

Supporting information

Table S1 Refinement parameters of $C_{1-x}GGO:xEu^{2+}$ ($x = 0-0.04$).

x	0	0.01	0.02	0.03	0.04
Sp. Gr	<i>Pnma</i>	<i>Pnma</i>	<i>Pnma</i>	<i>Pnma</i>	<i>Pnma</i>
a (Å)	11.4793(19)	11.4984(19)	11.5118(20)	11.5175(18)	11.5208(21)
b (Å)	6.4872(11)	6.4927(12)	6.503(11)	6.5086(12)	6.5104(13)
c (Å)	5.3194(10)	5.3282(11)	5.3326(11)	5.3363(13)	5.3382(14)
V (Å ³)	405.136(12)	406.776(11)	408.182(12)	408.99(12)	409.354(14)
Z	4	4	4	4	4
$2\theta/$ (°)	10-80	10-80	10-80	10-80	10-80
R_{wp} (%)	7.44	7.02	7.98	6.52	7.87
R_p (%)	5.97	5.32	6.21	4.87	6.09
χ^2	1.32	1.29	1.31	1.27	1.37

Table S2 Fractional atomic coordinates and isotropic displacement parameters (Å²) of $C_{0.97}GGO:0.03Eu^{2+}$.

Atom	x	y	z	B_{iso}	$Occ.$
Ca	0.5	0.5	0	0.20(24)	1
Gd	0.27889(13)	0.25	0.49458(67)	0.95(22)	1
Ga	0.59557(30)	0.25	0.56067(72)	0.75(23)	1
O1	0.5979(18)	0.25	0.2189(30)	0.5(29)	1
O2	0.6692(19)	0.4611(21)	0.7287(23)	0.5(30)	1
O3	0.4523(20)	0.25	0.7050(31)	0.5(29)	1

Table S3 The bond length distortion (Δd) of $[CaO_6]$ site in CGGO.

Bond	d_1 (nm)	d_2 (nm)	d_3 (nm)	d_4 (nm)	d_5 (nm)	d_6 (nm)	d_{av} (nm)	Δd (nm)
$[CaO_6]$	0.230347	0.230347	0.232949	0.232949	0.244069	0.244069	0.235788	0.000636

Table S4 A comparison with Eu^{2+} -doped orange-red emitting luminescent phosphors.

Phosphor	λ_{em} (nm)	FWHM (nm)	Refs.
$\text{K}_2\text{MgSiO}_4:\text{Eu}^{2+}$	648	231	47
$\text{Ca}_3\text{Si}_2\text{O}_7:\text{Eu}^{2+}$	630	154	48
$\text{BaSrGa}_4\text{O}_8:\text{Eu}^{2+}$	670	140	49
$\text{NaMgPO}_4:\text{Eu}^{2+}$	620	98	50
$\text{SrLaScO}_4:\text{Eu}^{2+}$	620	84	51
$\text{Sr}_2\text{Sc}_{0.5}\text{Ga}_{1.5}\text{O}_5:\text{Eu}^{2+}$	614	80	52
$\text{Sr}_2\text{LaGaO}_5:\text{Eu}^{2+}$	618	78	53
$\text{CaSc}_2\text{O}_4:\text{Eu}^{2+}$	650	78	54
$\text{Gd}_{2.8}\text{Ca}_{0.2}\text{GaO}_6:\text{Eu}^{2+}$	650	68	12
$\text{CaYGaO}_4:\text{Eu}^{2+}$	650	67	55
$\text{CaGdGaO}_4:\text{Eu}^{2+}$ (This work)	636	58	—
$\text{Ca}_3(\text{BO}_3)_2:\text{Eu}^{2+}$	640	50	42
$\text{Sr}[\text{LiAl}_3\text{N}_4]:\text{Eu}^{2+}$	652	54	56
$\text{Sr}[\text{Li}_2\text{Al}_2\text{O}_2\text{N}_2]:\text{Eu}^{2+}$	654	50	57

Table S5 Comparison of luminescent performance of $\text{CaGdGaO}_4:\text{Eu}^{2+}$ with that of other Eu^{2+} -doped orange-red phosphors.

Phosphor	Site occupancy	λ_{em} (nm)	FWHM (nm)	$I_{423\text{ K}}/I_{298\text{ K}}$ (%)	IQE (%)	Refs.
$\text{CaYGaO}_4:\text{Eu}^{2+}$	$[\text{CaO}_6]$	650	67	59%	50%	55
$\text{CaGdGaO}_4:\text{Eu}^{2+}$	$[\text{CaO}_6]$	636	58	68.5%	48.9%	—
$\text{Rb}_3\text{YSi}_2\text{O}_7:\text{Eu}^{2+}$	$[\text{Rb}_2\text{O}_6]$, $[\text{YO}_6]$	622	124	80%	32.6%	7
$\text{Ca}_2\text{SiO}_4:\text{Eu}^{2+}$	$[\text{Ca}(1\text{n})]$, $[\text{Ca}(2\text{n})]$	650	—	43%	50%	64
$\text{NaMgPO}_4:\text{Eu}^{2+}$	$[\text{NaO}_6]$	620	98	86%	72.3%	50

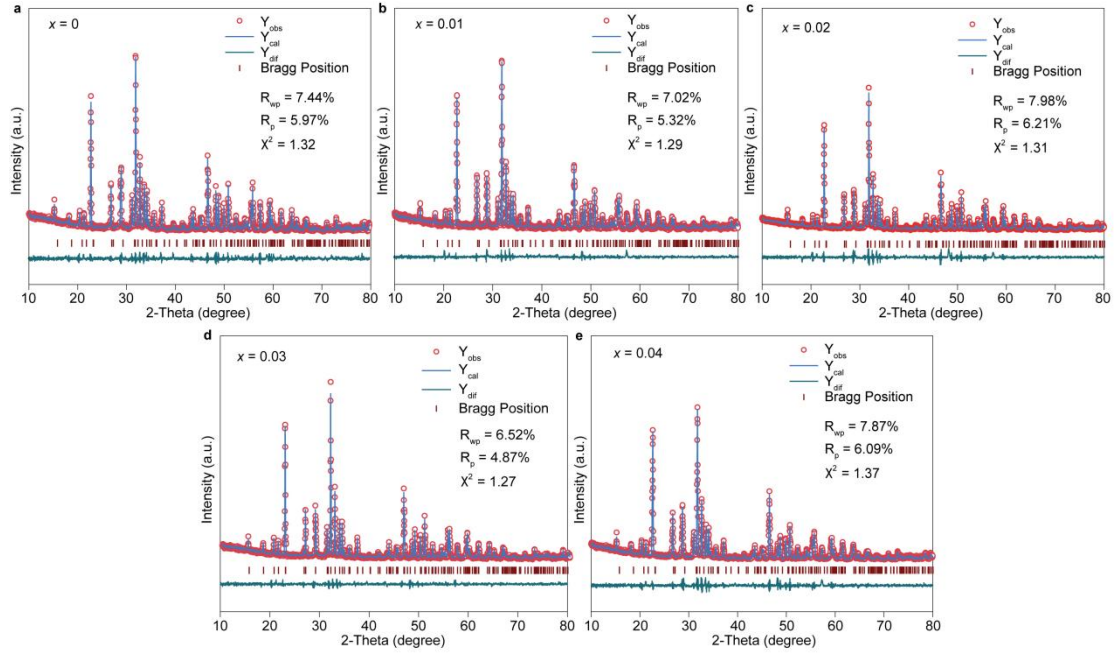


Fig.S1 Rietveld refinement results of $C_{1-x}GGO:xEu^{2+}$ a) $x = 0$. b) $x = 0.01$. c) $x = 0.02$. d) $x = 0.03$. e) $x = 0.04$.

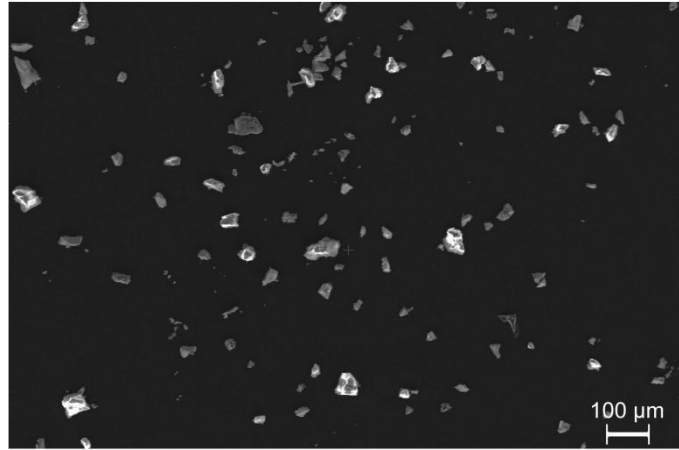


Fig.S2 SEM image of $C_{0.97}GGO:0.03Eu^{2+}$.

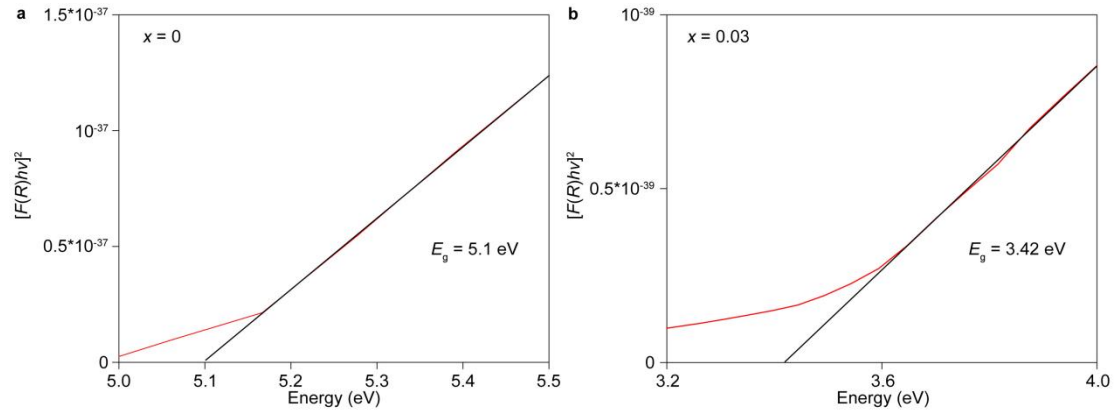


Fig.S3 a) The band gap of CGGO matrix. b) The band gap of $C_{0.97}GGO:0.03Eu^{2+}$.

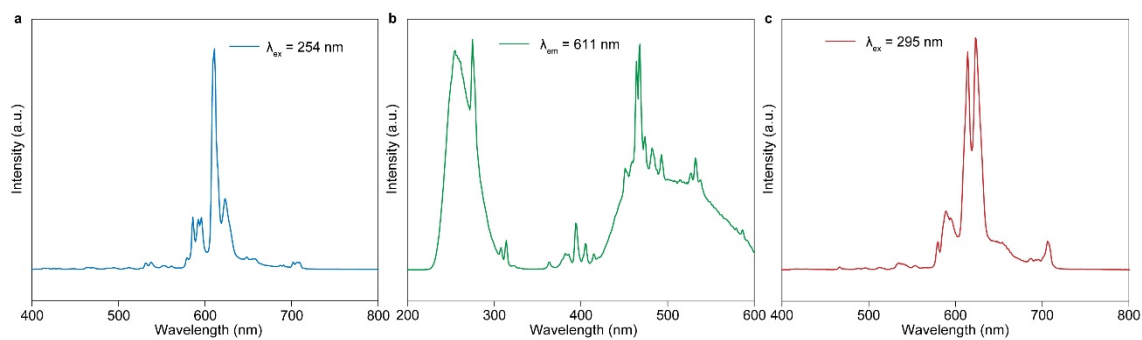


Fig.S4 a) PL spectrum under 254 nm light excitation. b) PLE spectrum monitored at 611 nm. c) PL spectrum under 295 nm light excitation.

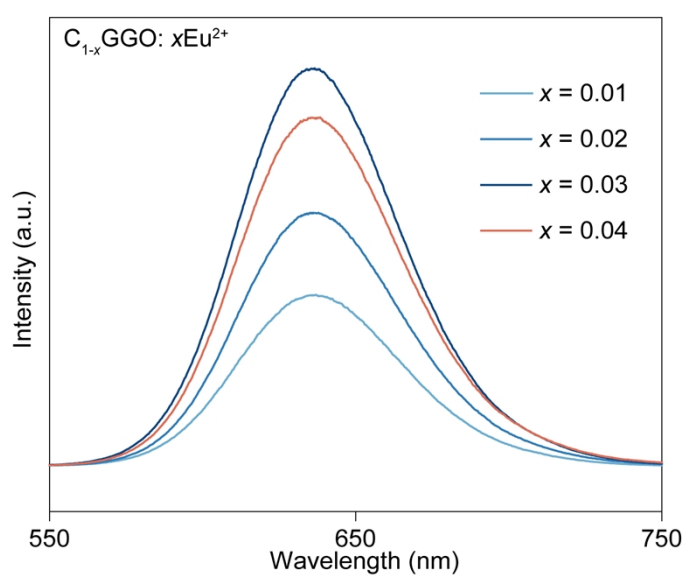


Fig.S5 PL spectra of $C_{1-x}GGO:xEu^{2+}$ ($x = 0.01-0.04$).

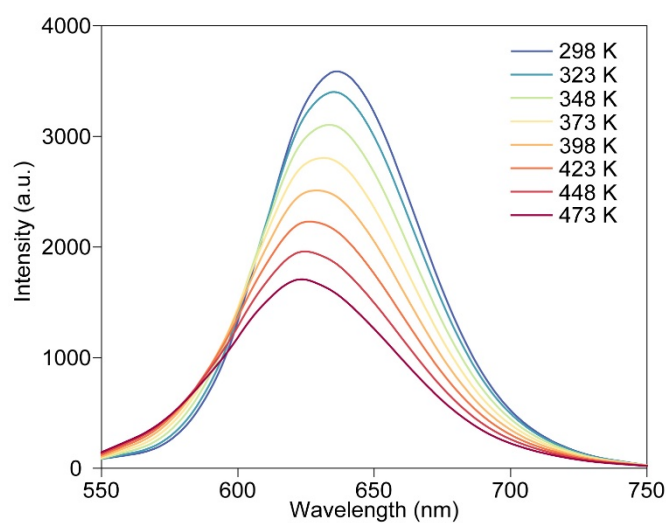


Fig.S6 Temperature-dependent emission spectra of $C_{0.97}GGO:0.03Eu^{2+}$.

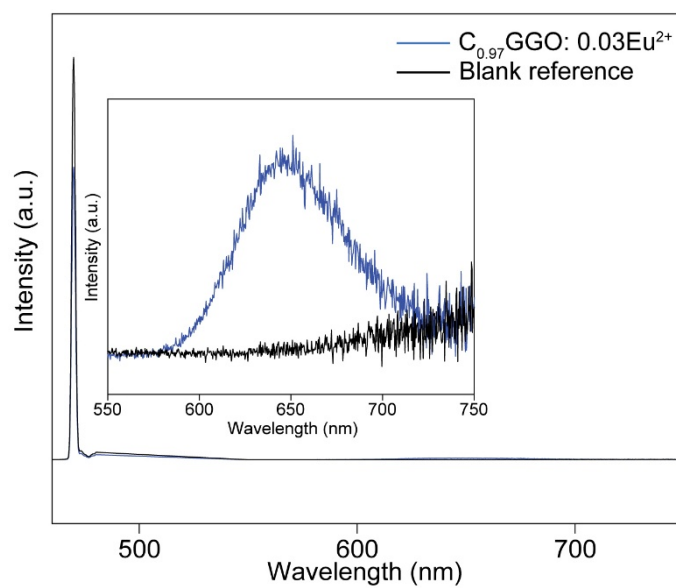


Fig.S7 Quantum-efficiency measurement diagram of $C_{0.97}\text{GGO}:0.03\text{Eu}^{2+}$.

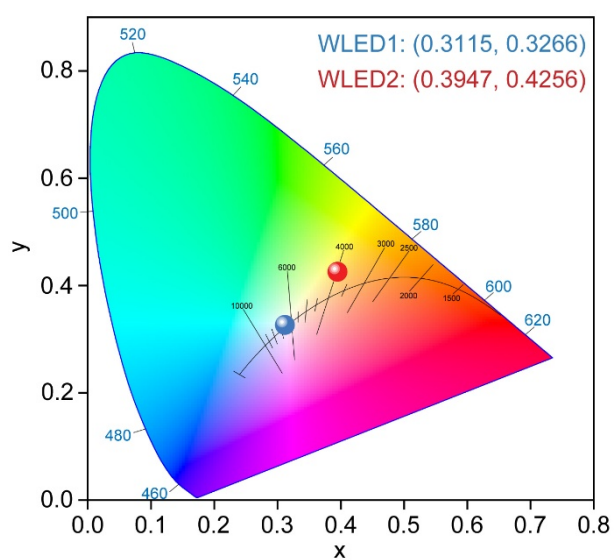


Fig.S8 CIE coordinate of WLED devices.

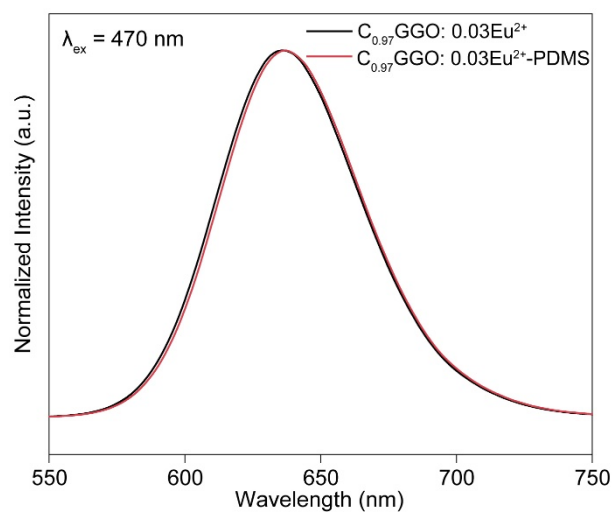


Fig.S9 The PL spectra of $C_{0.97}GGO:0.03Eu^{2+}$ and $C_{0.97}GGO:0.03Eu^{2+}$ -PDMS composite film ($\lambda_{ex} = 470$ nm).