

## Electronic Supplementary Information (ESI)

### Experiment section

#### The phosphor synthesis process

Take MGO:0.2%Mn<sup>4+</sup> (1 mmol) as example, the typical synthesis process is described as follow: according to the stoichiometric ratio, after weighing 0.5643 g MgO, 0.5221 g GeO<sub>2</sub>, and 0.0011 g MnCO<sub>3</sub>. All of them were mixed in an agate mortar and grinded homogeneously for 20 min, with adding ethanol for a better dispersibility. Then, the mixture was dried in the baking box with the temperature of 80 °C. The dried precursors were ground before shifting to the crucible and transferred to the tube furnace, and sintered at 1300 °C for 8 h in air. Finally, the samples were ground again after cooling down to room temperature for further characterization.

#### The WLEDs fabrication process

White-LEDs were fabricated by combining the light of the commercial YAG yellow phosphor, Mg<sub>15</sub>Ge<sub>5</sub>(1-0.2%)O<sub>24</sub>: 0.2%Mn<sup>4+</sup> red phosphor and blue-emitting InGaN chip. First step was mixing the epoxy resin A 0.1 g and B 0.1 g with the ratio of 1:1, then the proper amount of YAG and MGO:0.2%Mn<sup>4+</sup> phosphors were added and mixed thoroughly. Typically, the specific amount of the commercial YAG and red phosphor is 7 % the sum of epoxy resin A and B. Then slightly adjustment could be take based on the EL spectra. The obtained mixture was smoothly coated on the surface of InGaN chips with the thickness around 1.5 mm, and the fabricated LED was putted into the baking box and dried at 140 °C. All the measurements were conducted at a forward current of 20 mA, and the excitation wavelength of the LEDs is 422 nm.

Table S1. Related parameters of WLEDs with two typical compositions.

Crystallographic Data of Mg <sub>14</sub> Ge <sub>4.99</sub> O <sub>14</sub> :0.2%Mn <sup>4+</sup>					
Formula	Mg <sub>14</sub> Ge <sub>5(1-0.2%)</sub> O <sub>14</sub> :0.2%Mn <sup>4+</sup>				
Crystal space, Space group	Orthorhombic, Pbam(55)				
Lattice parameters/ Å, deg	a = 14.5245    α = 90 b = 10.2287    β = 90 c = 5.9503    γ = 90				
Cell volume/ Å <sup>3</sup> , Formula units per cell Z	884.0184 2				
Rwp/%	5.94				
Rp/%	3.98				
Fractional coordinates	Name	x	y	z	Occupancy
	Ge1	0.000000	0.000000	0.000000	1.0000
	Ge2	0.127948	0.502700	0.000000	1.0000
	Ge3	0.187485	0.325999	0.500000	1.0000
	Mg1	0.000000	0.500000	0.500000	1.0200
	Mg2	0.000000	0.000000	0.500000	0.9900
	Mg3	0.177324	0.177763	0.000000	0.9900
	Mg4	0.329292	0.151939	0.500000	0.9800
	Mg5	-0.008567	0.249042	0.249232	0.9900
	Mg6	0.329487	0.419889	0.254110	0.9900
	O1	0.084261	0.332094	0.000000	1.0000
	O2	0.419754	0.339220	0.000000	1.0000
	O3	0.247273	-0.008713	0.000000	1.0000
	O4	0.072680	0.316267	0.500000	1.0000
	O5	0.424039	0.334802	0.500000	1.0000
	O6	0.246986	-0.020698	0.500000	1.0000
	O7	0.080888	0.075673	0.210237	1.0000
	O8	0.409873	0.086188	0.241808	1.0000
	O9	0.240783	0.244099	0.278928	1.0000

**Table S2.** Specific CRIs R1–R14 for WLEDs with chip+YAG and chip+YAG+MGO, respectively.

<b>Composition</b>	<b>R1</b>	<b>R2</b>	<b>R3</b>	<b>R4</b>	<b>R5</b>	<b>R6</b>	<b>R7</b>
<b>Chip+YAG</b>	51.3	59.9	72.7	59.1	53.4	52.1	68.9
<b>Chip+YAG+MGO</b>	85.9	80.2	71.9	87.9	82.1	69.2	81.2

  

<b>Composition</b>	<b>R8</b>	<b>R9</b>	<b>R10</b>	<b>R11</b>	<b>R12</b>	<b>R13</b>	<b>R14</b>
<b>Chip+YAG</b>	39.8	-77.5	9.6	57.6	-3.9	50.3	83.6
<b>Chip+YAG+MGO</b>	86.0	92.2	53.0	91.4	21.6	83.1	83.3