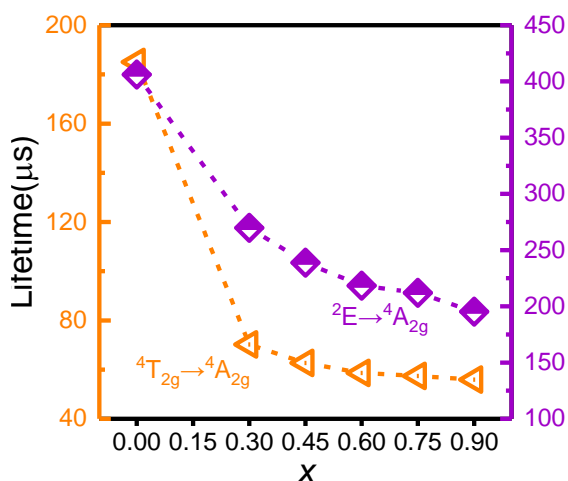


## Chemical unit co-substitution enabling broadband and tunable near-infrared emission in garnet-type $\text{Lu}_3\text{Sc}_2\text{Ga}_3\text{O}_{12}:\text{Cr}^{3+}$ phosphors

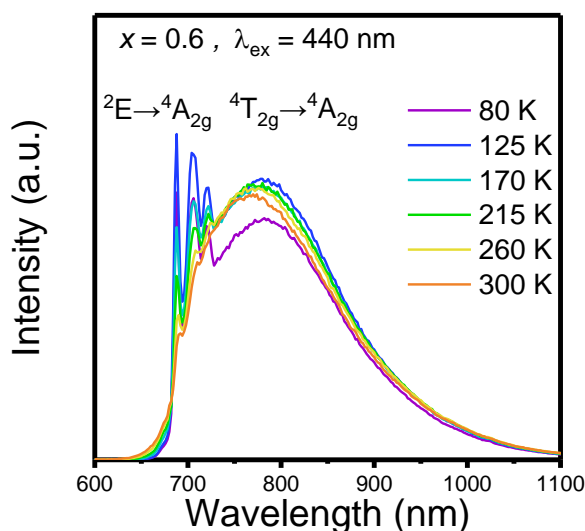
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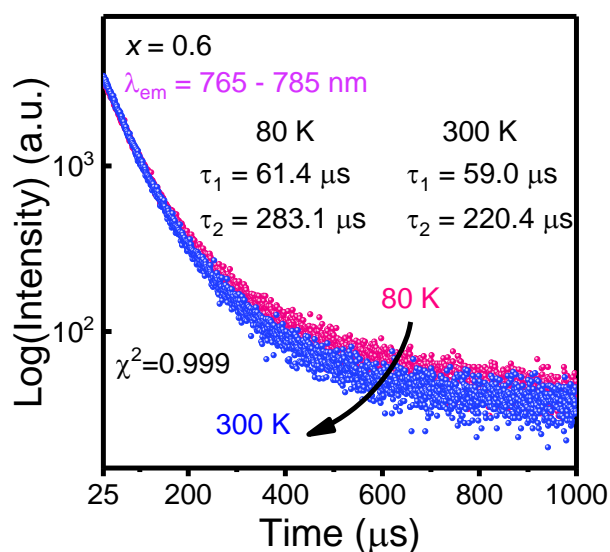


**Supplementary Figure 1.** Calculated lifetimes of  $\text{Lu}_3\text{Sc}_{1.98-x}\text{Mg}_x\text{Ga}_{3-x}\text{Si}_x\text{O}_{12}:\text{0.02Cr}^{3+}$  series ( $x = 0-0.9$ ) using bi-exponential fitting at room temperature.

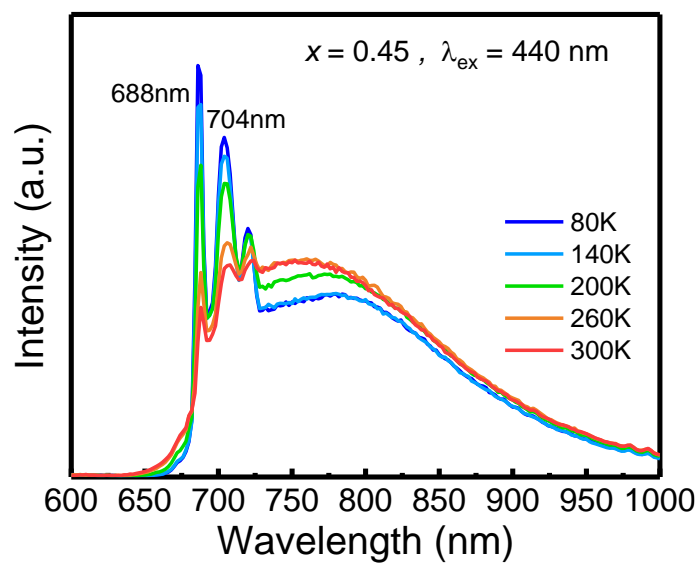


**Supplementary Figure 2.** Temperature-dependent PL spectra and phonon-assisted PL

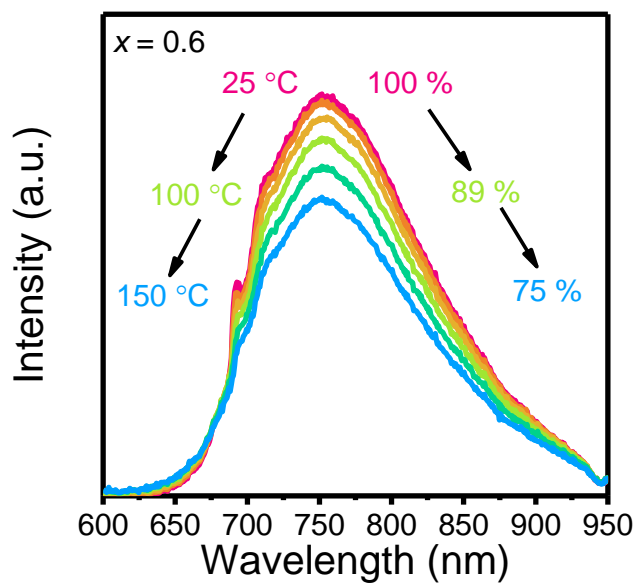
mechanism of LSMGS:Cr excited by 440 nm between 80 and 300K.



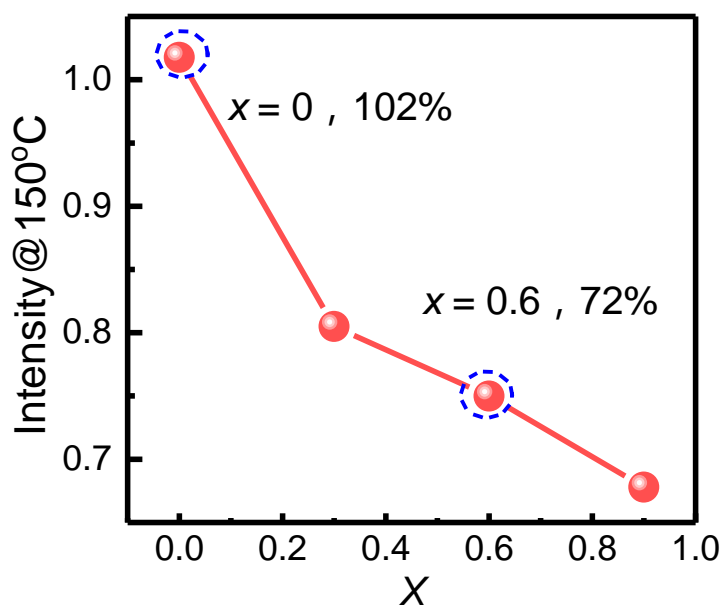
**Supplementary Figure 3.** Luminescence decay curves of LSMGS:Cr excited by 440 nm between 80 and 300K, respectively.



**Supplementary Figure 4.** Temperature-dependent PL spectra and phonon-assisted PL mechanism of  $\text{Lu}_3\text{Sc}_{1.98-x}\text{Mg}_x\text{Ga}_{3-x}\text{Si}_x\text{O}_{12}:0.02\text{Cr}^{3+}$  ( $x = 0.45$ ) excited by 440 nm between 80 and 300K.



**Supplementary Figure 5.** Temperature-dependent PL spectra of LSMGS:Cr excited by 440 nm between room temperature and 423K, respectively.



**Supplementary Figure 6.** Thermal stability of Lu<sub>3</sub>Sc<sub>1.98-x</sub>Mg<sub>x</sub>Ga<sub>3-x</sub>Si<sub>x</sub>O<sub>12</sub>:0.02Cr<sup>3+</sup> ( $x = 0, 0.3, 0.6, 0.9$ ) excited by 440 nm.