Supporting information

Structure and Luminescence Properties of Single-Component Melilite $Sr_2MgSi_2O_7$: Ce/Tb/Sm for *n*-UV *w*LEDs

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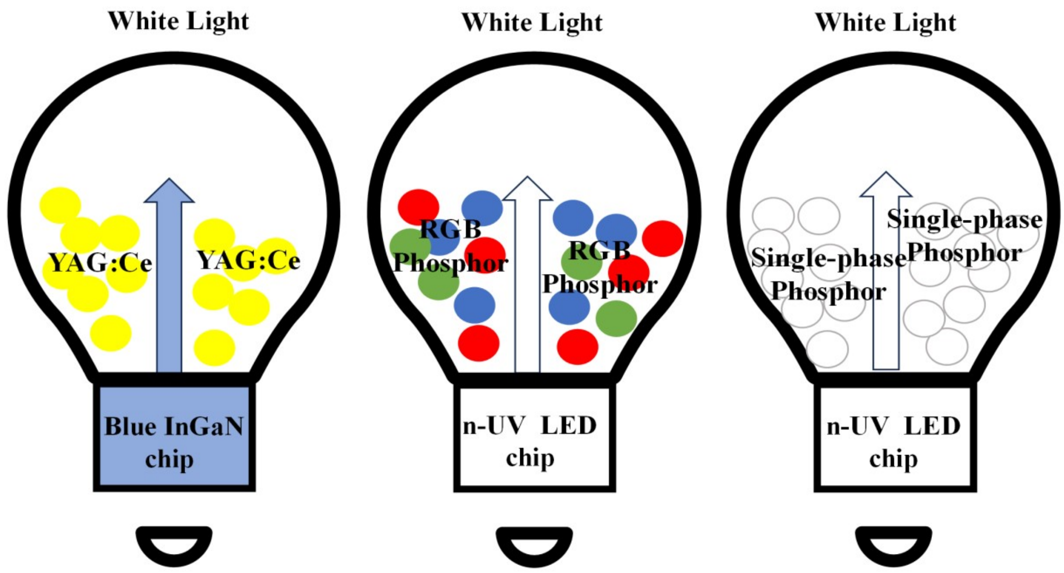
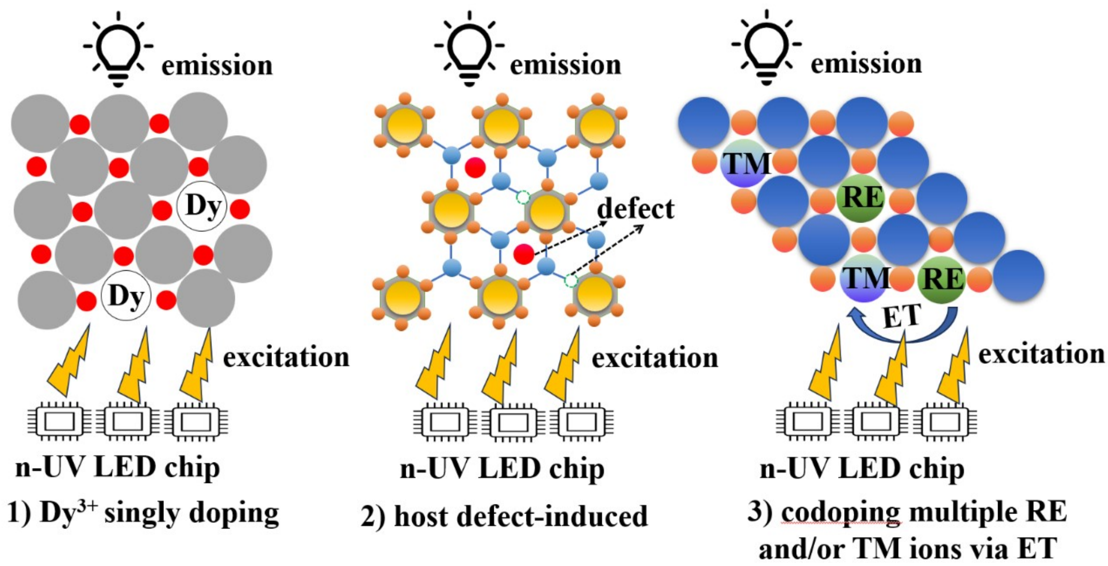


Scheme S1 Sketch map of the three mainstream modes for construction of pc-*w*LEDs (from left to right), blue InGaN LED chip + yellow phosphor YAG: Ce, ii) *n*-UV chip + red, green and blue phosphors, and iii) *n*-UV chip + single-phase RE/TM ions (co)doped phosphor.



Scheme S2 Sketch map of three ways to achieve white PL *via* the single-phase phosphor (from left to right), 1) singly doping, i.e., Dy^{3+}, 2) host defect-induced, and 3) codoping multiple RE and/or TM ions.

Table S1 Instrumental data used for Rietveld refinements of the $Sr_2MgSi_2O_7$ host and its RE and/or TM ions (co)doped derivatives

Items	Parameters
Primary and second radius	217.5 nm
Receiving slit length	13.65°
Source and sample length	12 mm
Primary slit aperture	2.5°
Reception slit divergence angle	0.2°
Receiving slit width	0.1 mm
Peak-shape function	Lorentzian

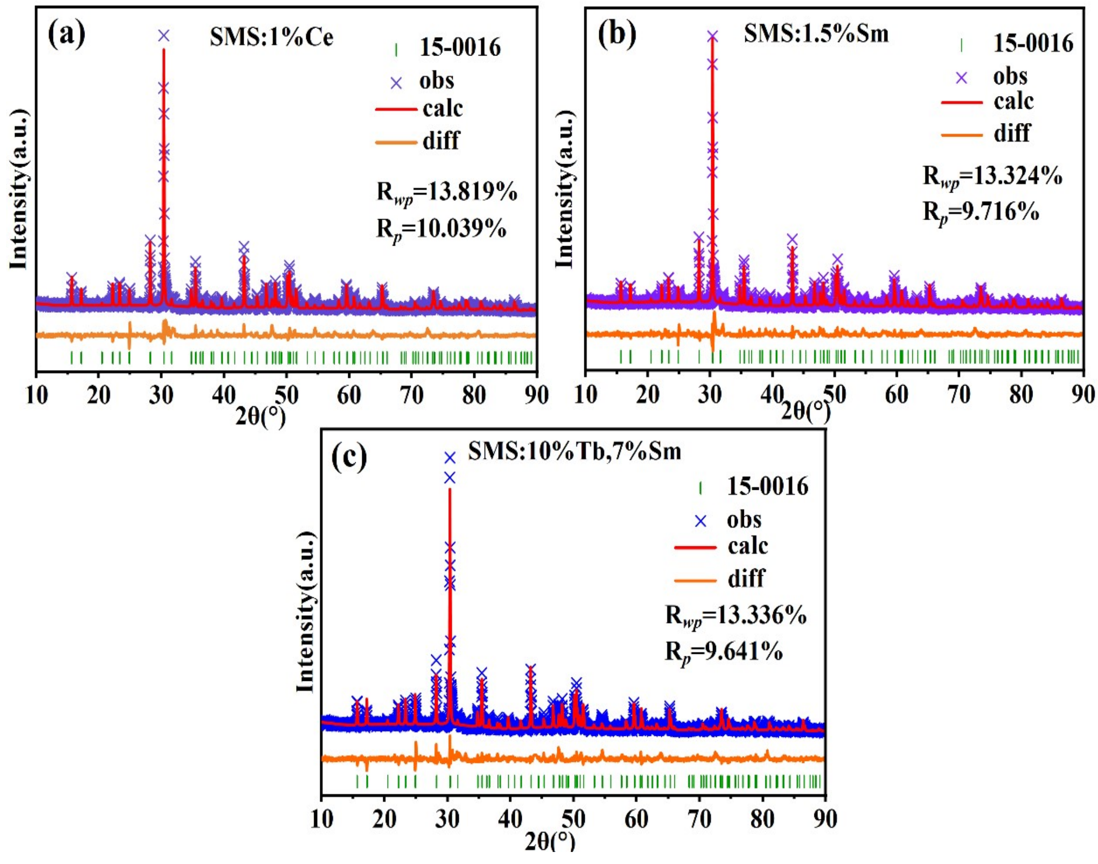


Fig.S1 Rietveld refinement of the powder XRD profiles for the representative samples SMS: 1%Ce a), SMS: 1.5%Sm b) and SMS: 10%Tb, 7%Sm c). The experimental data, calculated data and the corresponding difference profiles were also shown.

Table S2 Lattice parameters and atom positions of the $Sr_2MgSi_2O_7$: 1%Ce^{3+}, 13%Tb^{3+}, 1.5%Sm^{3+} sample

Atom	*x*	*y*	*z*	frac	U_{iso}
Sr	0.33410	0.16590	0.50740	0.78745	0.00988
Ce	0.33580	0.16413	0.50469	0.00810	0.00979
Tb	0.33232	0.16768	0.50376	0.12040	0.00982
Sm	0.34371	0.16624	0.50435	0.01320	0.00985
Mg	0.00000	0.00000	0.00000	1.00000	0.00633
Si	0.13530	0.37460	0.94580	1.00000	0.00684
O1	0.50000	0.00000	0.15800	1.00000	0.01267
O2	0.13840	0.36160	0.25060	1.00000	0.01267
O3	0.07880	0.19470	0.81110	1.00000	0.01267

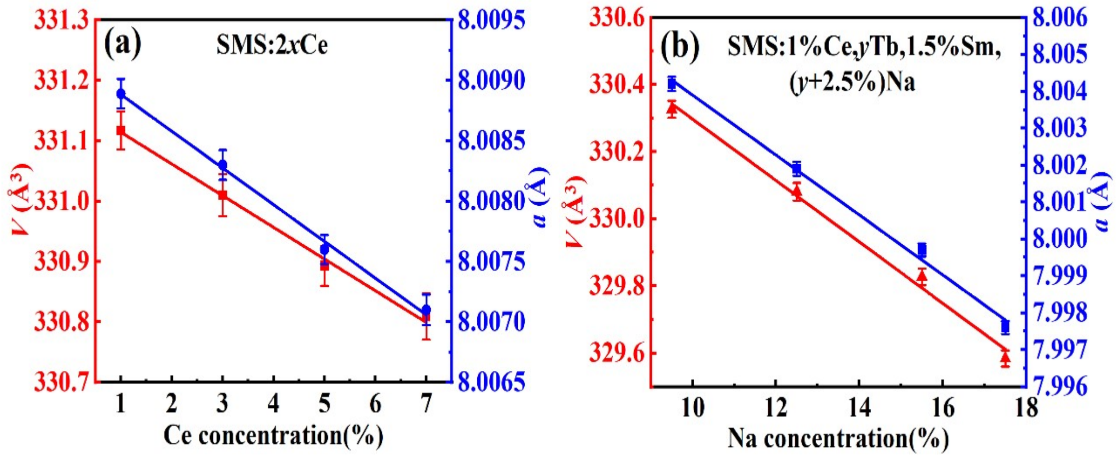


Fig.S2 The variations of the lattice parameters *a* and *V* as a function of Ce content a) and Tb/Na contents b), respectively.

Table S3 The weight and atomic percent of each atom in $Sr_2MgSi_2O_7$: 1%Ce^{3+}, 13%Tb^{3+},1.5%Sm^{3+} sample

Atom	Weight (%)	Atomic (%)
Sr	42.72	15.375
Mg	6.42	8.33
Si	14.84	16.67
O	29.59	58.34
Ce	0.37	0.08
Tb	5.46	1.08
Sm	0.6	0.125

Total	100	100

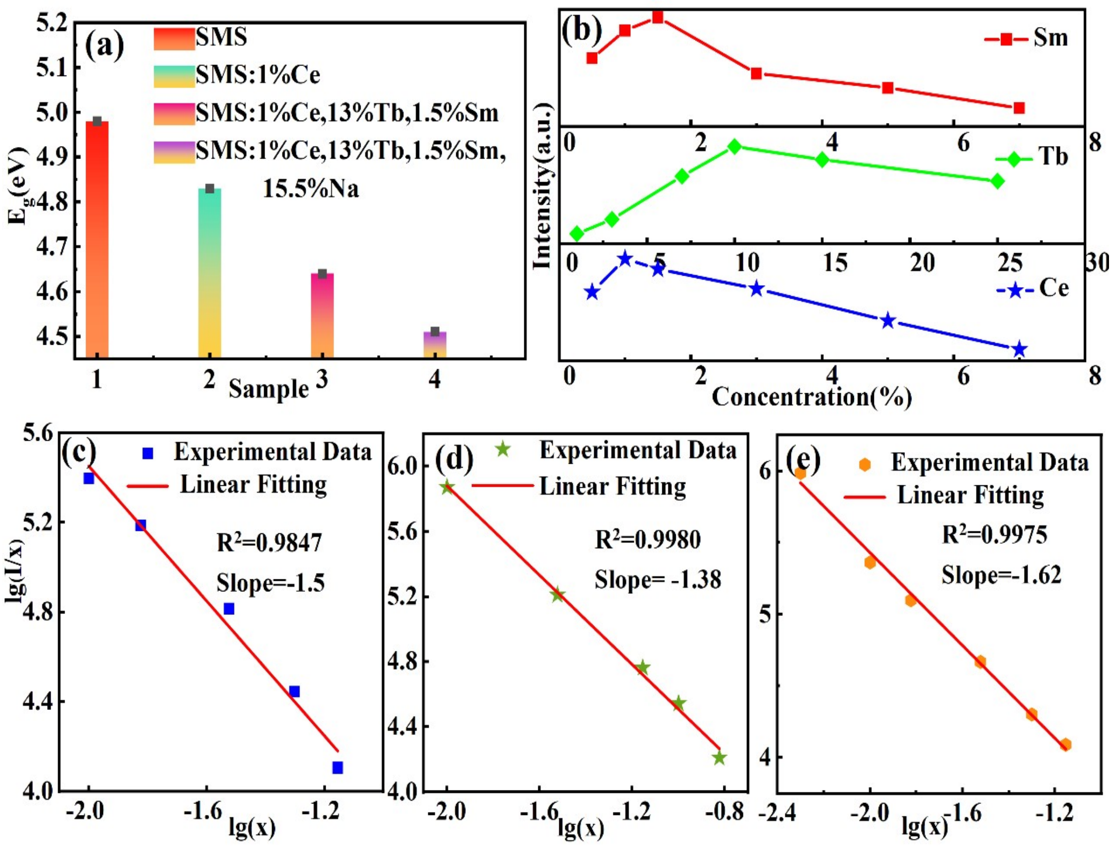


Fig.S3 a) The variation of the E_g values without and with different content of dopants for the SMS host. b) The variation of the PL intensity as a function of the doping concentration for the Ce, Tb and Sm singly doped samples, respectively. The fitting lines of the lg(I/x) *vs.* lg(x) in the phosphors of SMS: $2xCe^{3+}$ c), SMS: $2yTb^{3+}$ d) and SMS: $2zSm^{3+}$ e), respectively.

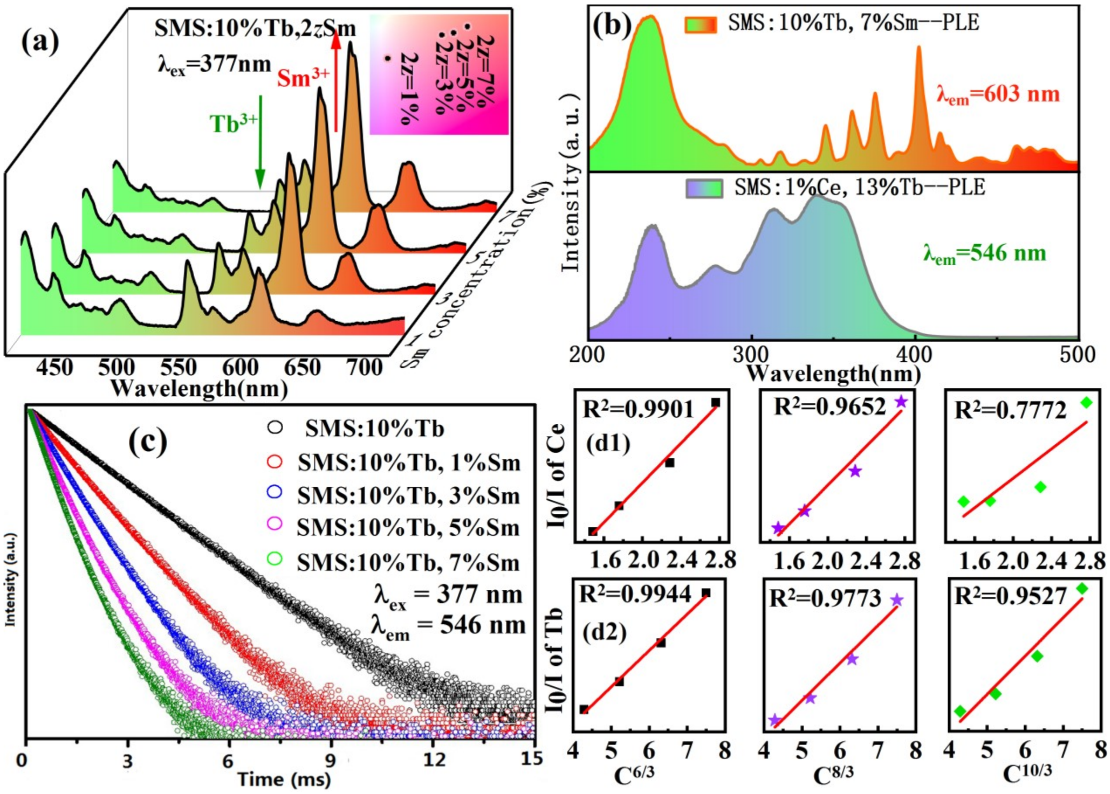


Fig.S4 a) The variations of the PL intensities for the Tb and Sm in the codoped phosphors SMS: 10%Tb, 2*z*Sm under λ_{ex} = 377 nm. The inset shows the CIE coordinates of the phosphors. b) The PLE spectra of the codoped phosphors SMS: 1%Ce, 13%Tb and SMS: 10%Tb, 7%Sm, respectively under monitored at 546 nm and 603 nm. c) The decay curves of Tb^{3+} PL in SMS: 10%Tb, 2*z*Sm phosphors under under λ_{ex} = 377 nm and λ_{em} = 546 nm. The fitting lines of the I_0/I *vs.* $C^{\theta/3}$ (θ = 6, 8, and 10) in the phosphors of SMS: 1%Ce, 2*y*Tb d1) and SMS: 10%Tb, 2*z*Sm d2), respectively.

Table S4 The average lifetimes of Ce/Tb ions and ET efficiencies in phosphors SMS: 1%Ce, 2*y*Tb and SMS: 10%Tb, 2zSm

Phosphor	0	5	7	10	13
1%Ce, 2*y*Tb	49.32 ns	33.02 ns	27.91 ns	21.49 ns	17.76 ns
η	-	33.05%	43.41%	56.43%	64%
Phosphor	0	1	3	5	7
10%Tb, 2zSm	1.81 ms	0.35 ms	0.27 ms	0.23 ms	0.19 ms
η	-	80.73%	85.07%	87.53%	89.5%

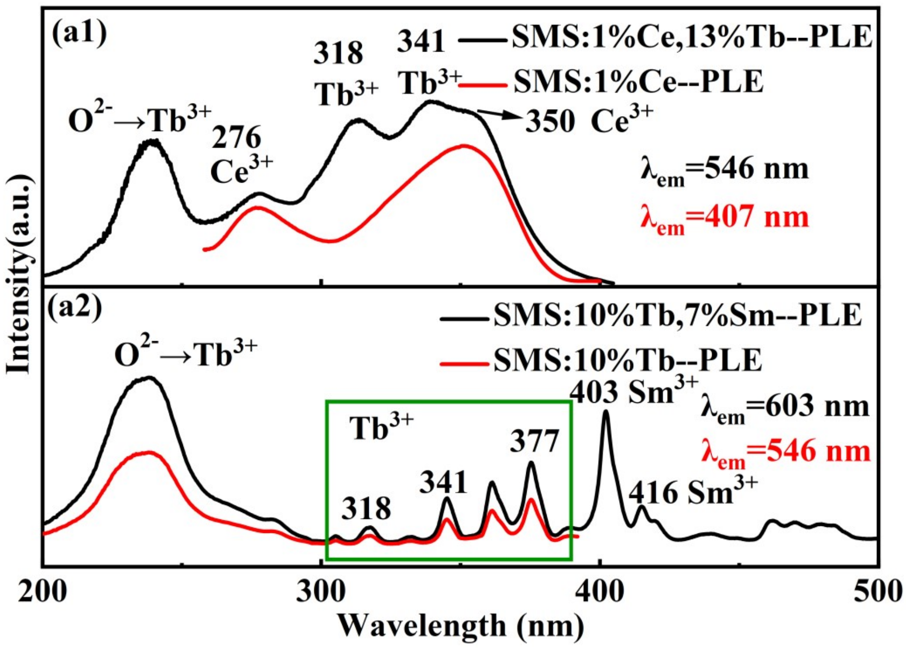


Fig.S5 The comparisons of the PLE spectra for the phosphors SMS: Ce (SMS: Tb) and SMS: Ce/Tb (SMS: Tb/Sm) monitored at the values of PL of Ce (Tb) and PL of Tb (Sm), respectively, in the a1 and a2.

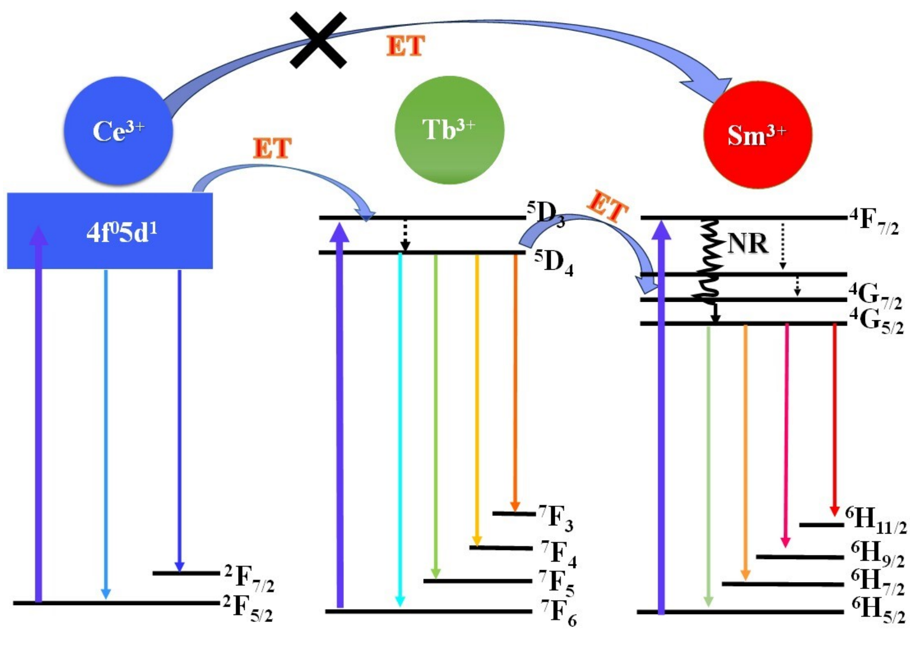


Fig.S6 ET processes, partial energy levels and visible emission transitions among the Ce/Tb/Sm ions in SMS host.

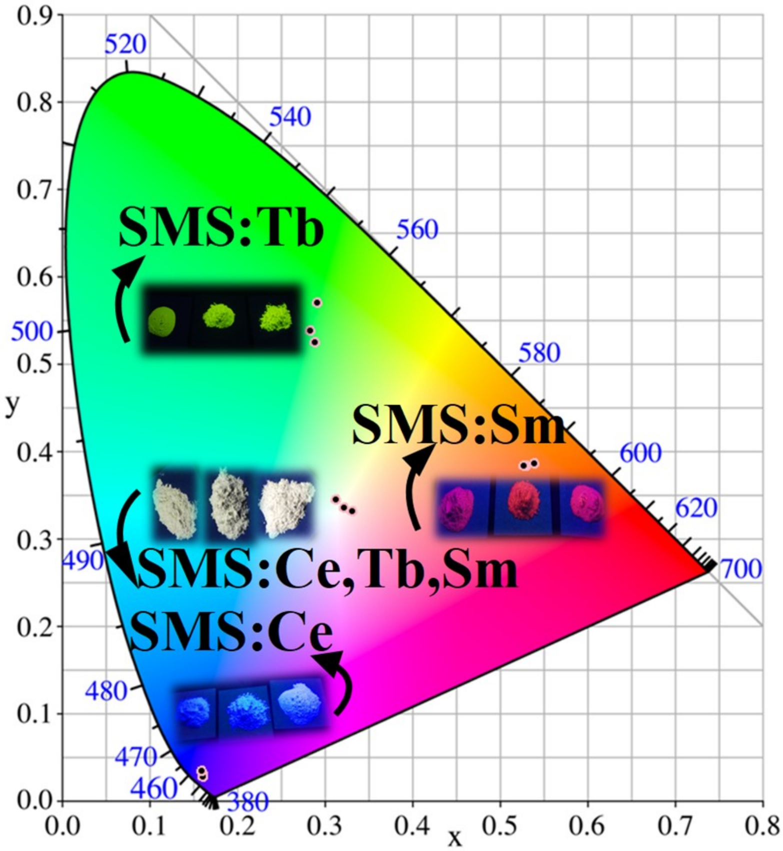


Fig.S7 CIE chromaticity diagram and digital photographs of the singly- and tri-doped SMS: Ce/Tb/Sm phosphors.

Table S5 CIE coordinates and CCT of $Sr_2MgSi_2O_7$: $x Ce^{3+}$, $y Tb^{3+}$, $z Sm^{3+}$, $(x + y + z)$ Na^+, $2a Ba^{2+}$ phosphors

Samples[a]	CIE(x , y)	Peak	CCT/K
x = 0.5%	(0.1604, 0.0315)	406 nm (Ce^{3+})	1736.725
x = 1%	(0.1598, 0.0285)	407 nm (Ce^{3+})	1745.604
x = 3%	(0.1584, 0.0346)	408 nm (Ce^{3+})	1722.446
y = 7%	(0.2886, 0.5252)	546 nm (Tb^{3+})	6451.44
y = 10%	(0.2829, 0.539)	546 nm (Tb^{3+})	6538.854
y = 13%	(0.2906, 0.5703)	546 nm (Tb^{3+})	6295.343
z=0.5%	(0.5381, 0.3683)	603 nm (Sm^{3+})	1729.224
z=1%	(0.5293, 0.3842)	603 nm (Sm^{3+})	1822.758
z=1.5%	(0.5391, 0.3881)	603 nm (Sm^{3+})	1795.578
x = 1%, y = 13%, z = 1.5%	(0.3312, 0.3226)	407 nm (Ce^{3+}),546 nm (Tb^{3+}),603 nm (Sm^{3+})	5554.556
x = 1%, y = 13%, z = 1.5% $(x + y + z)$ = 15.5%	(0.3124, 0.3458)	407 nm (Ce^{3+}),546 nm (Tb^{3+}),603 nm (Sm^{3+})	6409.623
x = 1%, y = 13%, z = 1.5% $(x + y + z)$ = 15.5%, $2a$ =10%	(0.3217, 0.3361)	407 nm (Ce^{3+}),546 nm (Tb^{3+}),603 nm (Sm^{3+})	6001.544

[a] *x, y, z, a* and $(x + y + z)$ represent the doping concentrations of Ce, Tb, Sm, Ba and Na in $Sr_2MgSi_2O_7$ phosphor, respectively.

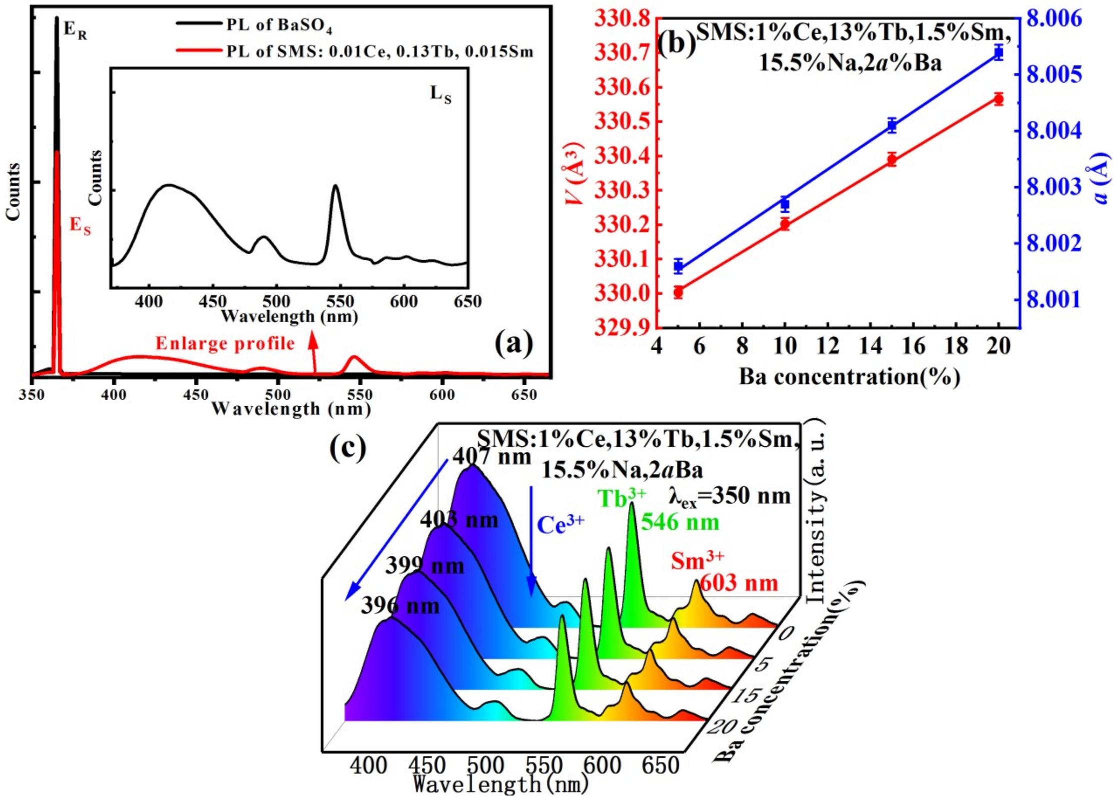


Fig.S8 a) Excitation line of $BaSO_4$ and the PL of the SMS: 1%Ce, 13%Tb, 1.5%Sm phosphor collected *via* the integrating sphere. The inset shows a magnification of the PL spectrum. b) The variation of the lattice parameters *a* and *V* as a function of Ba content in the phosphor SMS: 1%Ce, 13%Tb, 1.5%Sm, 15.5%Na.c) The variation of PL spectra from Ce as a function of Ba content in the same phosphor.