Supplementary Materials

Wavelength- tunable barium gallate persistent luminescence phosphors with enhanced luminescence

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1.Experiments

1.1. Preparation of BGO:Cr

$Ba_yGa_2O_4$: Cr_x (x=0- 0.10; y=0.08- 1) PersL phosphors were synthesized by a solid-state method. High purity $BaCO_3$ (99.00%), Ga_2O_3 (99.99%), and Cr_2O_3 (99.00%) were used as the precursors, which were sourced from Shanghai Aladdin Reagent Co., Ltd.,. The raw materials were mixed and ground in 1 mL of ethanol with an agate mortar thoroughly, in accordance with the stoichiometric ratio of $Ba_yGa_2O_4$: Cr_x (x=0- 0.10; y=0.08- 1). After grounding, the mixtures were transferred into a ceramiccrucible in a muffle furnace preheated at 100 °C for 1 h in an air atmosphere. Then, calcinations were performed at 1100 °C for 2 h, and cooled to room temperature and reground in order to obtain the wavelength- tunable barium gallate PersL phosphor samples.

1.2. Characterization

The phases were identified by X- ray diffraction (XRD) using a Bruker D8 X- ray diffractometer with Cu Kα radiation (λ= 0.15418 nm). The emission and excitation spectrum of the BGO: Cr PersL phosphors were measured using the LS- 55 fluorescence spectrophotometer (PerkinElmer, USA). Persistent luminescence was recorded with a high-resolution fluorescence spectrometer (Hitachi Instruments F- 7000) with the use of a 500 W xenon lamp as the excitation source. Persistent luminescence images were captured by an IVIS Lumina III imaging system (PerkinElmer, USA). The thermo-luminescence (TL) glow curves of the samples were obtained by an SL- 08 TL measuring instrument (China).

1.3. Information storage property

The information storage property was carried out in accordance with the methods mentioned elsewhere[1]. The BGO: Cr PersL powders (100 mg) were suspended in 2 mL of ethylene glycol and ethylalcohol (1: 1) solution, and then, the suspensions were spread on a glass dish and gradually dried via heating. Ultimately, flat layers of BGO: Cr were acquired. The flat layers were covered with photo masks of the letter K and were exposed to a 254 nm UV light for 2 min to record the characteristic phosphorescence of the K-patterns on the flat layers. After removing the UV light and the photo- mask, the luminous patterns were read out by a CCD camera at room temperature.

2.Supplementary Tables

Table S1 Emission wavelength and intensity values of $BaGa_2O_4$: Cr_x (x=0, 0.006, 0.02, 0.04 , 0.06, 0.08, 0.10) PersL phosphors.

Compound	Emission wavelength (nm) of peak	Emission intensity(a.u.) at peak
$BaGa_2O_4$	450	60.4
$BaGa_2O_4$: $Cr_{0.006}$	715	56.6
$BaGa_2O_4$: $Cr_{0.02}$	715	57.4
$BaGa_2O_4$: $Cr_{0.04}$	727	59.4
$BaGa_2O_4$: $Cr_{0.06}$	731	65.0
$BaGa_2O_4$: $Cr_{0.08}$	726	60.4.
$BaGa_2O_4$: $Cr_{0.10}$	731	62.1

Table S2 Emission wavelength and intensity values of $Ba_yGa_2O_4$: $Cr_{0.06}$ (y=0.08，0.10，0.12，0.14，0.16，0.18) PersL phosphors.

Compound	Emission wavelength (nm) of peak	Emission intensity(a.u.) at peak
$BaGa_2O_4$: $Cr_{0.06}$	731	65.0
$Ba_{0.08}Ga_2O_4$: $Cr_{0.06}$	728	71.8
$Ba_{0.10}Ga_2O_4$: $Cr_{0.06}$	737	73.7
$Ba_{0.12}Ga_2O_4$: $Cr_{0.06}$	738	81.7
$Ba_{0.14}Ga_2O_4$: $Cr_{0.06}$	739	81.9
$Ba_{0.16}Ga_2O_4$: $Cr_{0.06}$	738	78.3
$Ba_{0.18}Ga_2O_4$: $Cr_{0.06}$	739	77.4

3.Supplementary Figures

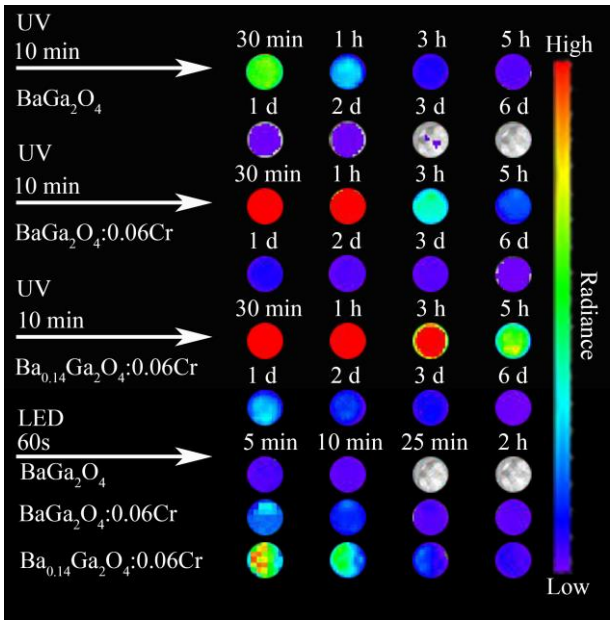


Fig. S1. NIR afterglow images of $BaGa_2O_4$, $BaGa_2O_4$: $Cr_{0.06}$, and $Ba_{0.14}Ga_2O_4$: $Cr_{0.06}$ PersL phosphors at different time.

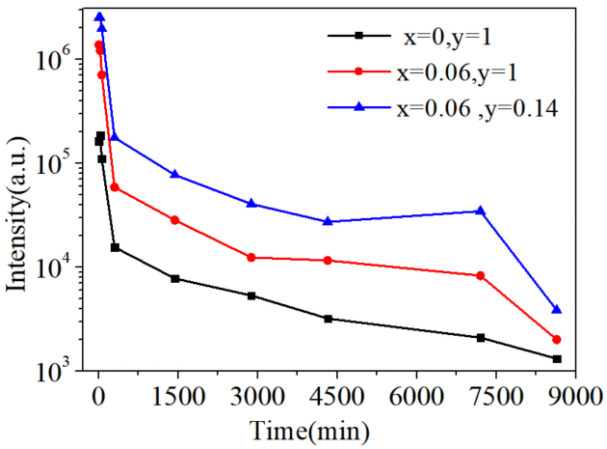


Fig. S2. Persistent luminescence decays of $BaGa_2O_4$, $BaGa_2O_4$: $Cr_{0.06}$, and $Ba_{0.14}Ga_2O_4$: $Cr_{0.06}$ PersL phosphors (Data correspond to the samples in Fig. S1).

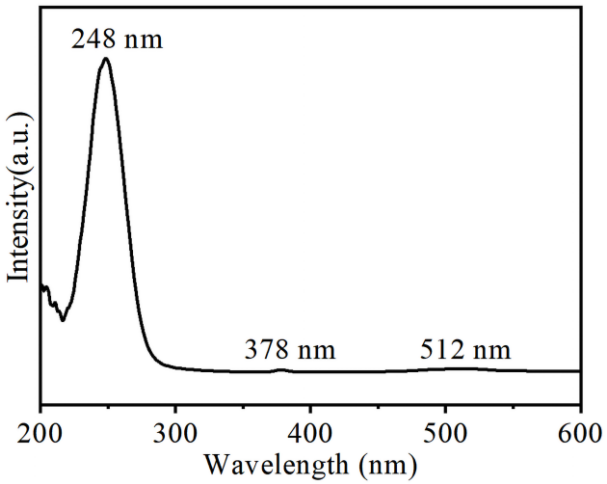


Fig. S3. Excitation spectra of $BaGa_2O_4$: $Cr_{0.06}$ PersL phosphors.

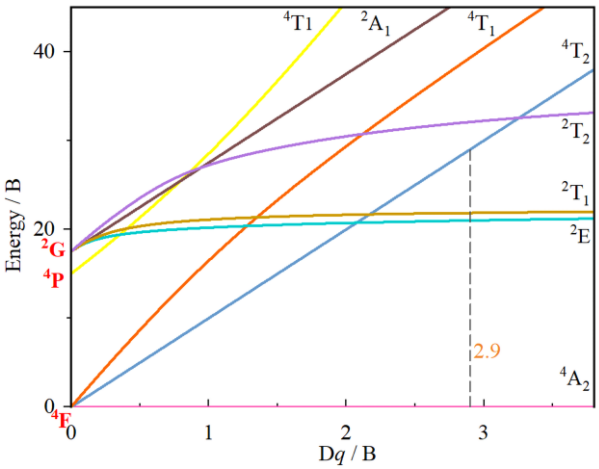


Fig. S4 Tanabe-Sugano energy diagram of a $3d^3$ system.

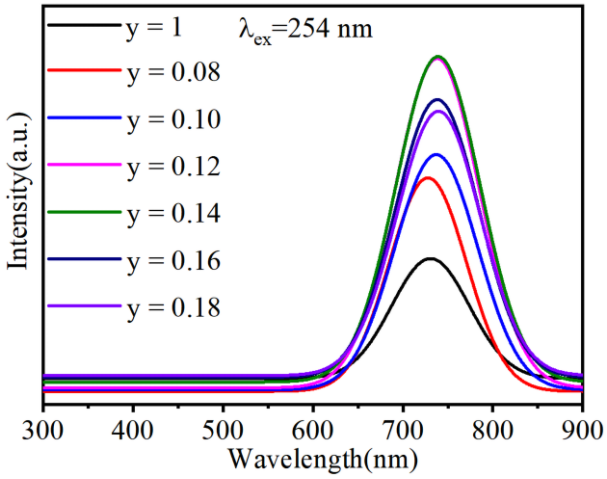


Fig. S5. Emission spectra of $Ba_yGa_2O_4$: $Cr_{0.06}$ (y=0.08，0.10，0.12，0.14，0.16，0.18, and 1) PersL phosphors.

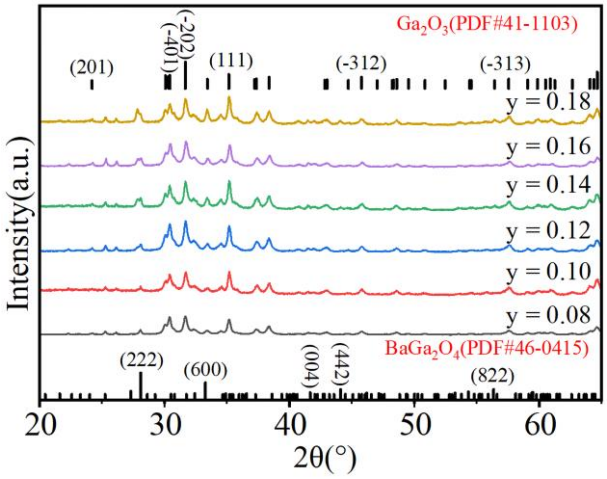
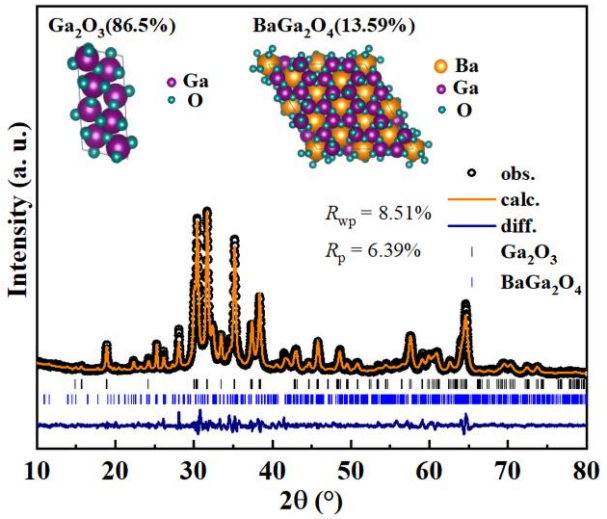


Fig. S6. XRD patterns of $Ba_yGa_2O_4$: $Cr_{0.06}$ (y=0.08，0.10，0.12，0.14，0.16，0.18) PersL phosphors.

(a)



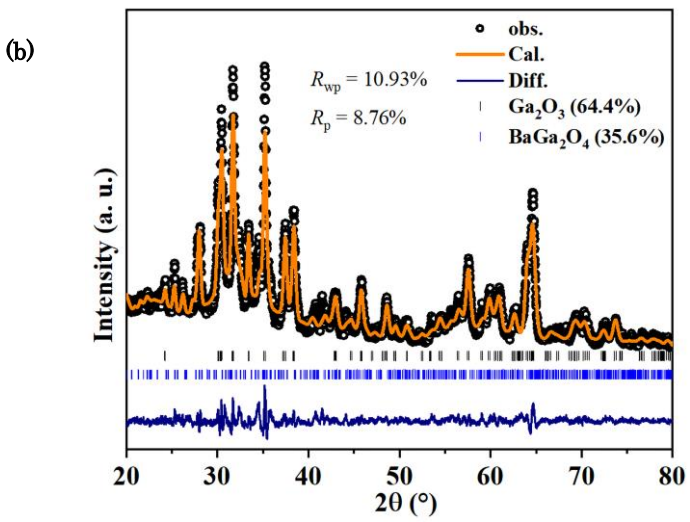


Fig. S7. Rietveld structure refinement patterns of **(a)** $Ba_{0.08}Ga_2O_4$: $Cr_{0.06}$, **(b)** $Ba_{0.14}Ga_2O_4$: $Cr_{0.06}$, inset of (a) represents the crystal structures of Ga_2O_3 and $BaGa_2O_4$.

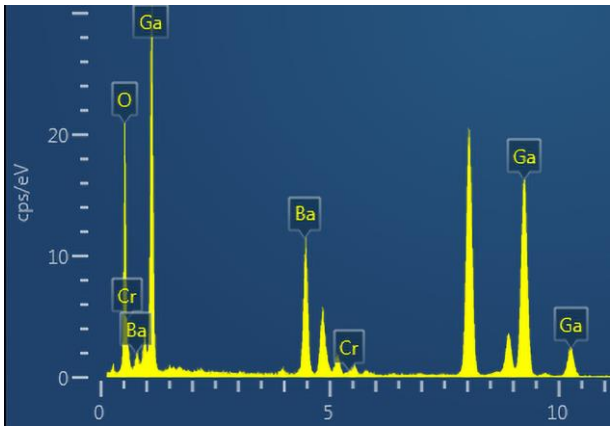


Fig. S8. EDS spectra of $BaGa_2O_4$: $Cr_{0.06}$ PersL phosphors.

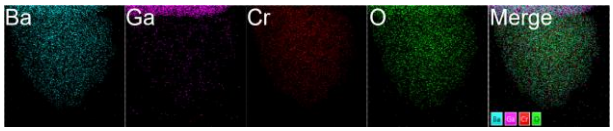


Fig. S9. Elemental distribution of $BaGa_2O_4$: $Cr_{0.06}$ PersL phosphors.

Acknowledgement

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References

1 H. F. Wang, X. Chen, F. Feng, X. Ji, and Y. Zhang, "EDTA etching: a simple way for regulating the traps, size and aqueous-dispersibility of Cr^{3+}-doped zinc gallate", Chem. Sci. **9**, 8923(2018).