Electronic Supplementary Material (ESI) for Materials Chemistry Frontiers.

Electronic Supporting Information

Design of Cr^{3+}-activated broadband NIR phosphors with tunable and abnormal thermal quenching behavior for NIR pc-LEDs

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Table S1 Main parameters of $Lu_{2.7}Ca_{0.3}Ga_{4.7}Si_{0.3}O_{12}$ refinement.

Chemical formula	Space group	Cell parameters	Volume (Å^3)	R_p%	R_{wp}%
$Lu_{2.7}Ca_{0.3}Ga_{4.7}Si_{0.3}O_{12}$	$Ia\bar{3}d$	a = b = c = 12.18 (Å) α = β = γ = 90 (°)	1807.42	6.00	10.23

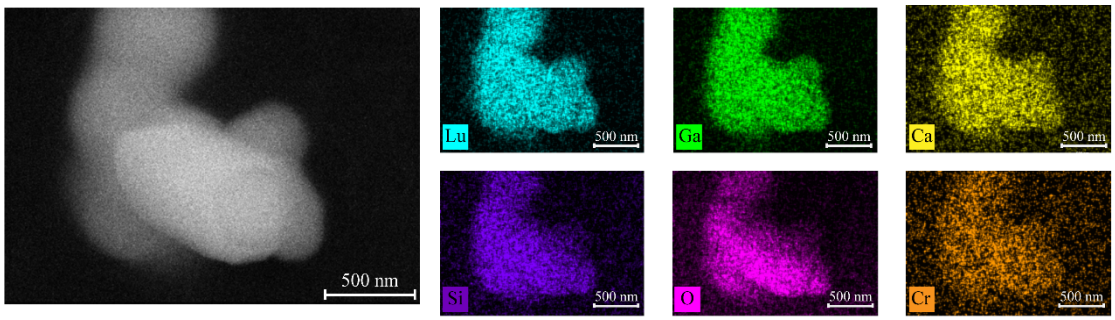

Fig. S1. SEM and elemental mapping images of $Lu_{2.7}Ca_{0.3}Ga_{4.7}Si_{0.3}O_{12}:Cr^{3+}$ phosphor.

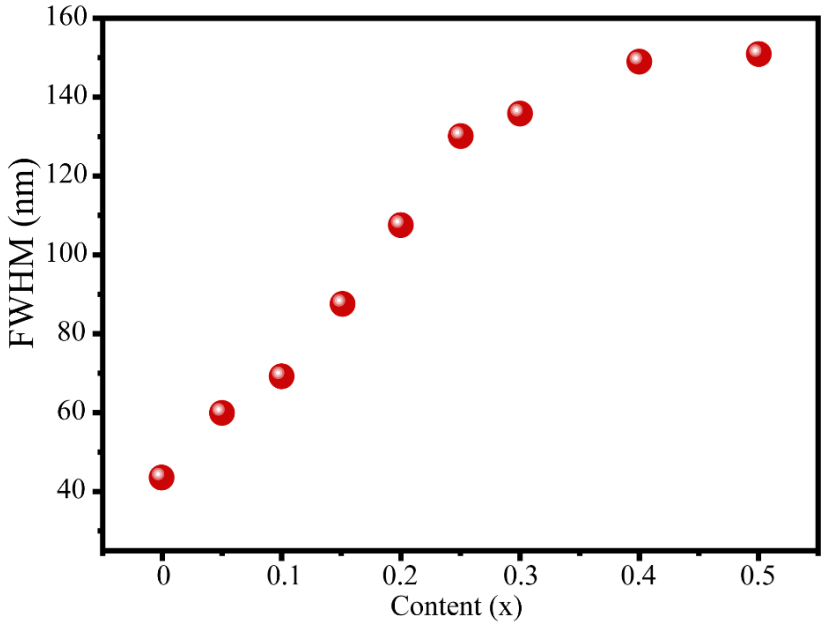

Fig. S2. FWHM of $Lu_{3-x}Ca_xGa_{5-x}Si_xO_{12}$:0.01$Cr^{3+}$ (x = 0-0.5).

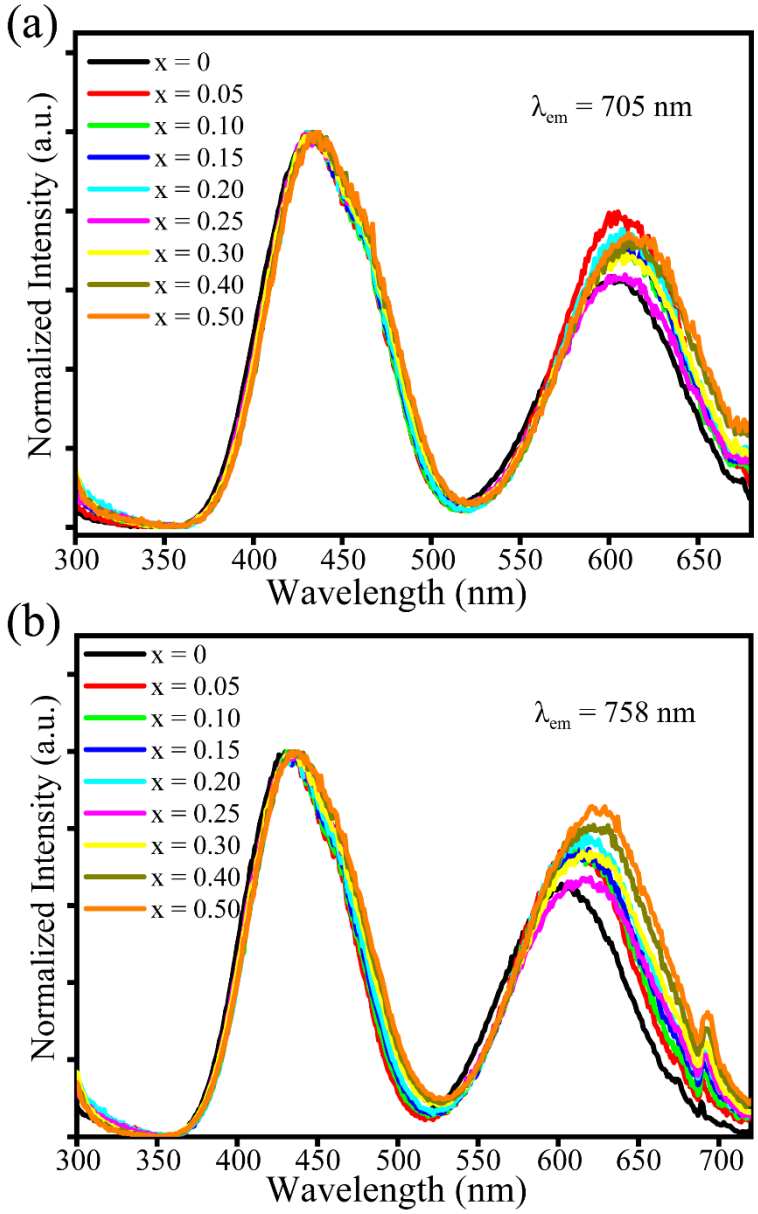

Fig. S3. PLE spectra of $Lu_{3-x}Ca_xGa_{5-x}Si_xO_{12}$:0.01$Cr^{3+}$ (x = 0-0.5).

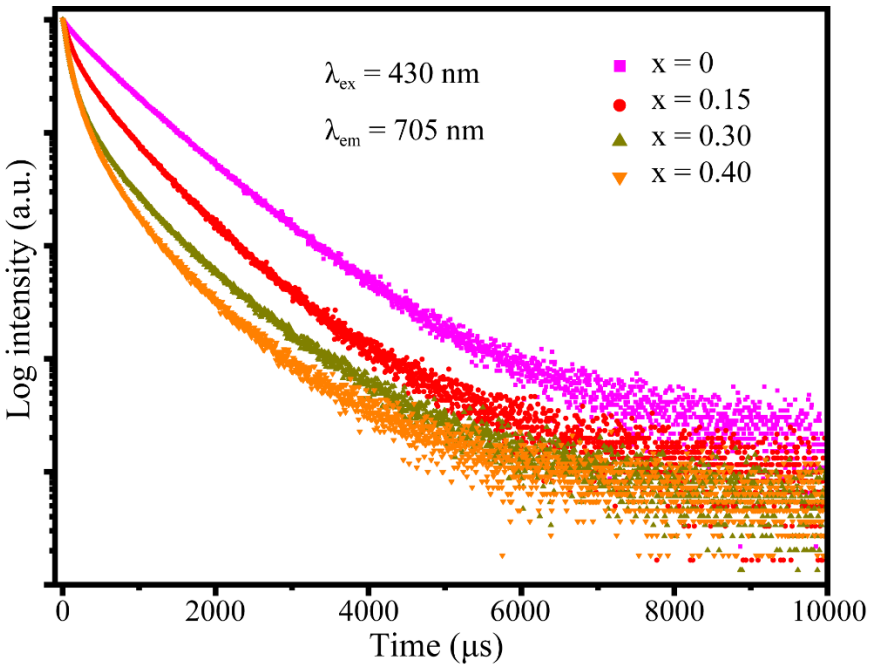

Fig. S4. PL decay curves of $Lu_{3-x}Ca_xGa_{5-x}Si_xO_{12}$:0.01$Cr^{3+}$ (x = 0-0.4).

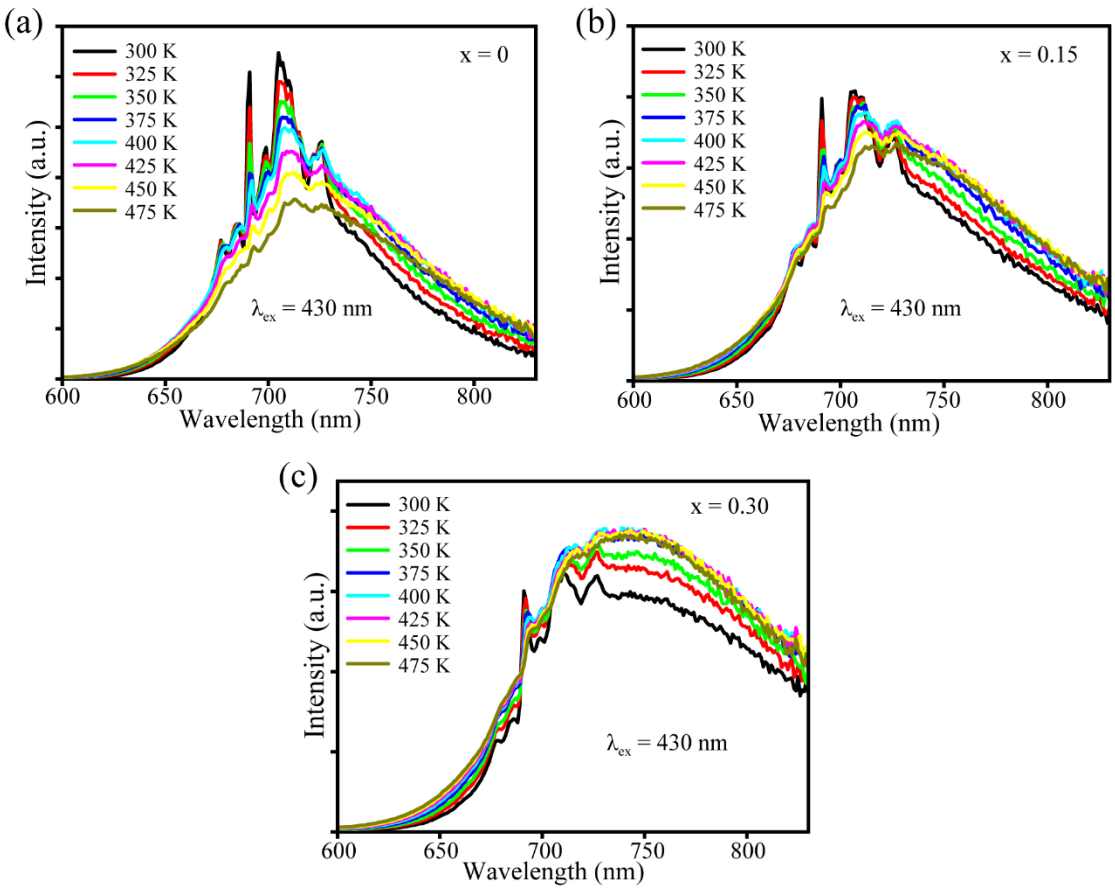

Fig. S5. PL spectra of $Lu_{3-x}Ca_xGa_{5-x}Si_xO_{12}$:0.01$Cr^{3+}$ (x = 0-0.3) as a function of temperature (300-475 K).

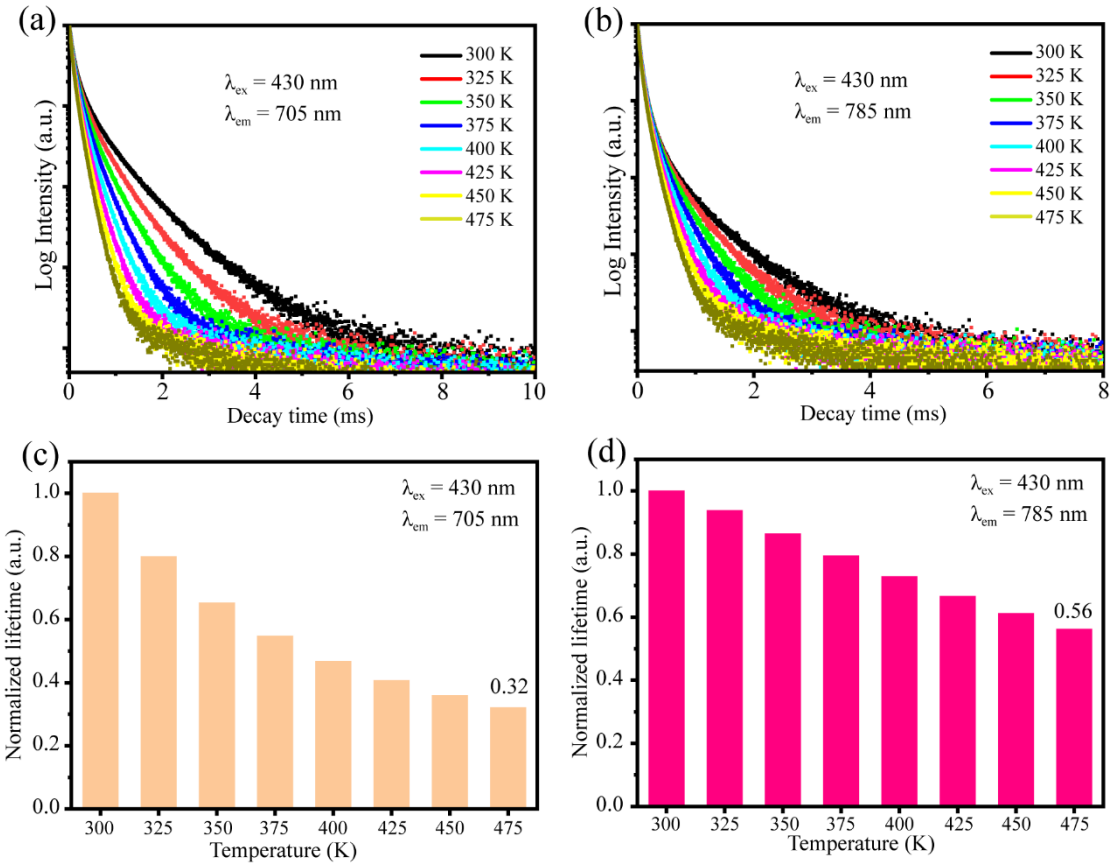

Fig. S6. Decay curves of (a) $^2E \rightarrow {}^4A_2$ (λ_{em} = 705 nm) and (b) $^4T_2 \rightarrow {}^4A_2$ (λ_{em} = 785 nm) transitions of $Lu_{2.7}Ca_{0.3}Ga_{4.7}Si_{0.3}O_{12}:Cr^{3+}$ as a function of temperature. Normalized lifetime (the lifetime at 300 K is set as 1) of (c) $^2E \rightarrow {}^4A_2$ (λ_{em} = 705 nm) and (d) $^4T_2 \rightarrow {}^4A_2$ (λ_{em} = 785 nm) transitions of $Lu_{2.7}Ca_{0.3}Ga_{4.7}Si_{0.3}O_{12}:Cr^{3+}$ as a function of temperature.

It can be seen from **Fig. S6** that the lifetime of both $^2E \rightarrow {}^4A_2$ and $^4T_2 \rightarrow {}^4A_2$ transitions decreases with temperature from 300 to 475 K due to enhanced nonradiative transitions. Furthermore, it should be noted that the decrease rate of the lifetime of $^2E \rightarrow {}^4A_2$ transition is much higher than that of $^4T_2 \rightarrow {}^4A_2$, which means that the efficiency of electron migration from ^2E to $^4T_2$ states is much higher than the nonradiative $^4T_2 \rightarrow {}^4A_2$ transition, indicating that the radiative $^4T_2 \rightarrow {}^4A_2$ broadband emission can be possibly strengthened at high temperatures.

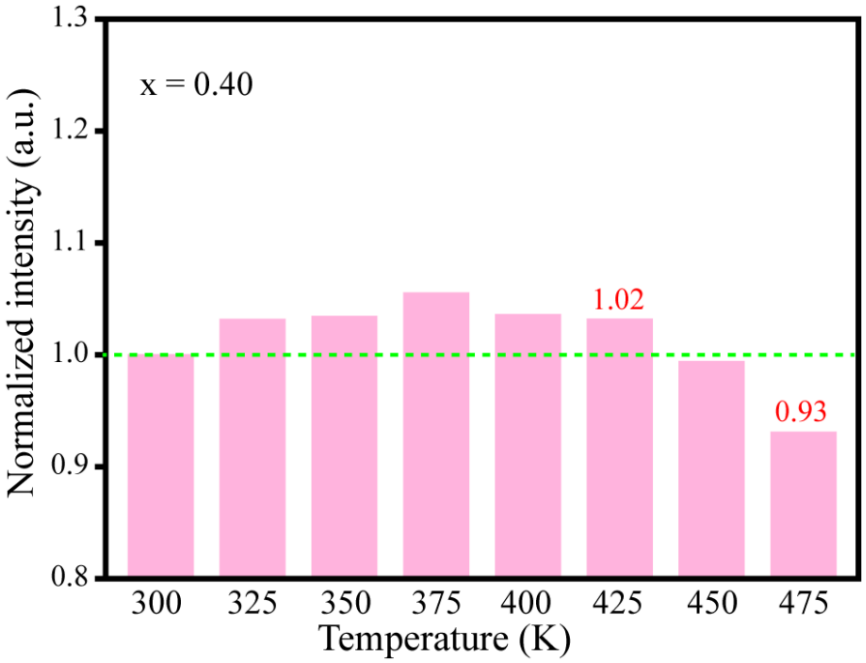

Fig. S7. PL intensity of $Lu_{2.6}Ca_{0.4}Ga_{4.6}Si_{0.4}O_{12}$:0.01$Cr^{3+}$ (x = 0.40) as a function of temperature (300-475 K).

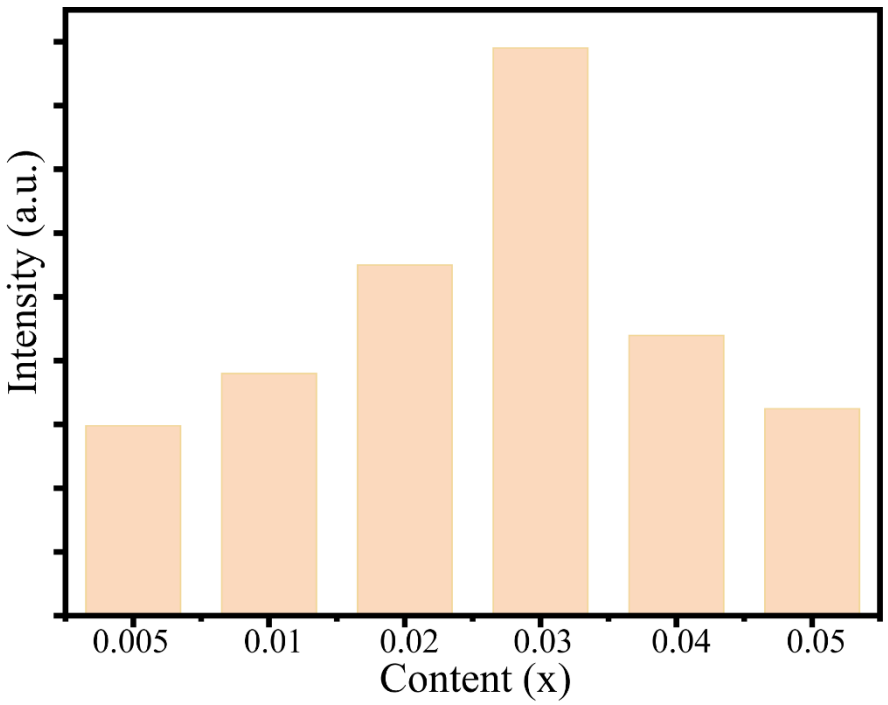

Fig. S8. PL intensity of $Lu_{3-x}Ca_xGa_{5-x}Si_xO_{12}$:0.01$Cr^{3+}$ (x = 0-0.5).

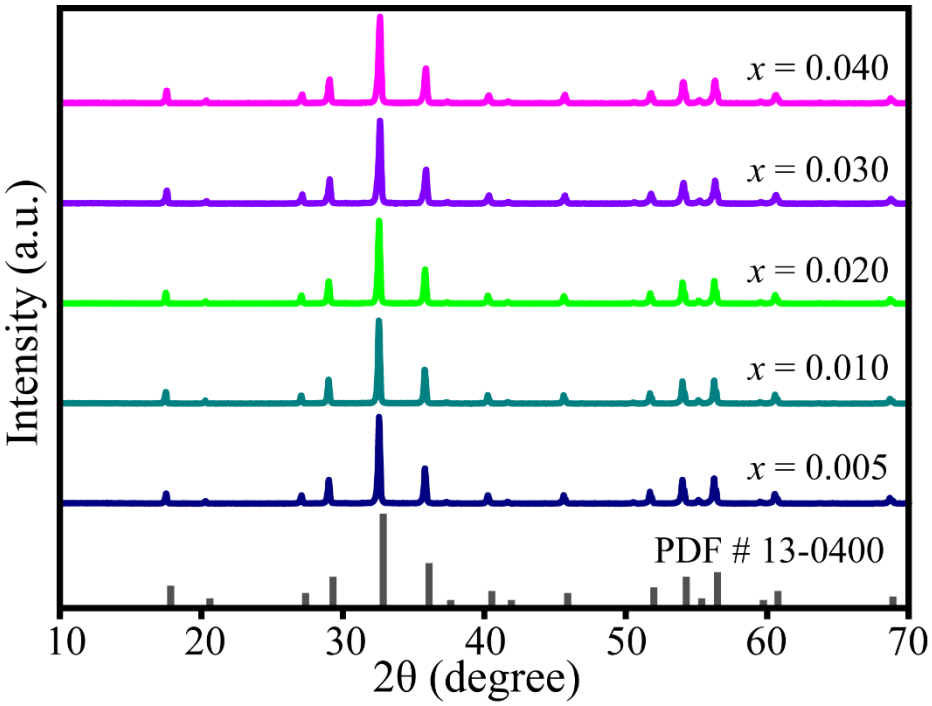

Fig. S9. XRD patterns of $Lu_{2.7}Ca_{0.3}Ga_{4.7-x}Si_{0.3}O_{12}:xCr^{3+}$ (x = 0.005-0.040).

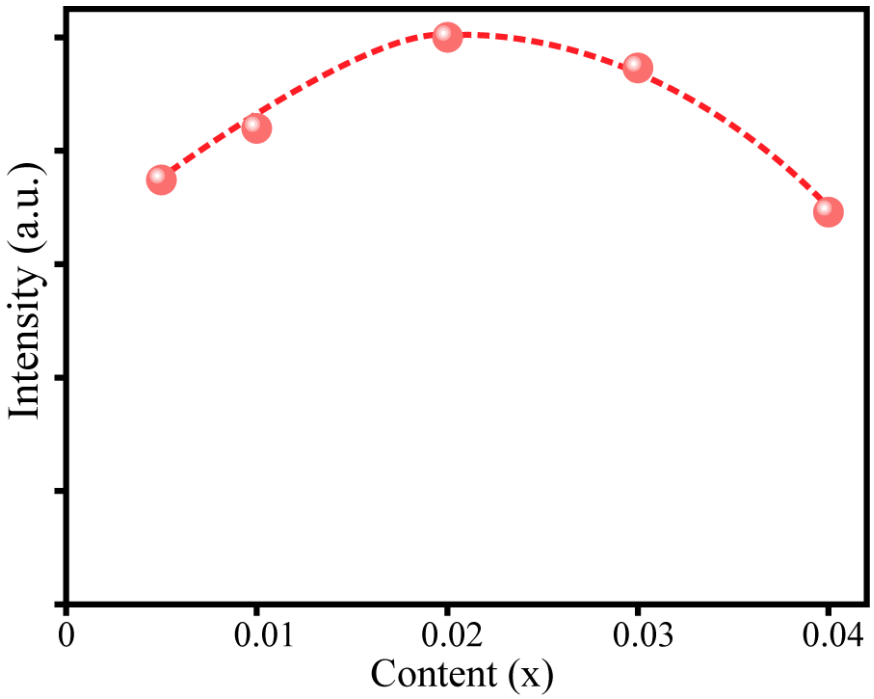

Fig. S10. PL intensity of $Lu_{2.7}Ca_{0.3}Ga_{4.7-x}Si_{0.3}O_{12}$:$x$$Cr^{3+}$ (x = 0.005-0.040).

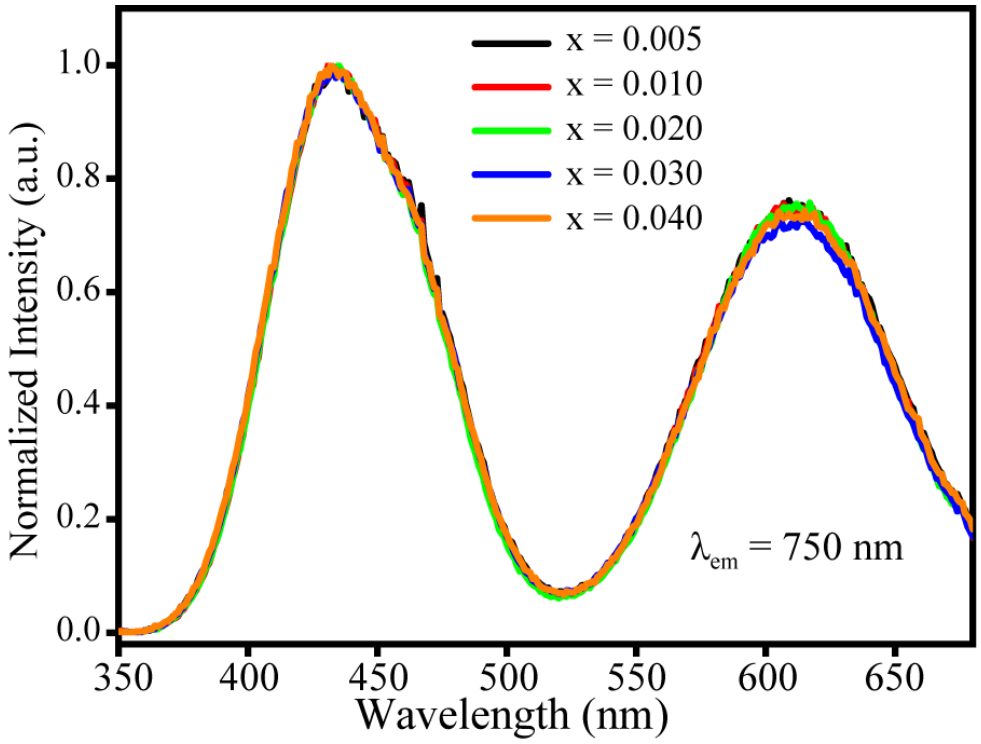

Fig. S11. PLE spectra of $Lu_{2.7}Ca_{0.3}Ga_{4.7-x}Si_{0.3}O_{12}$:$x$$Cr^{3+}$ (x = 0.005-0.040).

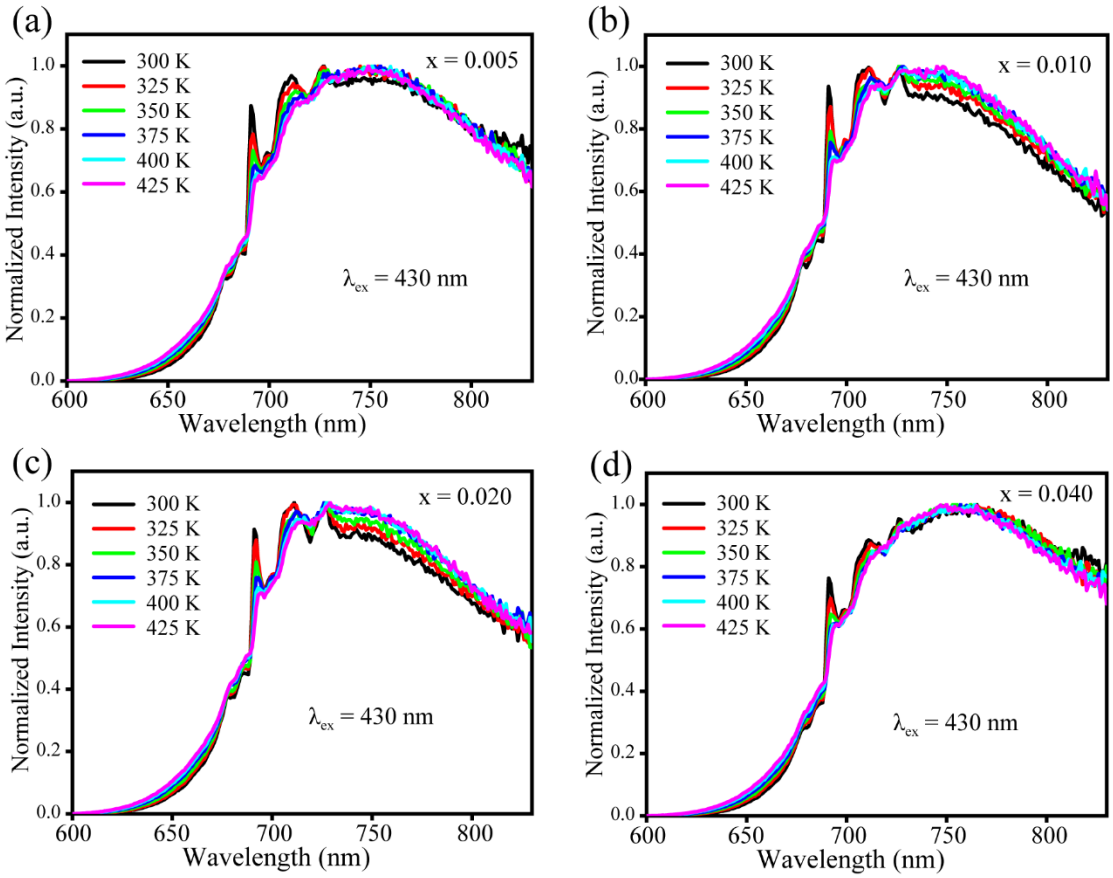

Fig. S12. PL spectra of $Lu_{2.7}Ca_{0.3}Ga_{4.7-x}Si_{0.3}O_{12}:xCr^{3+}$ (x = 0.005-0.040) as a function of temperature (300-425 K).

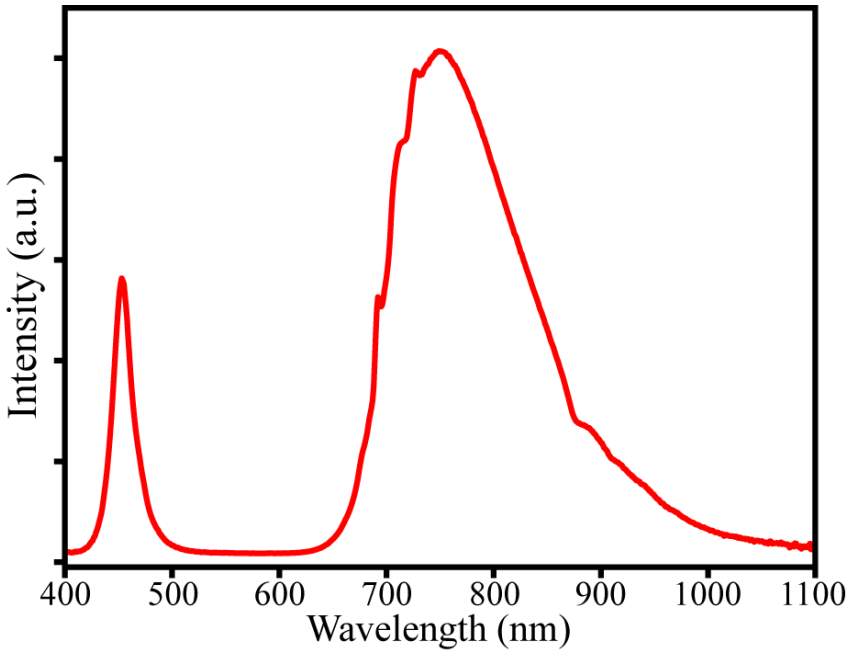

Fig. S13. Electroluminescence spectrum of the fabricated NIR-LED device (300 mA).