

Ca₇Mg_{1.8}Zn_{0.2}Ga₆O₁₈:Bi³⁺/Mn⁴⁺ phosphor: energy transfer enables tunable colour emission and high sensitivity in optical thermometry

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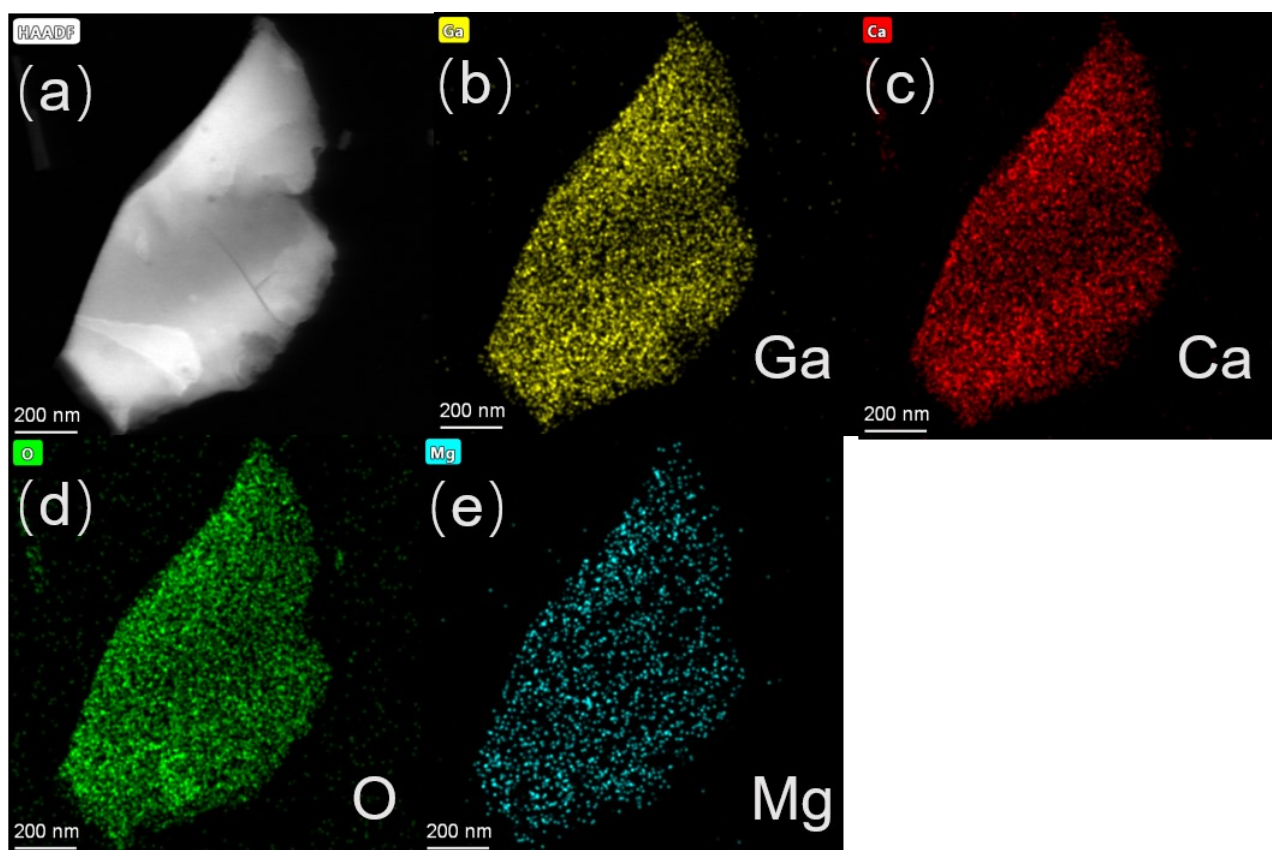


Fig. S1 (a) TEM images of CMGO. (b-e) The elemental mapping images for Ga, Ca, O, Mg in CMGO.

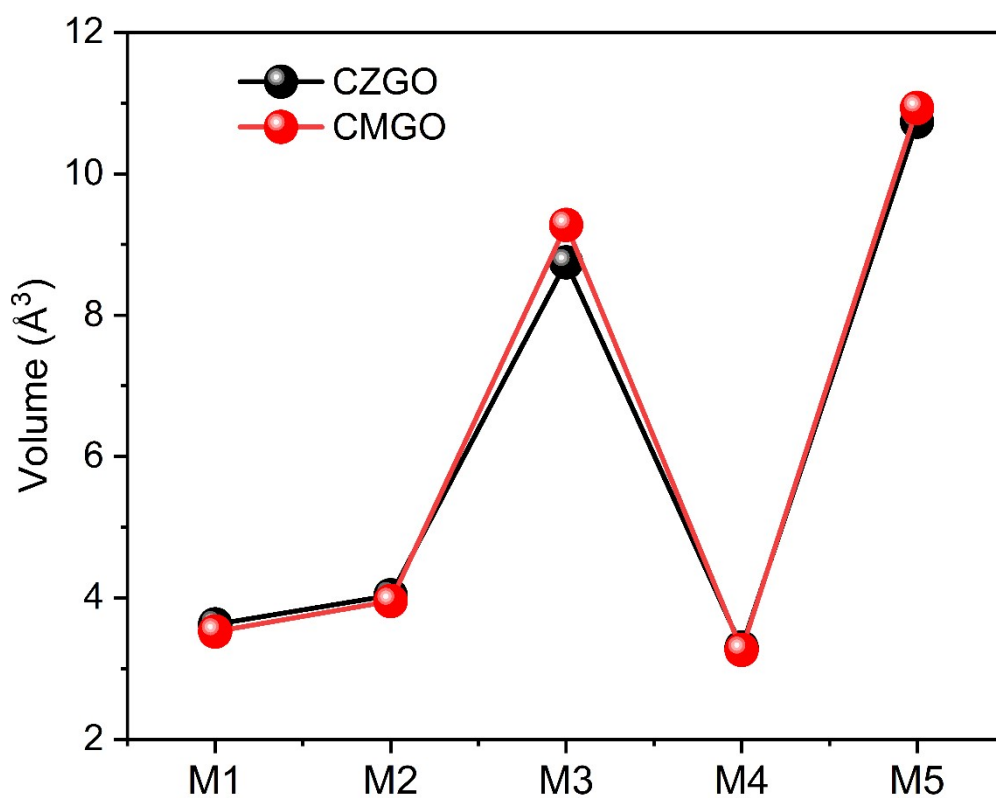


Fig. S2 Comparison of polyhedral volumes in CMGO:Bi³⁺ and CZGO:Bi³⁺.

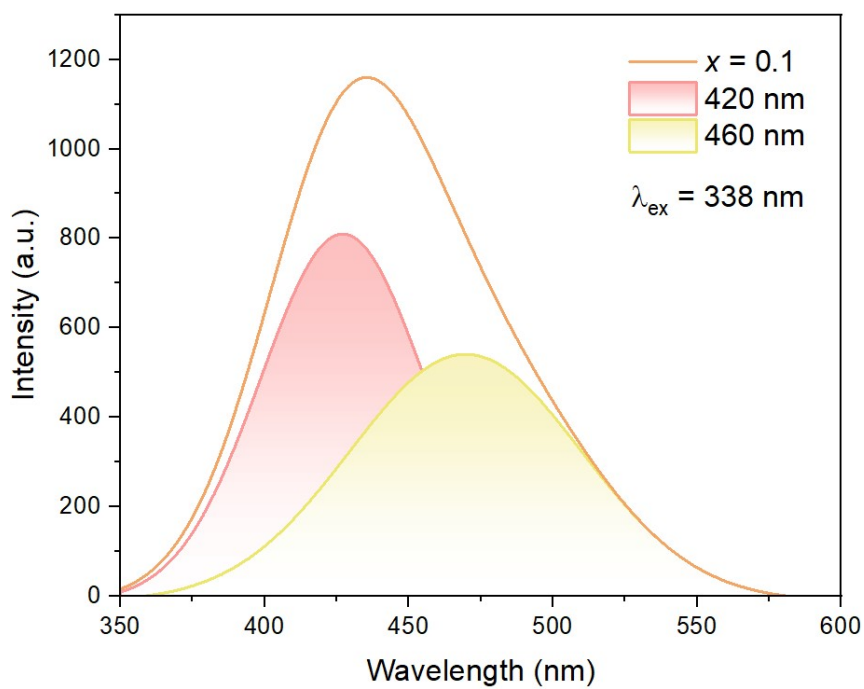


Fig. S3 Deconvolution of the emission spectrum of CMZ_{0.1}GO:Bi³⁺.

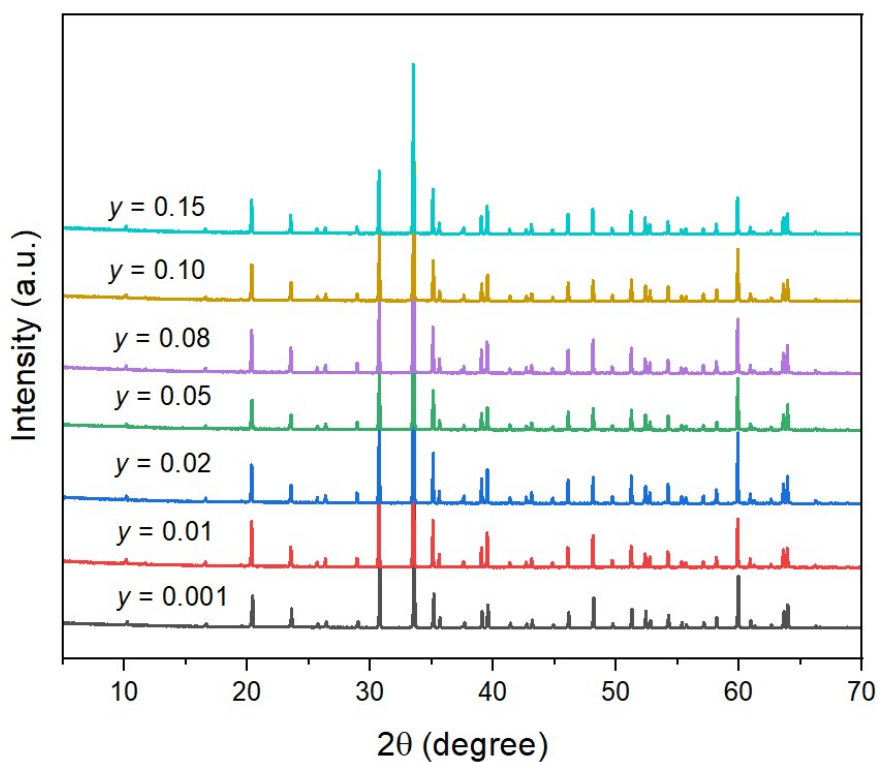


Fig. S4 PXRD patterns for the phosphor series CMZ_{0.2}GO:Bi³⁺/*y*Mn⁴⁺ (*y* = 0.001, 0.01, 0.02, 0.05, 0.08, 0.1, 0.15).

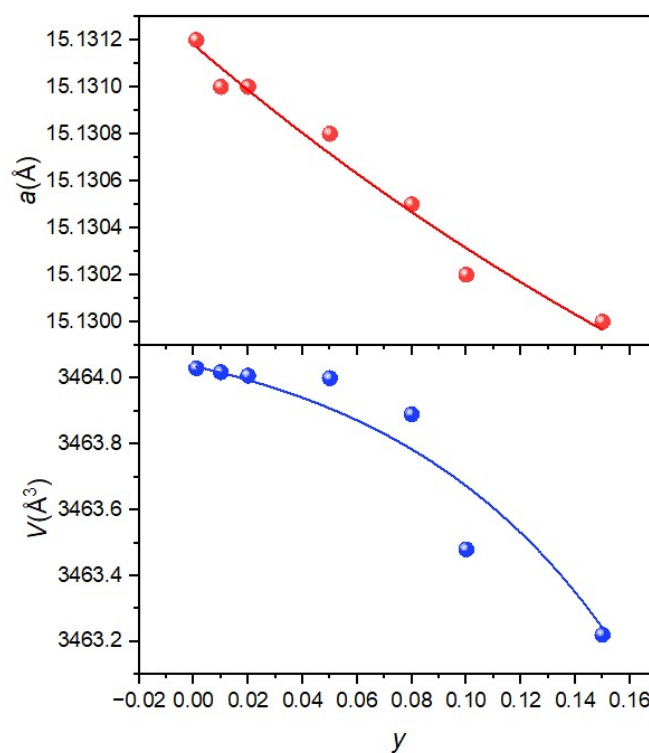


Fig. S5 Plots of lattice parameters as a function of Mn^{4+} -content (y) in $\text{CMZ}_{0.2}\text{GO}:\text{Bi}^{3+}/y\text{Mn}^{4+}$.



Fig. S6 The digital photographs of $\text{CMZ}_{0.2}\text{GO}:\text{Bi}^{3+}/y\text{Mn}^{4+}$ ($y = 0, 0.001, 0.01, 0.02, 0.05, 0.08, 0.10, 0.15$) under 365 nm light irradiation.

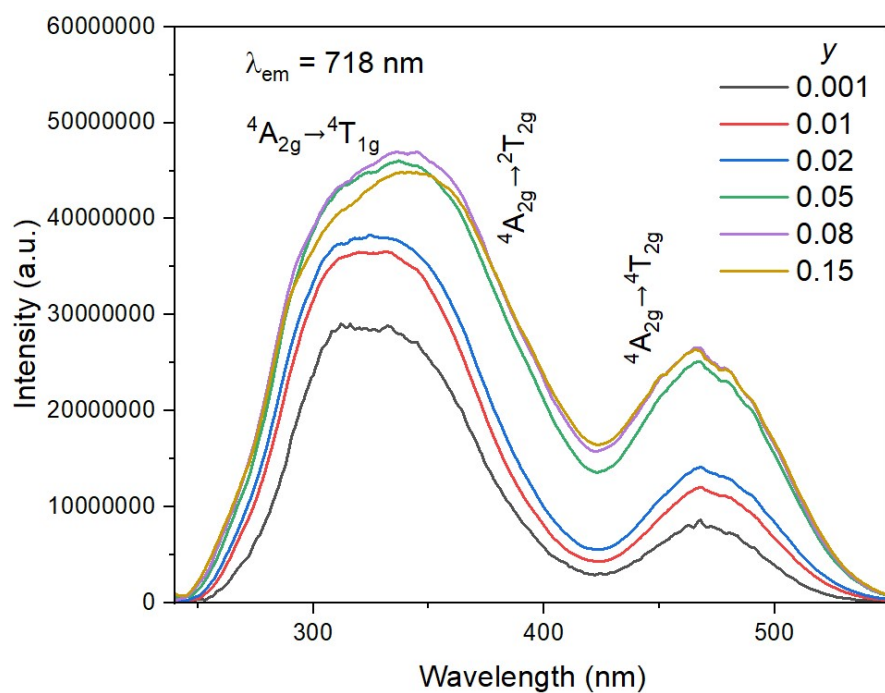


Fig. S7 PLE spectra of CMZ_{0.2}GO:Bi³⁺/*y*Mn⁴⁺ under emission at 718 nm.

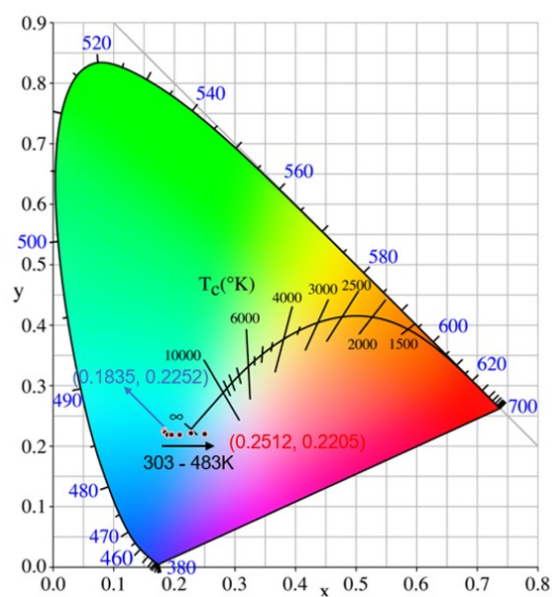


Fig. S8 CIE coordinates of CMZ_{0.2}GO:Bi³⁺/0.001Mn⁴⁺ at temperatures from 303K to 483K.

Table S1 Comparison of Ca-O bond lengths in CMGO and CZGO.

Bonds	CZGO	CMGO
	length (Å)	length (Å)
Ca1-O4×3	2.301(3)	2.330(3)
Ca1-O2×3	2.401(9)	2.3966(9)
<Ca1-O3>	2.35(2)	2.363(2)
Ca2-O2	2.358(4)	2.362(4)
Ca2-O4×4	2.511(2)	2.548(2)
Ca2-O3×2	2.614(1)	2.6134(1)
<Ca2-O>	2.519(2)	2.540(2)
Ga1-O4×3	1.945(3)	1.918(3)
Ga1-O3	1.991(9)	1.988(9)
<Ga1-O>	1.957(5)	1.936(5)
Ga2-O1	1.985(2)	1.946(2)
Ga2-O4×3	1.998(3)	1.976(3)
Ga3-O3×3	1.784(8)	1.800(8)
Ga4-O4×4	1.862(2)	1.845(2)
Ga5-O2×6	2.004(4)Å	2.006(4)

Table S2. The estimated lifetimes of different Bi³⁺-emitters and their average lifetimes in CMZ_{0.2}GO:Bi³⁺/*y*Mn⁴⁺.

<i>y</i>	τ_1/ns	τ_2/ns	τ/ns
0	42.13	586.04	569.20
0.01	61.29	539.2	517.41
0.02	72.89	532.23	507.77
0.05	95.72	489.85	448.13
0.08	80.08	456.06	409.32
0.10	83.24	445.29	399.81
0.15	79.32	393.01	339.42

Table S3. Fitted Parameter for CMZ_{0.2}GO:Bi³⁺/0.001Mn⁴⁺.

Sample	B	C	ΔE
CMZ _{0.2} GO:Bi ³⁺ /0.001Mn ⁴⁺	0.45	1999.09	0.23 eV