

Site engineering strategy toward enhanced luminescence thermostability of Cr³⁺ doped broadband NIR phosphor and its application

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Table S 1. The refined structural parameters of SGO with P $6_3/mmc$.

Atom	x	y	z	Occ.	Site		
1 Ga Ga ^I	0.000(0)	0.000(0)	0.000(0)	1.000	2a	space group	<i>P</i> $6_3/mmc$ (194)
3 Ga Ga ^{II}	0.000(0)	0.000(0)	0.242(7)	0.500	4e		
4 Ga Ga ^{III}	0.333(3)	0.666(7)	0.027(4)	1.000	4f	symmetry	hexagonal
6 Ga Ga ^{IV}	0.333(3)	0.666(7)	0.190(1)	1.000	4f	Lattice	a=5.793(0)
7 Ga Ga ^V	-0.168(5)	0.163(1)	0.109(5)	1.000	12k	parameters (Å)	c=22.819(1)
8 O O ^I	0.000(0)	0.000(0)	0.150(7)	1.000	4e		
9 O O ^{II}	0.666(7)	0.333(3)	0.055(3)	1.000	4f	<i>R_p</i>	7.101
10 O O ^{III}	0.181(8)	-0.181(8)	0.250(0)	1.000	6h	<i>R_w</i>	9.413
11 O O ^{IV}	0.155(5)	-0.155(5)	0.052(5)	1.000	12k	<i>R_{exp}</i>	4.219
12 O O ^V	0.504(5)	-0.504(5)	0.150(0)	1.000	12k		
13 Sr Sr ^I	0.666(7)	0.333(3)	0.250(0)	1.000	2d		

Table S 2. Ga-O bond length data derived from refined results.

	Bond length (Å)	Average (Å)		Bond length (Å)	Average (Å)		Bond length (Å)	Average (Å)
Ga ^I -O	1.967(1)	1.967	Ga ^{IV} -O	1.944(7)	1.996	Ga ^V -O	2.073(5)	1.979
	1.967(1)			2.046(3)			1.923(4)	
	1.967(1)			1.944(7)			1.874(7)	
	1.967(1)			2.046(3)			2.073(5)	
	1.967(1)			2.046(3)			1.874(4)	
	1.967(1)			1.944(7)			2.056(2)	

Table S 3. Photoluminescence properties of some Cr³⁺ doped shost.

Host	E _m (nm)	IQE (%)	EQE (%)	I _{500K} (%)	Refs
LiScP ₂ O ₇	877	38	20	< 20	S1
LaSc ₃ (BO ₃) ₄	850	23	~	< 30	S2
ScBO ₃	800	72.8	~	~	S3
La ₂ MgZrO ₆	825	58	~	< 40	S4
Ca ₂ LuZr ₂ Al ₃ O ₁₂	760	69.1	31.5	40	S5
Ca ₂ LuScGa ₂ Ge ₂ O ₁₂	800	53	~	< 40	S6
Ca ₃ Sc ₂ Si ₃ O ₁₂	~770	92.3	25.5	90	S7
Y ₂ CaAl ₄ SiO ₁₂	744	75.9	~	< 80	S8
SrGa ₁₂ O ₁₉	770	98.2	45	86.5	This work

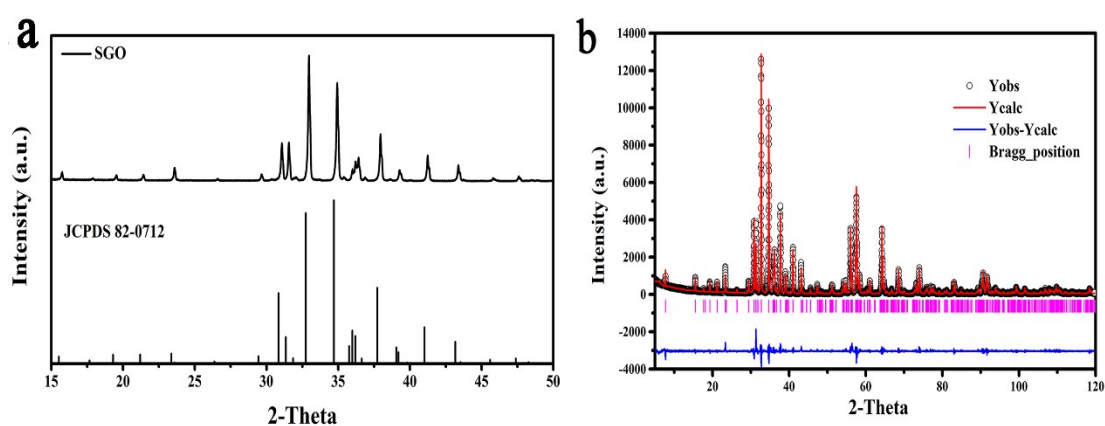


Figure S1. (a) XRD patterns of un-doped SGO and standard Bragg reflection peaks of JCPDS 82-0712. (b) Rietveld refinement result of un-doped SGO.

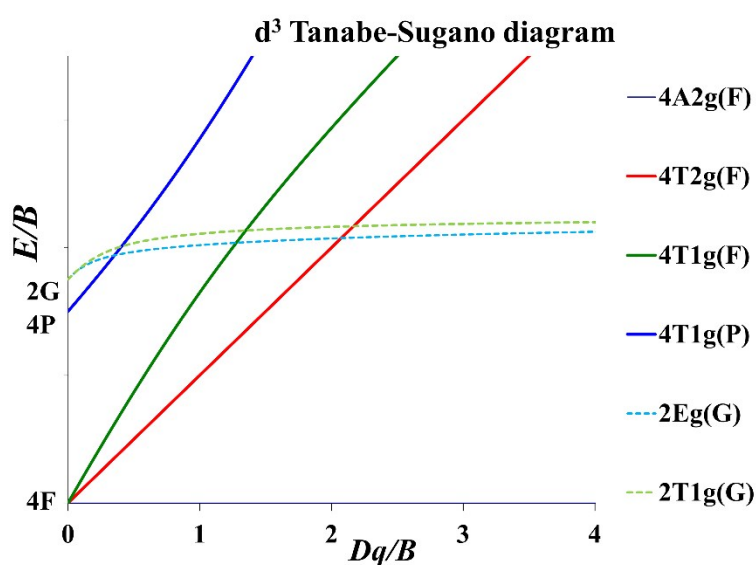


Figure S2. Tanabe—Sugano energy-level diagram for Cr³⁺ ([Ar]3d³) in SGO host.

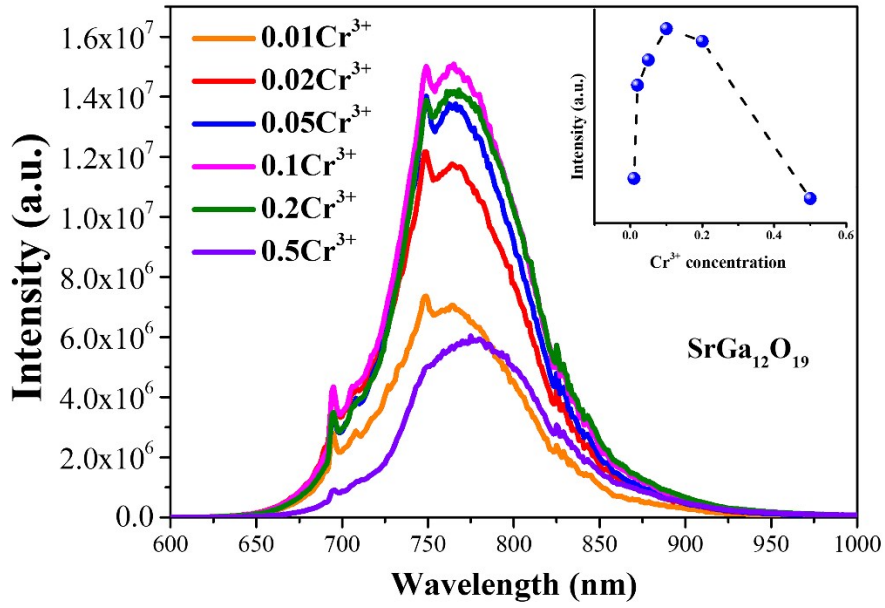


Figure S3. Concentration-dependence PL spectra for $\text{SrGa}_{12-x}\text{O}_{19}:x\text{Cr}^{3+}$ ($x=0.01, 0.02, 0.05, 0.1, 0.2, 0.5$). The inset shows the integrated intensity vs Cr^{3+} concentration scatters.

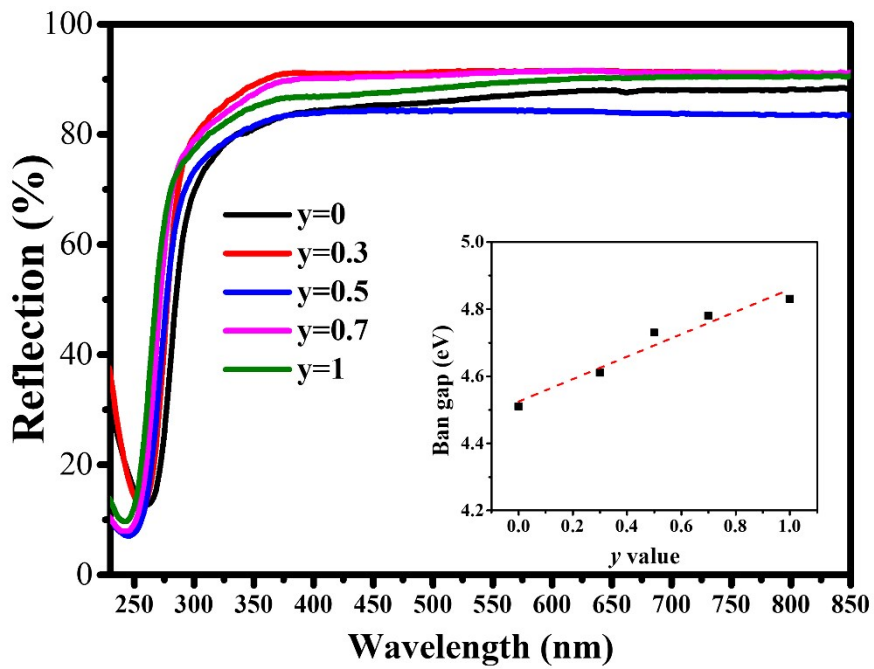


Figure S4. UV diffuse reflection spectra for the solid solution $(\text{SrGa})_{1-y}(\text{LaMg})_y\text{Ga}_{11}\text{O}_{19}$. ($y=0-1$). The inset shows the bandgap (eV) as a function of y value.

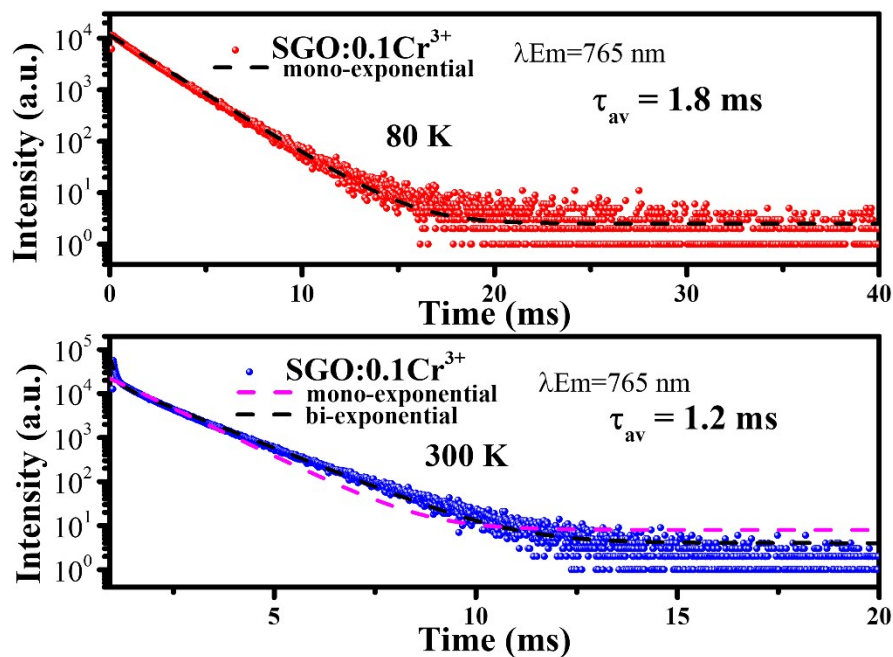


Figure S5. luminescence decay curves and multi-exponential fitting of $\text{SrGa}_{12}\text{O}_{19}:0.1\text{Cr}^{3+}$ at 80 and 300 K.

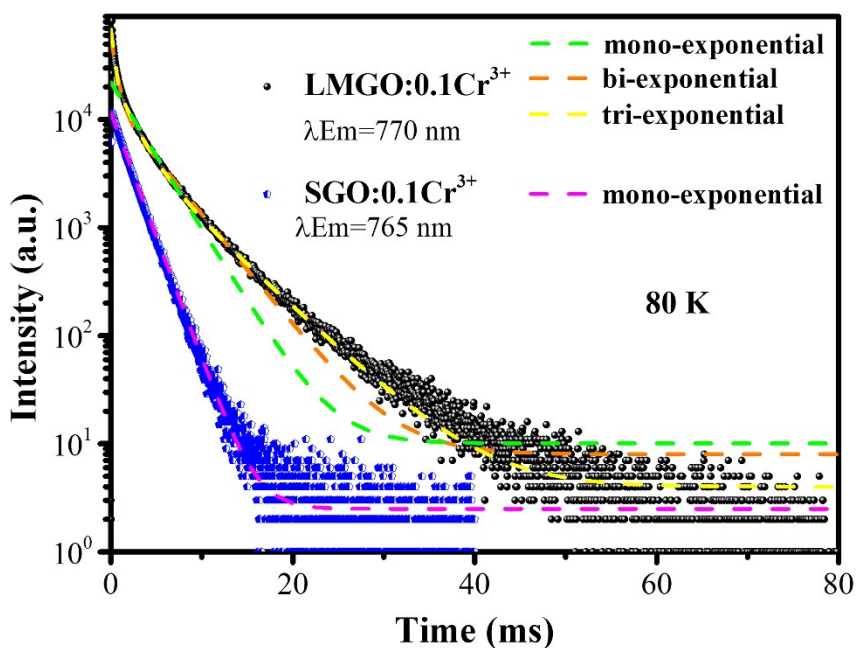


Figure S6. luminescence decay curves for $\text{LaMgGa}_{10.9}\text{O}_{19}:0.1\text{Cr}^{3+}$ and $\text{SrGa}_{11.9}\text{O}_{19}:0.1\text{Cr}^{3+}$, and multi-exponential fitting results at 80 K.

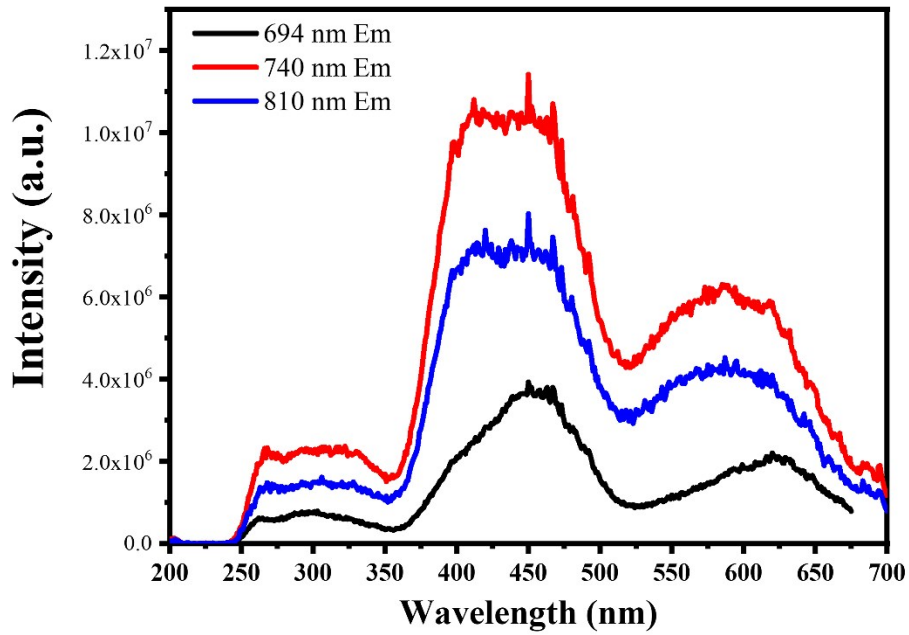


Figure S7. PLE spectra of SGO:0.1Cr³⁺ monitoring at different emission wavelength (694, 740, 810 nm).

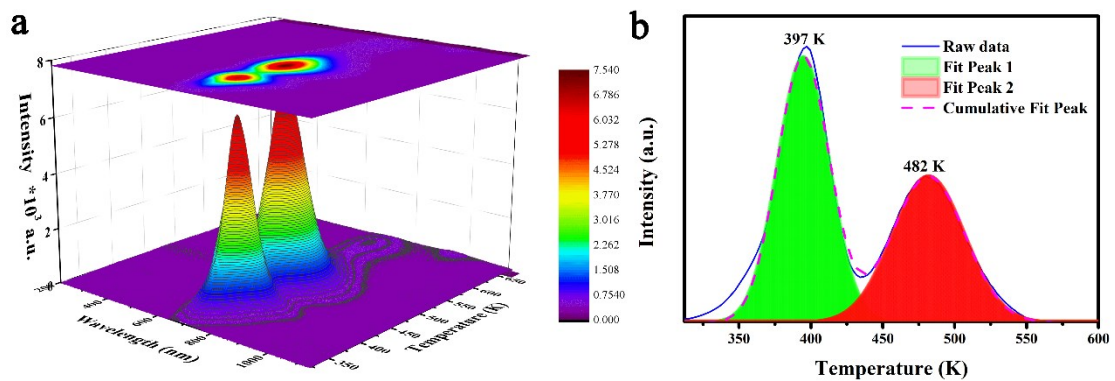


Figure S8. (a) 3D-TL curves for SGO:0.1Cr³⁺. The x and y axes denote the temperature (K) and emission wavelength (nm), respectively. (b) 2D-TL curve for SGO:0.1Cr³⁺ and Gaussian fitting curves.

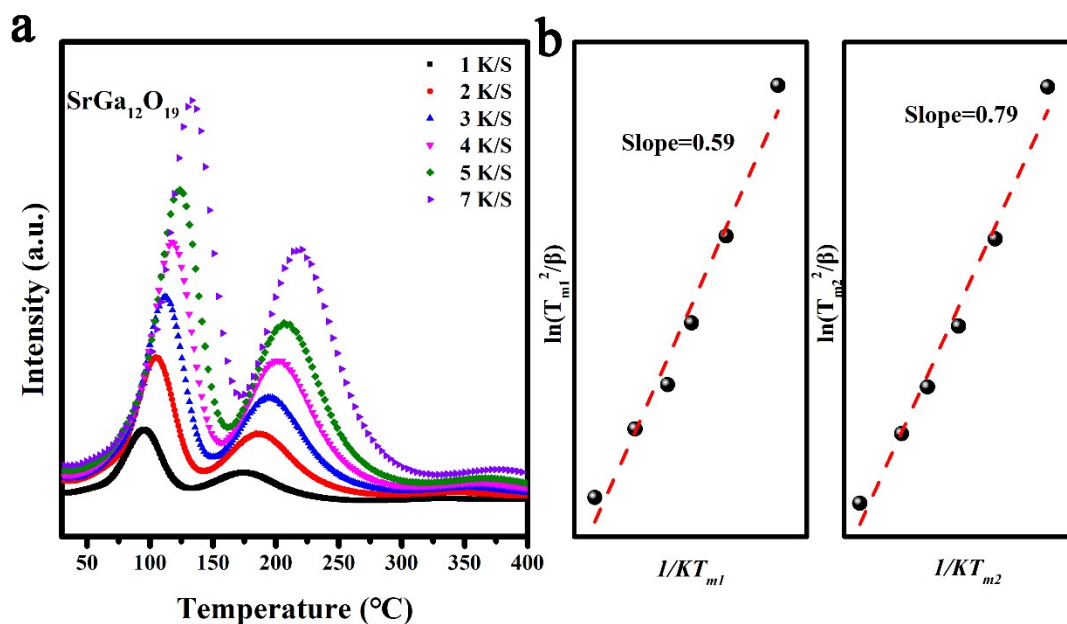


Figure S9. (a) 2D-thermoluminescence curves of SrGa₁₂O₁₉:0.1Cr³⁺ via tunable heating rate β ($\beta=1, 2, 3, 4, 5, 7$ K/s) approach. (b) $\ln(T_m^2/\beta)$ versus $1/kT_m$ scatter and linear fitting results.

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