:Bi phosphor at 77K.

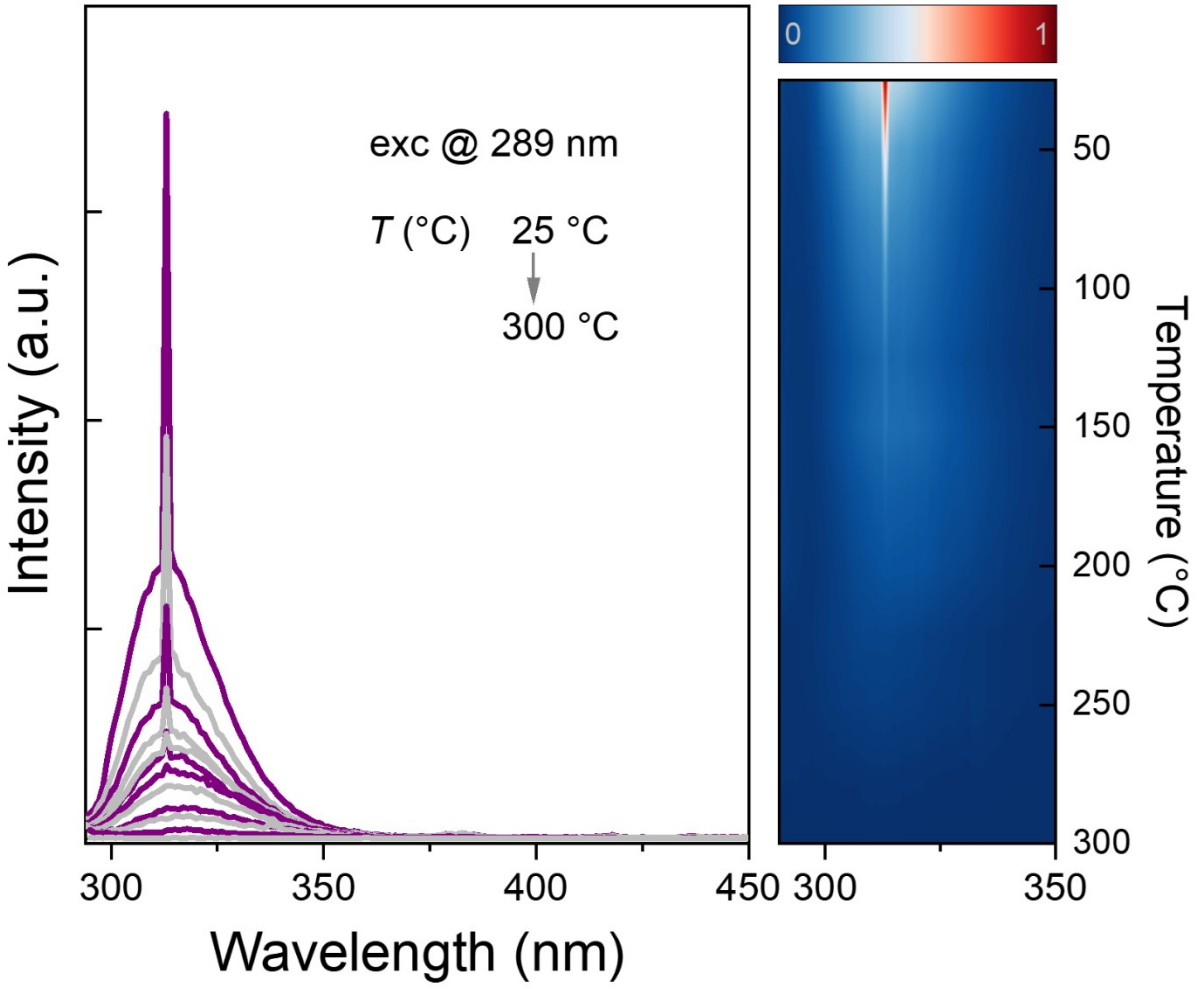


Fig. S4. Emission spectra of YGGG:Bi phosphor at different temperatures ranging from 25 °C to 300 °C under the excitation of 289 nm.

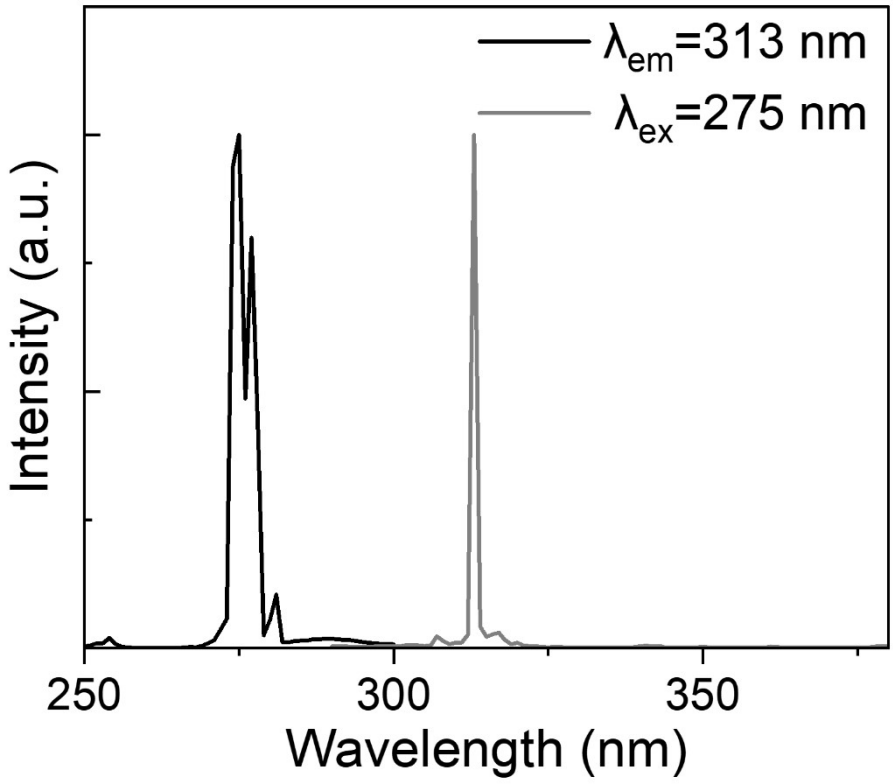


Fig. S5. Photoluminescence excitation and emission spectra of YGGG host at room temperature.

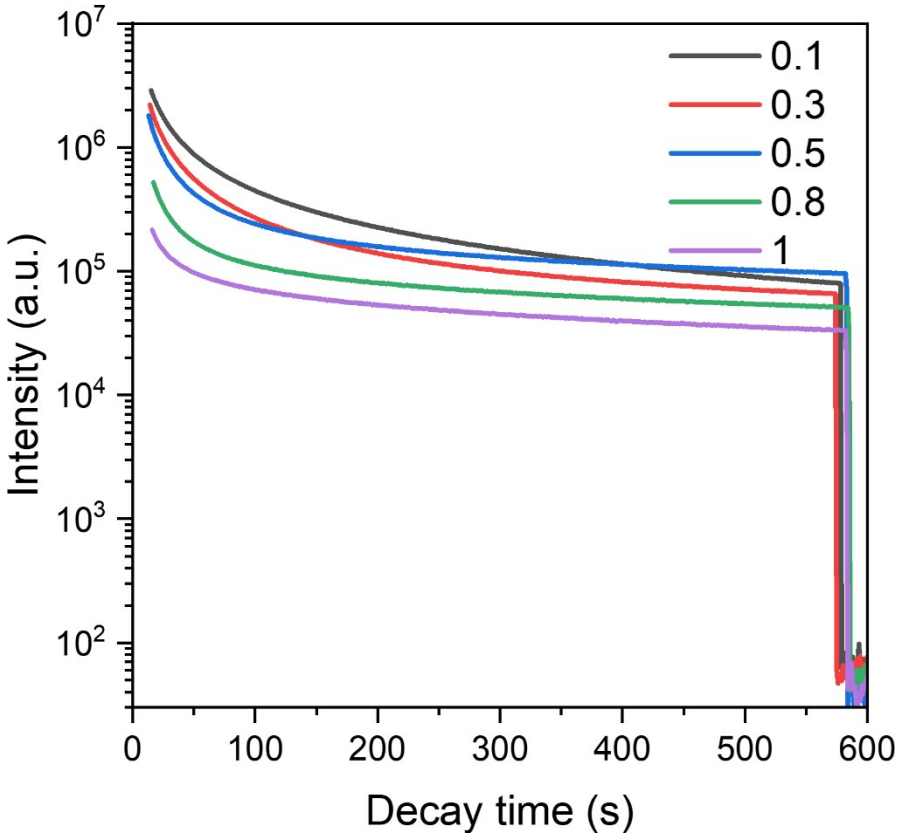


Fig. S6. NB-UVB persistent luminescence decay curves of $Y_{3-x}Gd_xGa_5O_{12}$:0.3%Bi^{3+} (x= 0.1, 0.3, 0.5, 0.8 and 1) phosphors monitored at 313 nm emission after irradiation by 254 nm UV lamp for 10 min at room temperature.

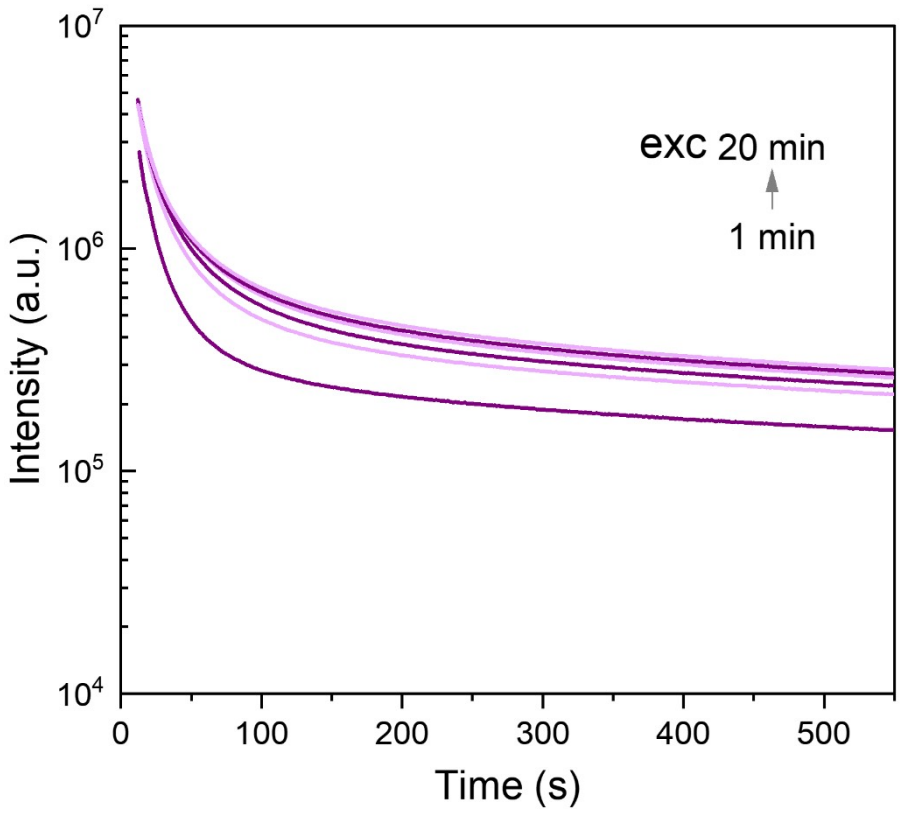


Fig. S7. Effect of excitation duration on the charging capability and the persistent luminescence performance of YGGG:Bi phosphor. The persistent luminescence decay curves were monitored at 313 nm after irradiation by 254 nm UV lamp for various time from 1 min to 20 min.

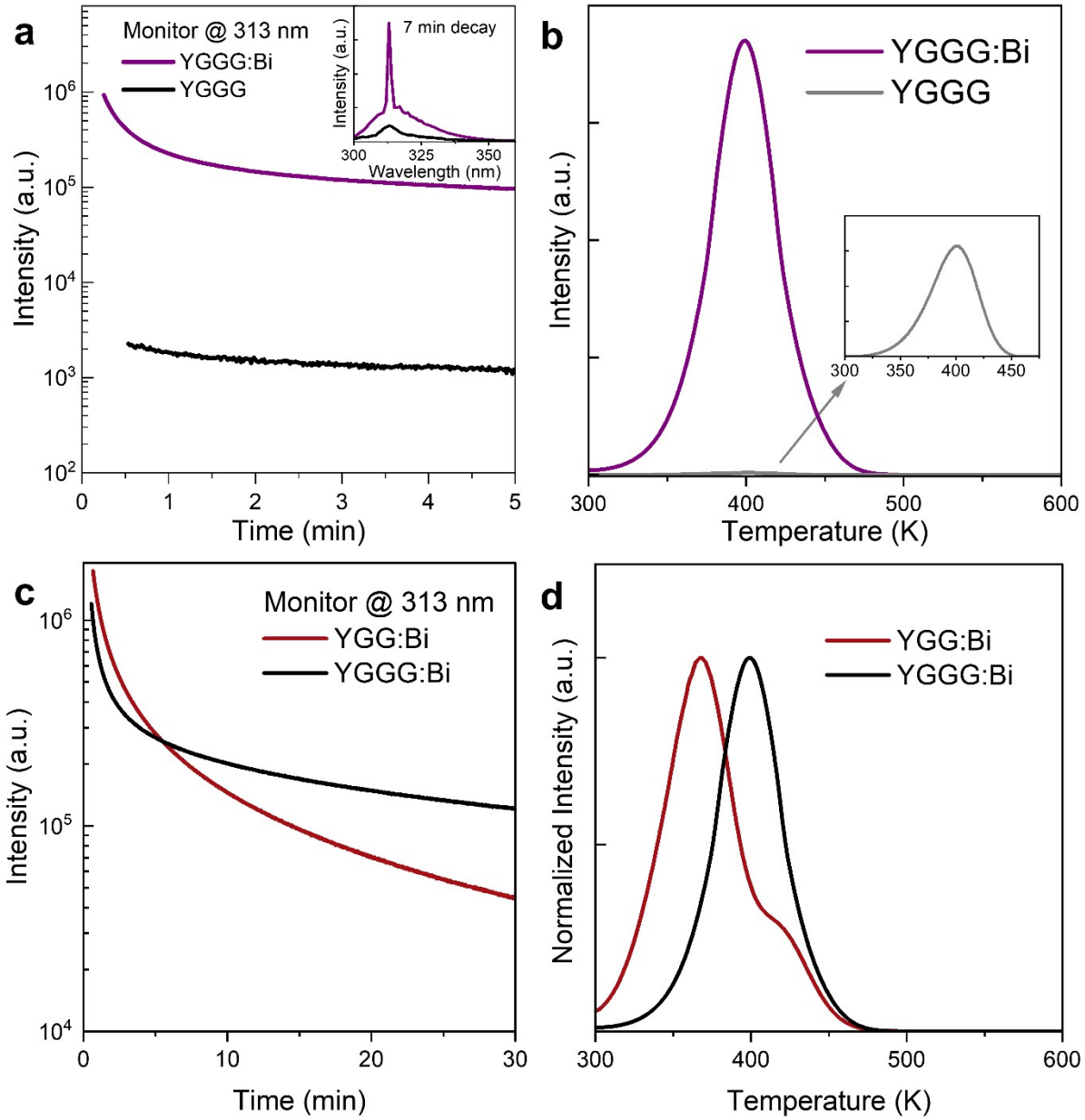


Fig. S8. (a, c) Persistent luminescence performance of YGGG host, YGG:Bi and YGGG:Bi phosphors after irradiation by 254 nm UV lamp for 15 min at room temperature. The inset of Fig. S8a plots the persistent luminescence emission spectra at 7 min decay. (b, d) Thermoluminescence spectra of YGGG host, YGG:Bi and YGGG:Bi samples after exposed to 254 nm UV lamp for 15 min at room temperature.

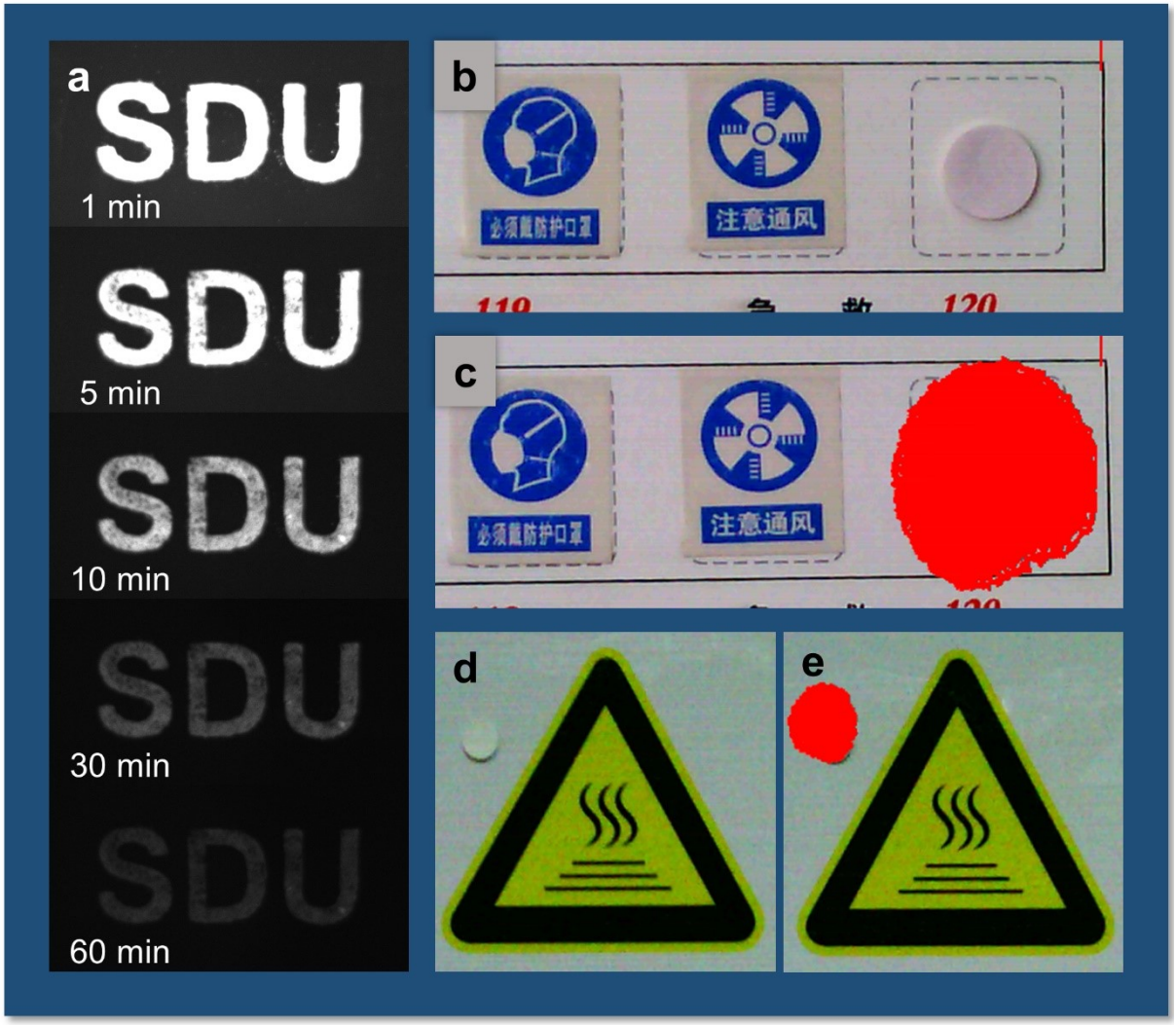


Fig. S9. (a) Persistent luminescence images of "SDU" letters formed by YGGG:Bi powders on a whiteboard in bright indoor environment. The pattern was irradiated by 254 nm UV lamp for 15 min. The luminescence images were taken at different decay instants from 1 min to 60 min. (b, d) Visible images of YGGG:Bi phosphor disks in different bright indoor surroundings. (c, e) NB-UVB persistent luminescence images of the phosphor disks taken at 5 s decay after irradiation by 254 nm UV lamp for 15 min. The UVB luminescence is represented by red color.

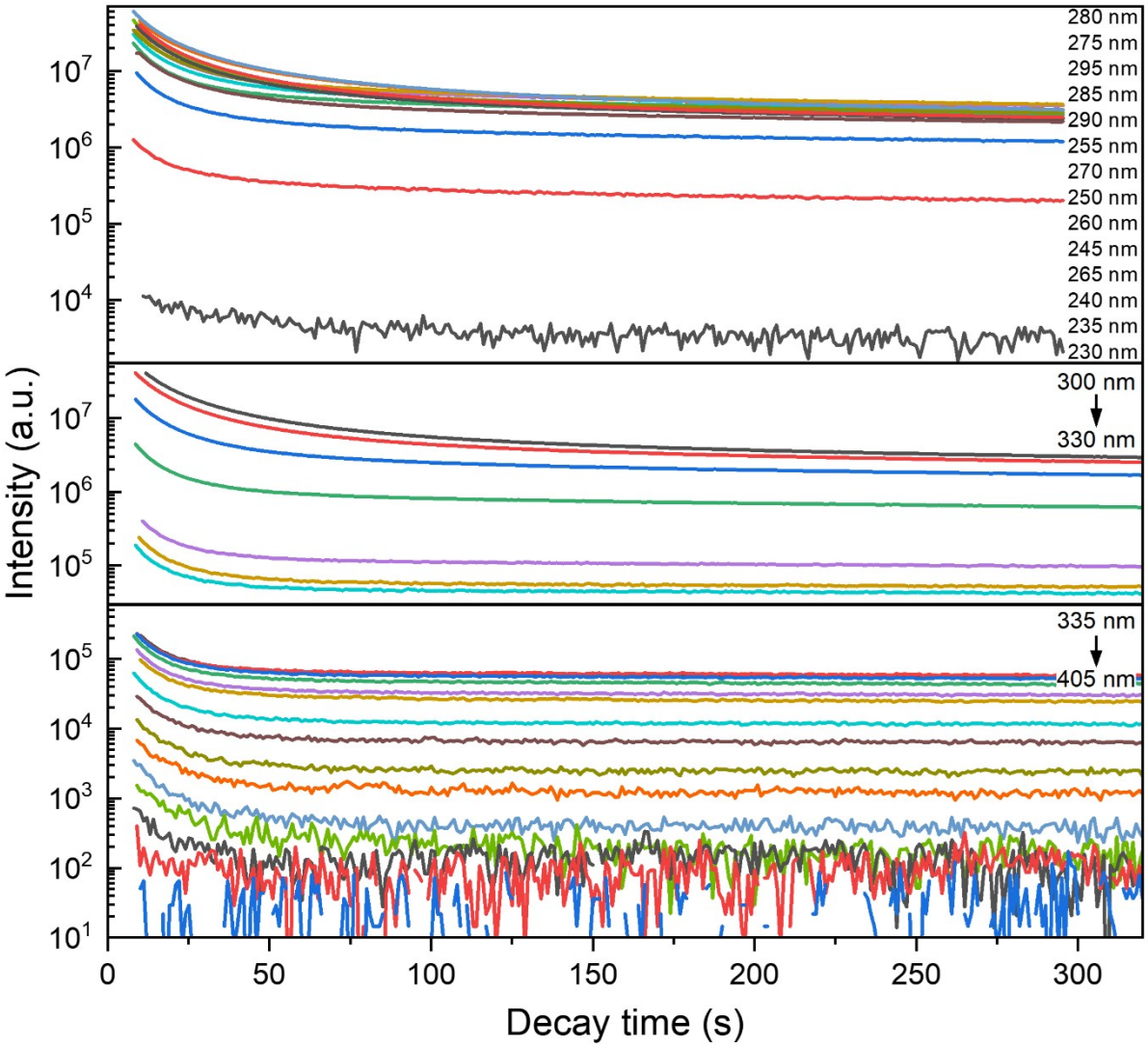


Fig. S10. Persistent luminescence decay curves of YGGG:Bi phosphor irradiated by 230–405 nm lights for 5 min. The monitoring wavelength is 313 nm. The afterglow intensity at time of 30 s after the stoppage of the irradiation was used to plot the persistent luminescence excitation spectrum shown in Fig. 4a.

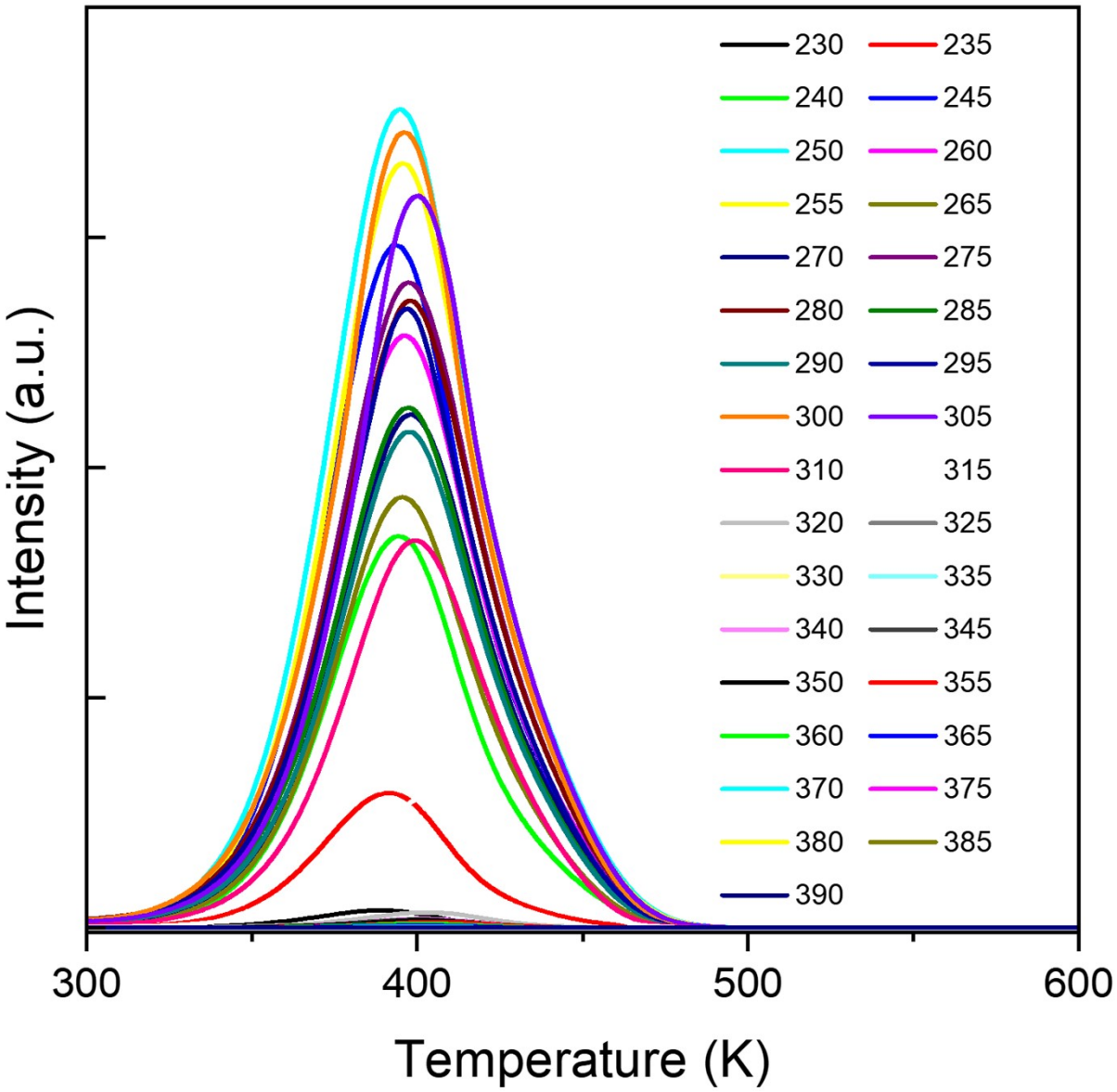


Fig. S11. Thermoluminescence spectra of YGGG:Bi phosphor after irradiation by monochromatic light with wavelength varying from 230 to 390 nm for 15 min at room temperature.

Table S1. Comparison of the reported UVB persistent phosphors

Materials	Excitation	Emission	Afterglow	Sunlight excitable	Ref.
$Lu_3Al_2Ga_3O_{12}:Pr^{3+},Gd^{3+}$	450 nm	313 nm	~ 1 h	No	1
$Y_3(Al,Ga)_5O_{12}:Bi^{3+}$	254 nm	303, 316 nm	~ 1 h	No	2
$Sr_3Gd_2Si_6O_{18}:Pr^{3+}$	254 nm	311 nm	> 12 h	No	2
$Y_2GdAl_2Ga_3O_{12}:Pr^{3+}$	254 nm	311 nm	> 12 h	No	2
$Sr_3Y_2Si_6O_{18}:Pb^{2+}$	254 nm	299 nm	> 12 h	No	2
$Sr_3Gd_2Si_6O_{18}:Pb^{2+}$	254 nm	311 nm	> 12 h	No	2
$Y_3Al_2Ga_3O_{12}:Bi^{3+}$	254 nm	307 nm	~ 6 h	No	2
$Y_2GdAl_2Ga_3O_{12}:Bi^{3+}$	254 nm	311 nm	> 12 h	No	2
$BaLu_2Al_2Ga_2SiO_{12}:Pr^{3+}$	254 nm	301 nm	> 3 h	No	3
$Y_3Ga_5O_{12}:Bi^{3+}$	254 nm	313 nm	> 60 h	Yes	4
$Y_3Ga_5O_{12}:Bi^{3+},Gd^{3+}$	254 nm	313 nm	> 24 h	Yes	This work

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