Supporting Information

Dynamic and multimodal luminescence of Mn²⁺-doped Mg₄Ga₈Ge₂O₂₀ persistent phosphor for anti-counterfeiting applications

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Space group	P-1
a	0.88468 Å
b	0.98164 Å
с	1.02852 Å
α	63.808 °
β	84.754 °
γ	65.405 °
Rwp	9.98%
Rexp	4.01%
χ^2	6.19

Table S1. Rietveld refinement data of x = 0.25 sample.

Table S2. The effective lifetime of the blue (450 nm) and red (650 nm) bands when excited with254 nm.

	τ _{eff} (ms)	τ _{eff} (ms)
	λex=254 nm,	$\lambda_{ex}=254$ nm,
	λ _{em} =450 nm	λem=650 nm
0 Mn	7.1	-
0.01 Mn	5.1	38.7
0.05 Mn	6.4	64.7
0.5 Mn	-	17.4



Figure S1. PLE and PL spectra of the undoped MGGO sample, $\lambda_{ex} = 254$ nm and $\lambda_{em} = 460$ nm.



Figure S2. (a), (b), (c), and (d) PL spectra of x = 0.005, 0.05, 0.1, and 0.5 samples at different time periods after the start of excitation, $\lambda_{ex} = 254$ nm; (e), (f), (g), and (h) dependence of the CIE 1931 chromaticity coordinates on time after the start of excitation for the same samples.



Figure S3. PL decay kinetics of selected samples of the (a) red band and (b) blue band after excitation with 254 nm.



Figure S4. Contour plots of XRL spectra in continuous excitation t = 0 - 20 min of (a) x = 0.05, (b) x = 0.1, (c) x = 0.25, and (d) x = 0.5 samples.



Figure S5. Time-dependent changes of blue and red emission intensity excited with (a) 10 μ J/cm², (b) 25 μ J/cm², and (c) 70 μ J/cm².



Figure S6. Digital images of MGGO samples before irradiation (first row) and instantly after irradiation (second row) with UV for a few minutes.



Figure S7. Contour plot of initial stages of PersL decay for (a) x = 0.005, (b) x = 0.01, (c) x = 0.05, (d) x = 0.1, (e) x = 0.25, and (f) x = 0.5 samples after irradiation with 263 nm for 5 min.



Figure S8. Contour plot of initial stages of PersL decay for (a) x = 0.005, (b) x = 0.01, (c) x = 0.05, (d) x = 0.1, (e) x = 0.25, and (f) x = 0.5 samples after irradiation with X-rays for 10 min.



Figure S9. (a) PersL spectrum at 10 K temperature and (b) low-temperature TSL curve of x = 0.05 sample, $\lambda_{ex} = 254$ nm.



Figure S10. Contour plots of TSL measurements of MGGO samples after irradiation for 60 s with X-rays (a-f) and UV (g-l).



Figure S11. T_{max} - T_{stop} and IRA plots of x = 0.05 sample, irradiated with (a), (b) X-rays and (c), (d) UV.



Figure S12. (a) T_{max} - T_{stop} and (b) IRA plots of x = 0.05 sample, irradiated with X-rays. T_{stop} range: -40 - 50 °C.



Figure S13. EPR spectra of MGGO samples where (a) x = 0.00, (b) x = 0.01, (c) x = 0.05, (d) x = 0.1, (e) x = 0.25, and (f) x = 0.5 before and after UV irradiation.



Figure S14. UV-induced EPR spectra (difference between spectra "after UV irradiation" and "before irradiation" from Figure S13) of the MGGO samples.



Figure S15. X-ray fluorescence analysis of the x = 0.25 sample.