SUPPORTING INFORMATION

Unlocking dual Mn^{3+}/Mn^{4+} emissions in garnet phosphors for WLED and plant growth lighting applications

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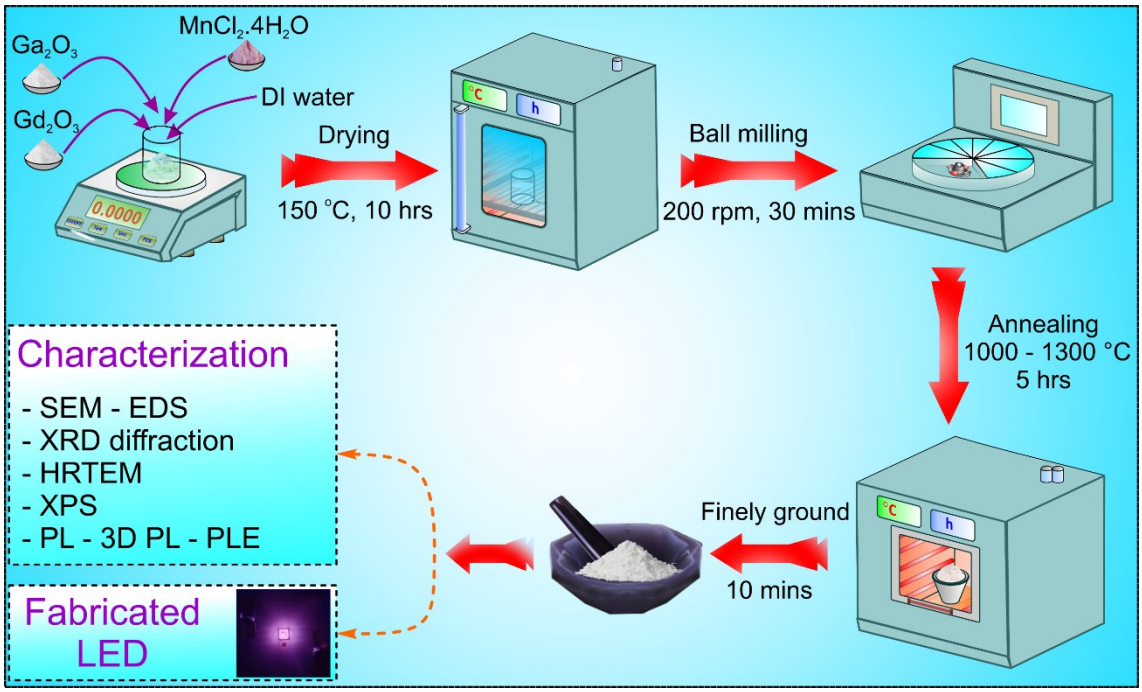

Fig. S1. Experimental process for synthesizing red and far-red emitting $Gd_3Ga_5O_{12}$:Mn phosphors

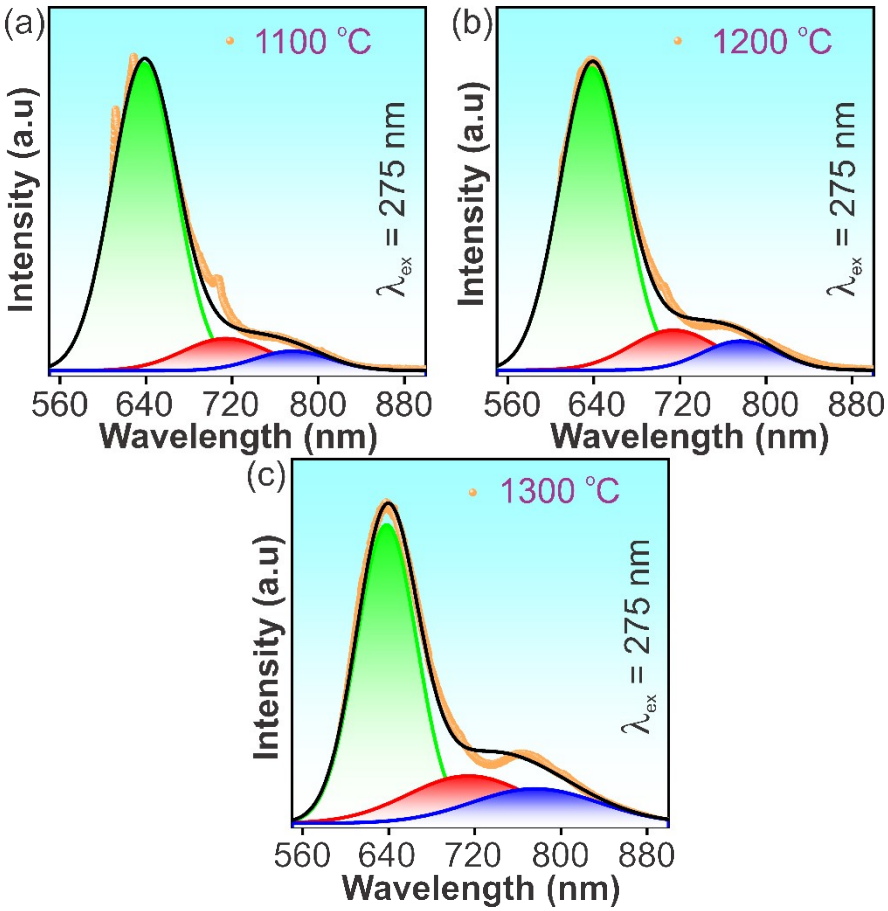

Fig. S2. Fitting peaks of $Gd_3Ga_5O_{12}$:0.2%Mn samples annealed at different temperatures excited at 275 nm wavelength

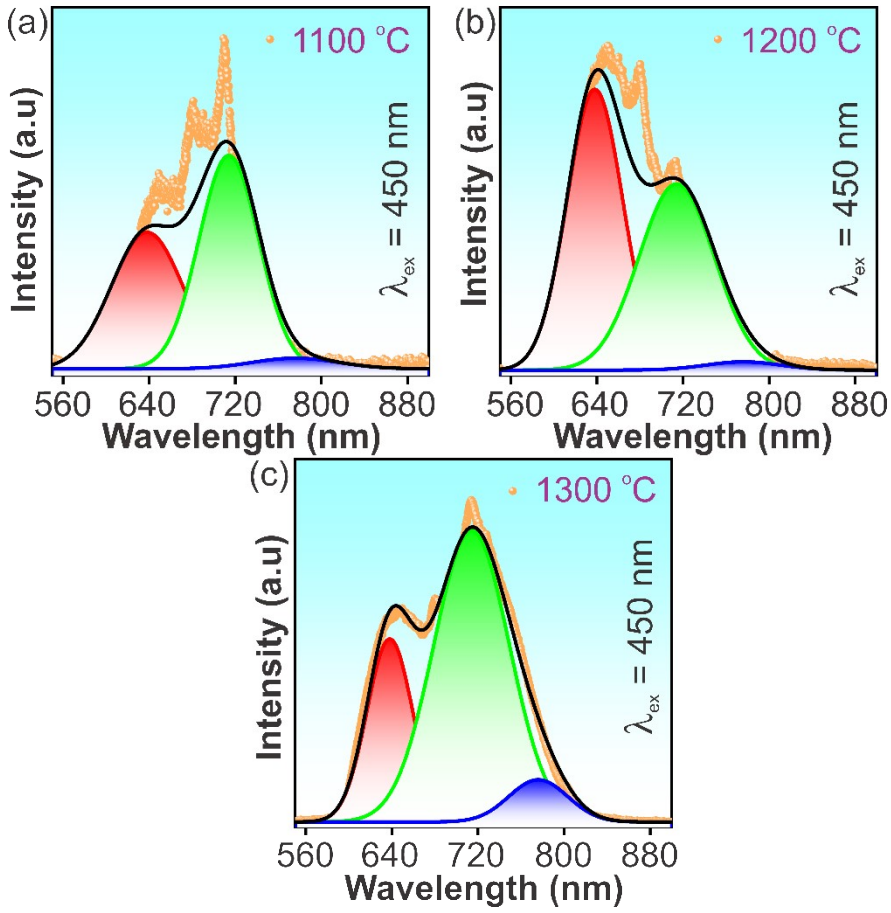

Fig. S3. Fitting peaks of $Gd_3Ga_5O_{12}$:0.2%Mn samples annealed at different temperatures excited at 450 nm wavelength

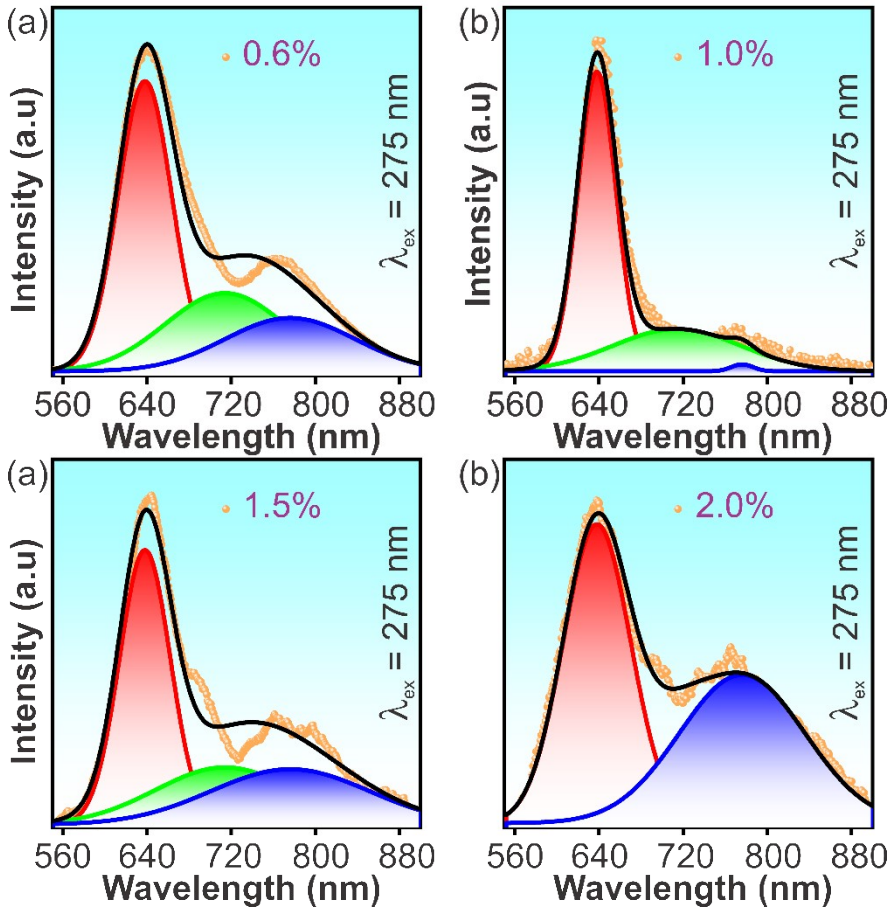

Fig. S4. Fitting peaks of $Gd_3Ga_5O_{12}$: x% Mn samples annealed at 1300 ℃ excited at 275 nm wavelength

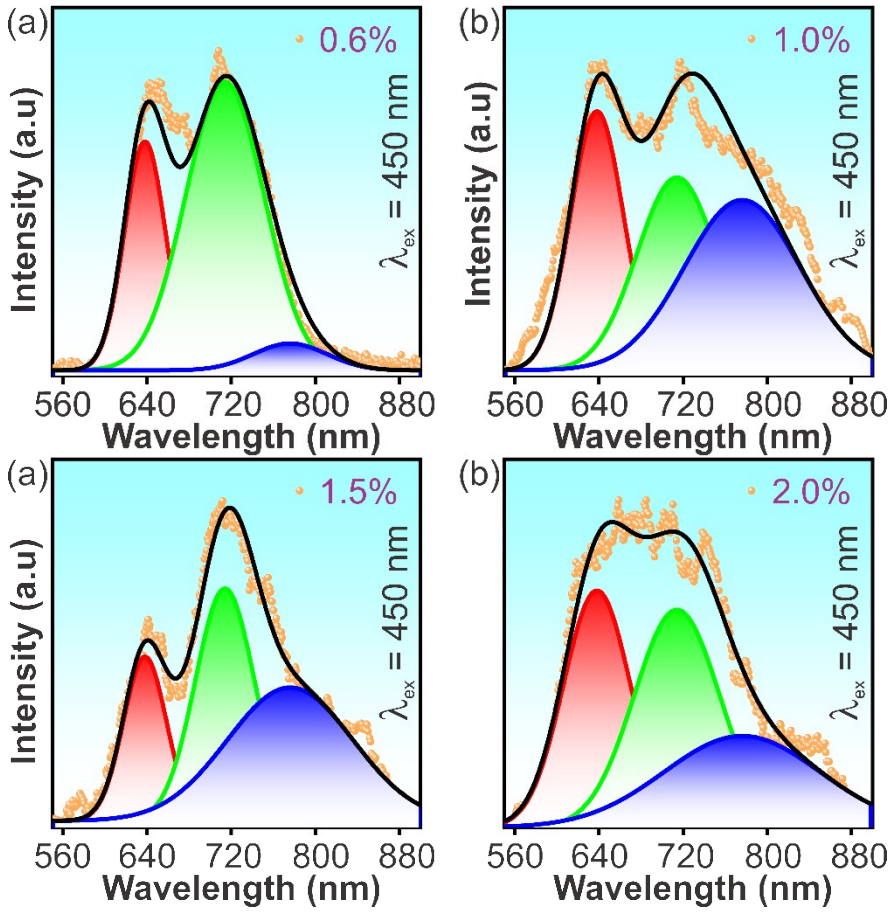

Fig. S5. Fitting peaks of $Gd_3Ga_5O_{12}$:x% Mn samples annealed at 1300 ℃ excited at 450 nm wavelength

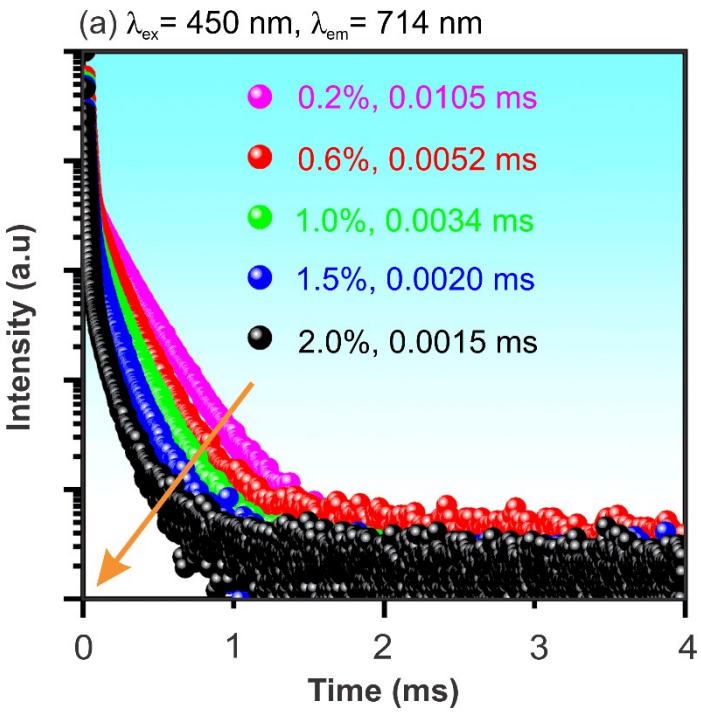

Fig. S6. Lifetime curves for the 714 nm peak under 450 nm excitation, with the arrow indicating the increase of doping concentration

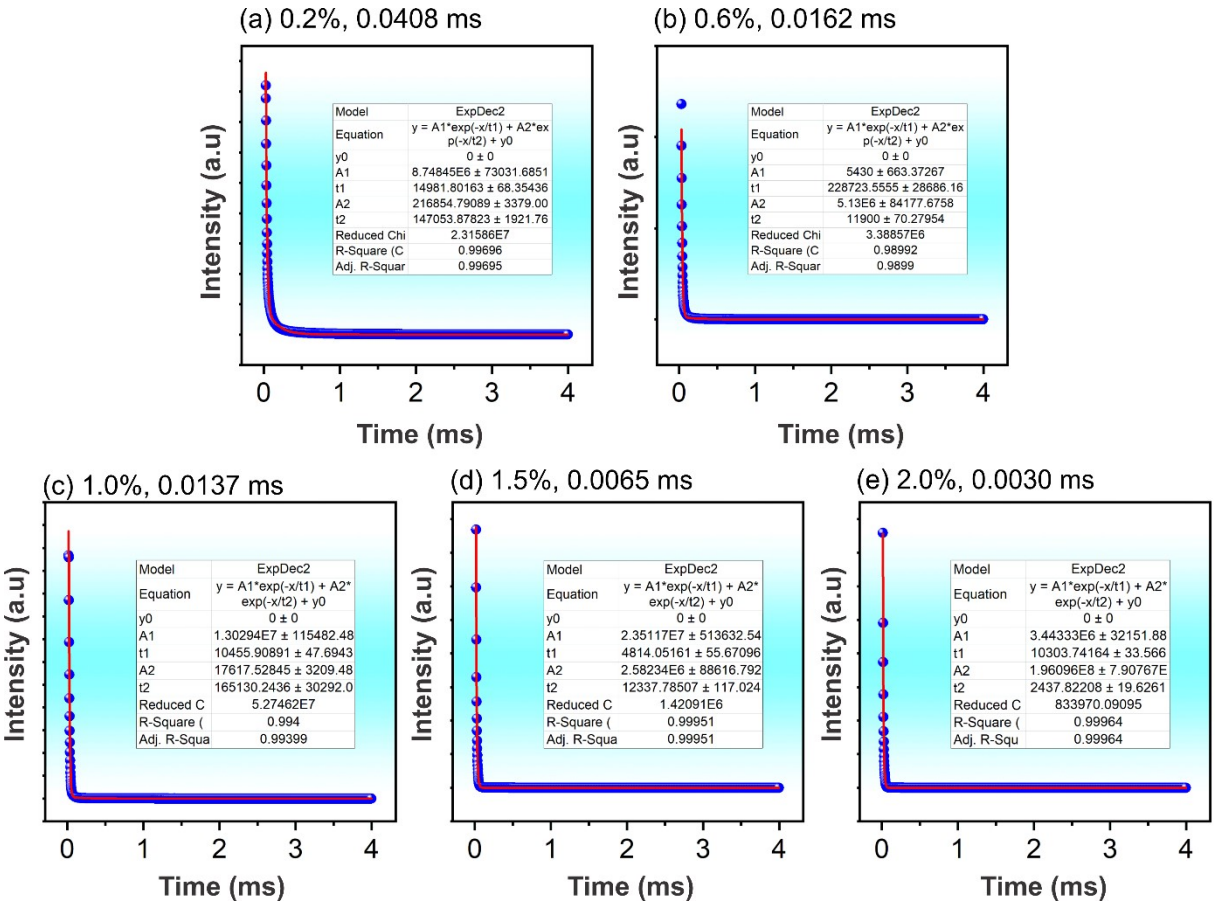

Fig. S7. The fitting lifetime curves for the 638 nm peak under 275 nm excitation, with the $Gd_3Ga_5O_{12}$:x% Mn samples annealed at 1300 °C

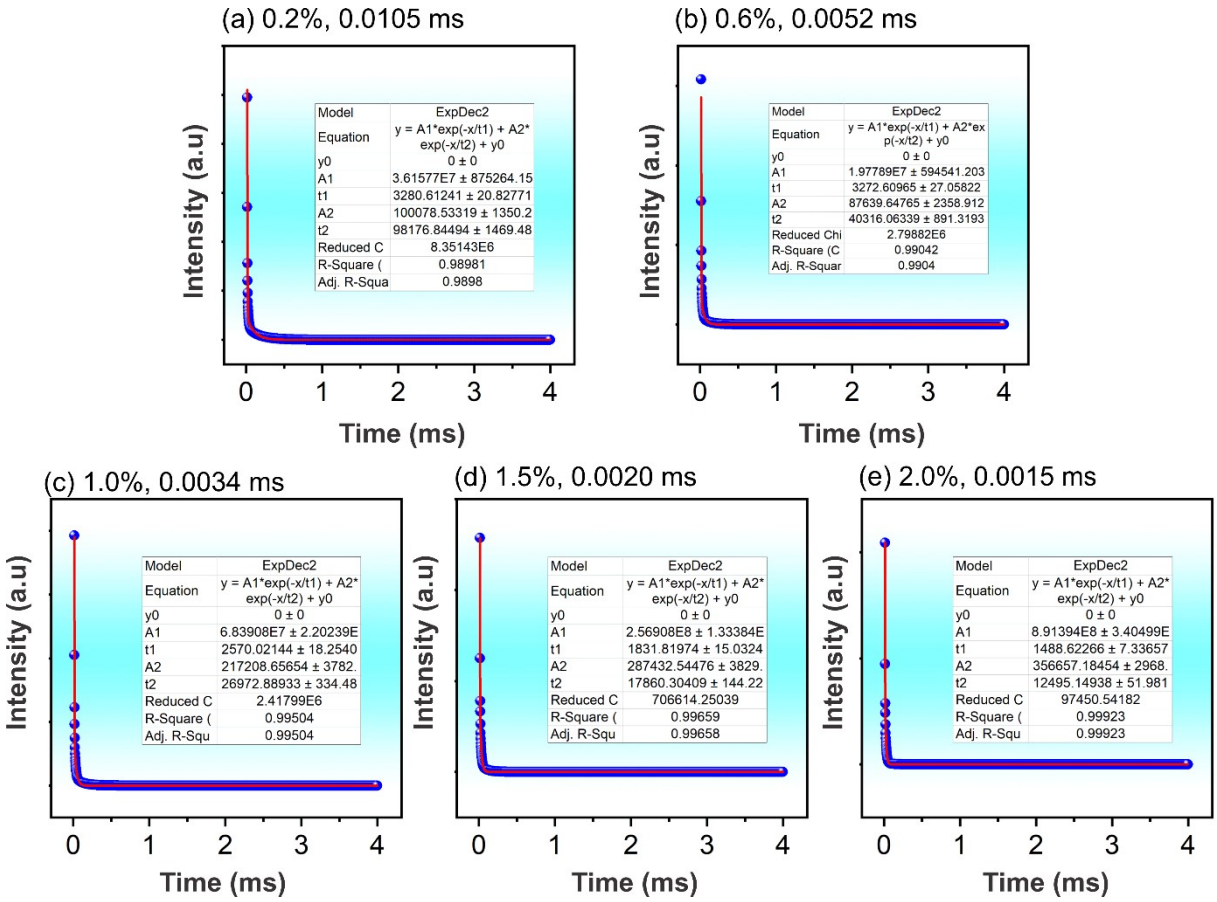

Fig. S8. The fitting lifetime curves for the 714 nm peak under 450 nm excitation, with the $Gd_3Ga_5O_{12}$:x% Mn samples annealed at 1300 ℃

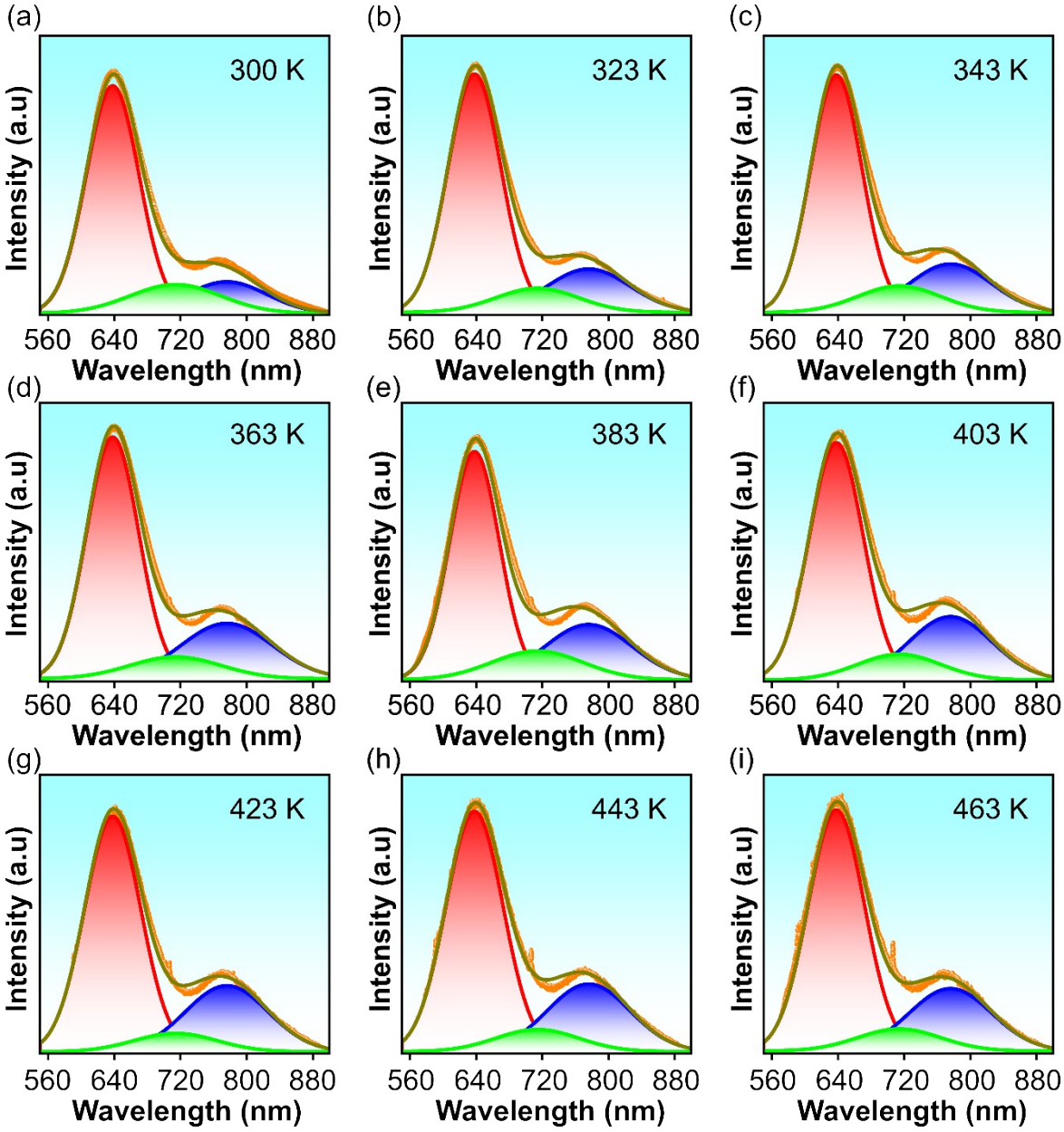

Fig. S9. Fitting peaks of $Gd_3Ga_5O_{12}$:0.2% Mn samples annealed at 1300 ℃ excited at 275 nm wavelength at different measured temperature

Table S1. Integral intensity of fitting peaks of $Gd_3Ga_5O_{12}$: 0.2% Mn annealed at different temperatures under 275 nm excitation wavelength

Samples	638 nm	776 nm	Mn^{3+} (638 + 776)	Mn^{4+} (714 nm)
1100 ℃	2.22517E6	164809	309707	2.38998E6
1200 ℃	3.44437E6	386486	607207	3.83086E6
1300 ℃	5.19885E6	1.25547E6	1.65227E6	6.45432E6

Table S2. Integral intensity of fitting peaks of $Gd_3Ga_5O_{12}$: 0.2% Mn annealed at different temperatures under 450 nm excitation wavelength

Samples	638 nm	776 nm	Mn^{3+} (638 + 776)	Mn^{4+} (714 nm)
1100 ℃	85125.6	8000	111345.3	93125.6
1200 ℃	301387.8	12000	271534.9	313387.8
1300 ℃	457035.3	135118.6	1.20528E6	592153.9

Table S3. Integral intensity of fitting peaks of $Gd_3Ga_5O_{12}$: x% Mn annealed at 1300 ℃ under 275 nm excitation wavelength

Samples	638 nm	776 nm	Mn^{3+} (638 + 776)	Mn^{4+} (714 nm)
0.6%	2.16939E6	962003	3.13139E6	1.29455E6
1.0%	1.2708E6	16913.6	1.28771E6	601771
1.5%	591205.3	371076	962281.3	336326.8
2.0%	562301.9	518348.5	1.08065E6	45448

Table S4. Integral intensity of fitting peaks of $Gd_3Ga_5O_{12}$: x% Mn annealed at 1300 ℃ under 450 nm excitation wavelength

Samples	638 nm	776 nm	Mn^{3+} (638 + 776)	Mn^{4+} (714 nm)
0.6%	323574.9	68351	391925.9	780910.46
1.0%	152000	220000	372000	172000
1.5%	76784.4	182201.5	258985.9	148939.1
2.0%	107152.8	96954.4	204107.2	126510.3

Table S5. Integral intensity of fitting peaks of $Gd_3Ga_5O_{12}$: 0.2% Mn annealed at 1300 ℃ under 275 nm excitation wavelength measure at different temperatures

Samples	638 nm	776 nm	Mn^{3+} (638 + 776)	Mn^{4+} (714 nm)
303 K	4.60065E6	956429	5.6E6	1000000
323 K	3.8E6	1.08E6	4.88E6	600000
343 K	2.666E6	860000	3.526E6	480000
363 K	1.9E6	760000	2.66E6	300000
383 K	1.3E6	550000	1.85E6	300000
403 K	1.08E6	443000	1.523E6	180000
423 K	868000	358000	1.226E6	100000
443 K	675000	275000	950000	90000
463 K	520000	198000	718000	70000

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