Supporting Information

$Lu_2CaMg_2(Si_{1-x}Ge_x)_3O_{12}$: Ce^{3+} Solid-solution Phosphors: Bandgap Engineering for Blue-light Activated Afterglow Applicable to AC-LED

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Table S1. Refinement results of interatomic distances in $Lu_{1.99}CaMg_2Si_{1.5}Ge_{1.5}O_{12}$ solid-solution phosphors.

Bonds	Distance (nm)	Bonds	Distance (nm)
$Lu_1(Ca_1)$-O_1	0.2514	Mg_1-O_1	0.1979
$Lu_1(Ca_1)$-O_2	0.2387	$Si_1(Ge_1)$-O_1	0.1695

Table S2. Estimated thermal quenching parameters of Ce^{3+}-doped LCMSGO solid-solution phosphors.

Sample	$T_{0.5}$ (K)	E_q (eV)
Si:Ge=2:1	360	0.207
Si:Ge=1:1	320	0.188
Si:Ge=1:2	290	0.158
LCMGO	240	0.149

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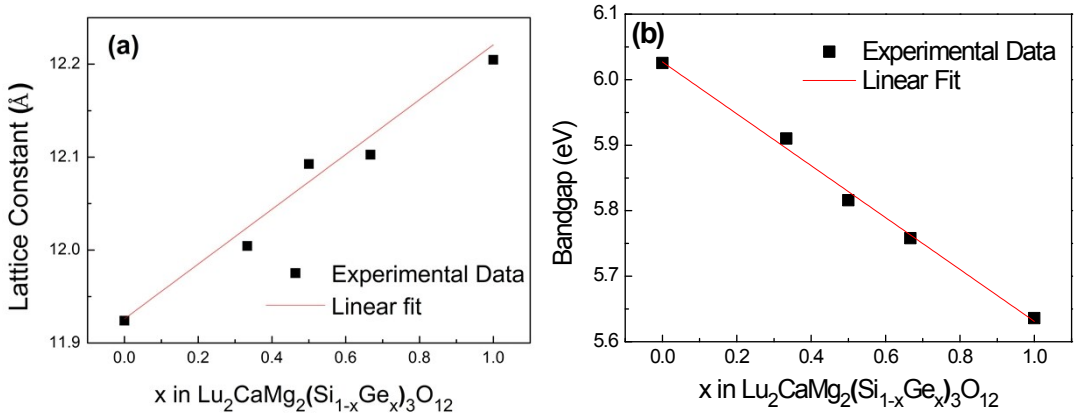

Figure S1. Dependence of the (a) lattice constant and (b) bandgap on x of the compounds $Lu_2CaMg_2(Si_{1-x}Ge_x)_3O_{12}$.

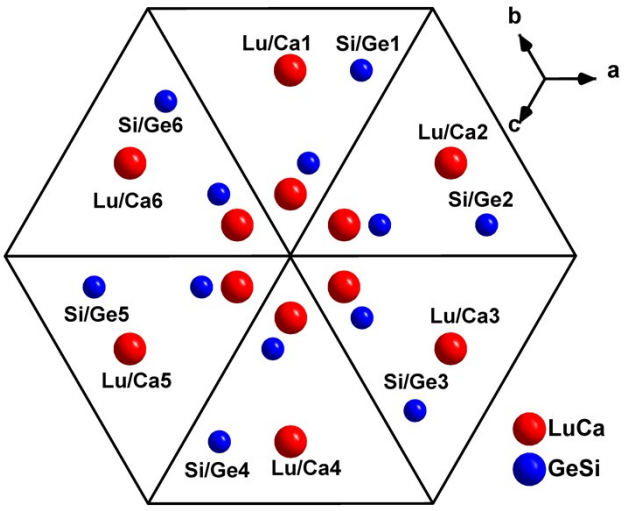

Figure S2. Schematic illustration of the method dealing with the Lu/Ca and Ge/Si cation disorders in DFT calculation. In order to remain the symmetry to the most extent, the Si/Ge1, Si/Ge3, and Si/Ge5 sites were set to be occupied by Si, while the Si/Ge2, Si/Ge4, and Si/Ge6 sites by Ge; likewise, the Ca/Lu1 and Ca/Lu4 sites were set to be occupied by Ca, while the Ca/Lu2, Ca/Lu3, Ca/Lu5, and Ca/Lu6 sites by Lu.

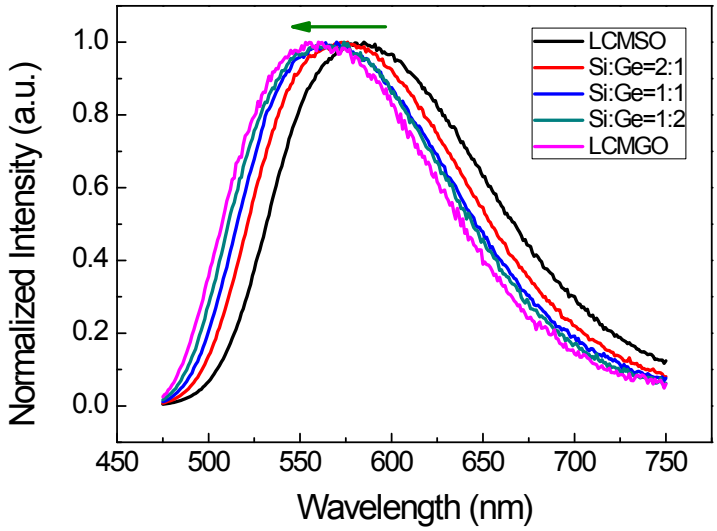

Figure S3. Normalized emission spectra of the $Lu_2CaMg_2(Si_{1-x}Ge_x)_3O_{12}$:0.01$Ce^{3+}$ (x=0-1) samples with various Si:Ge ratio upon 460 nm excitation.

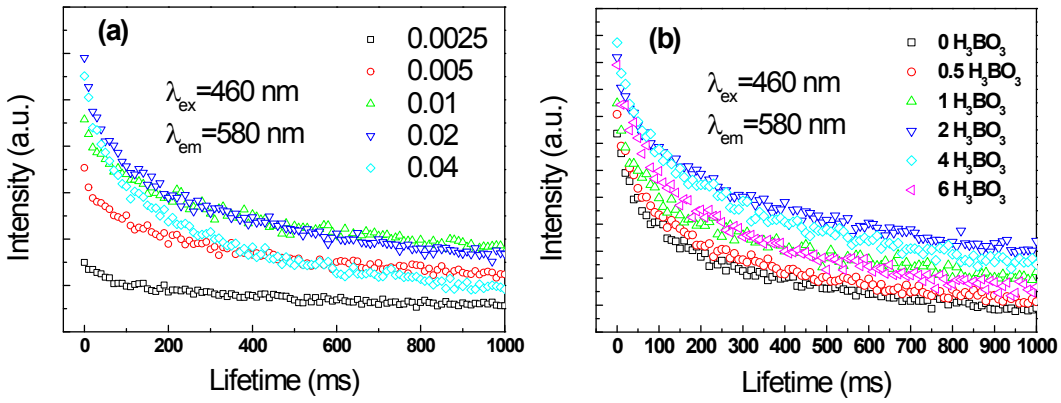

Figure S4. PersL decay curves for (a) the $Lu_2CaMg_2(Si_{1-x}Ge_x)_3O_{12}$:x$Ce^{3+}$ phosphors (x=0.005-0.04) and (b) the $Lu_2CaMg_2Si_{1.5}Ge_{1.5}O_{12}$:0.01$Ce^{3+}$ phosphors with various the H_3BO_3 amount (0-6 wt%).

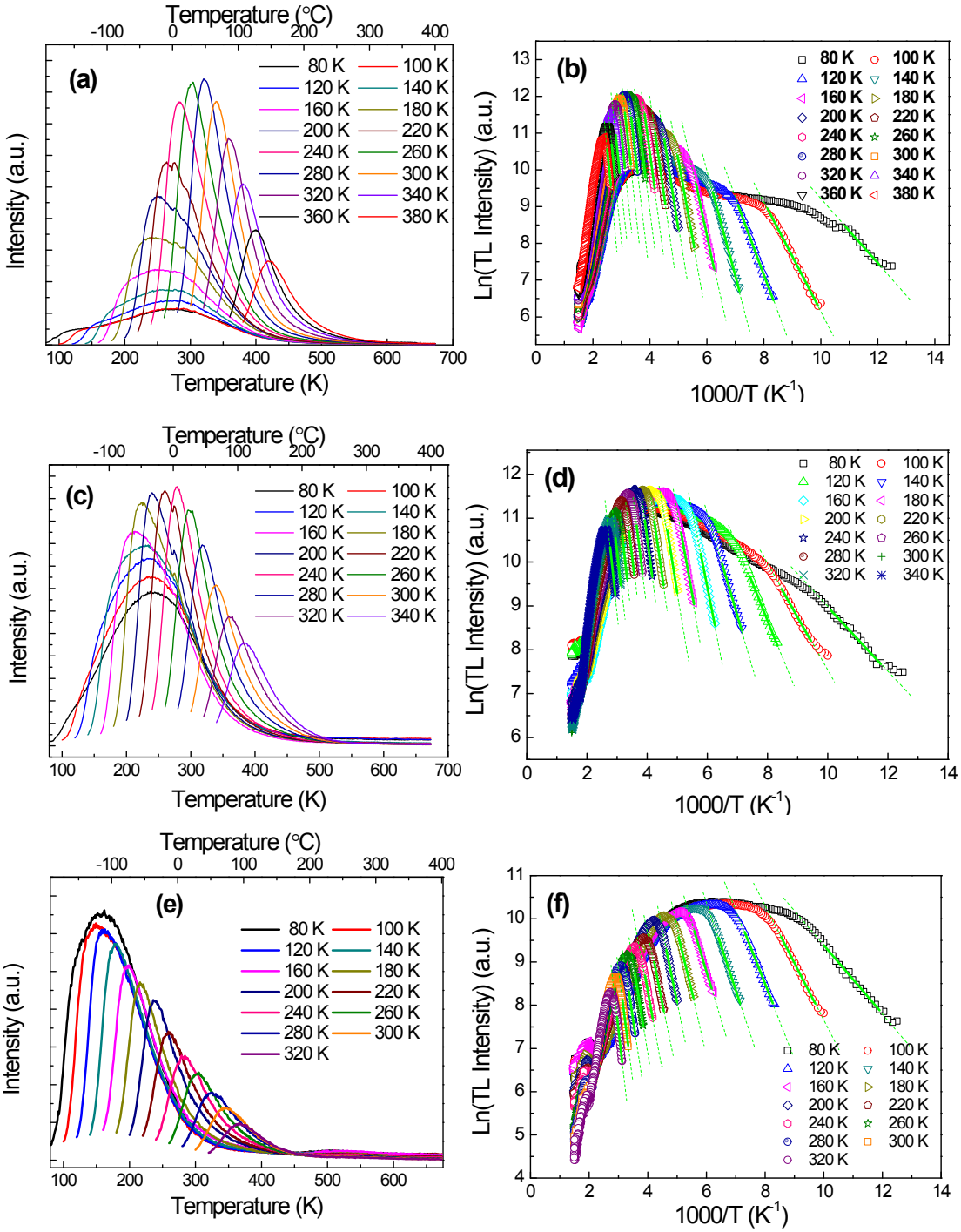

Figure S5. TL curves by pre-heating/cooling the (a) Si:Ge=1:1, (c) Si:Ge=1:2, and (e) LCMGO samples at different T_{exc} (excitation wavelength: 460 nm, heating rate: 1K/s). Corresponding initial rise analyses on the TL curves of (b) Si:Ge=1:1, (d) Si:Ge=1:2, and (f) LCMGO samples as a function of T_{exc}.

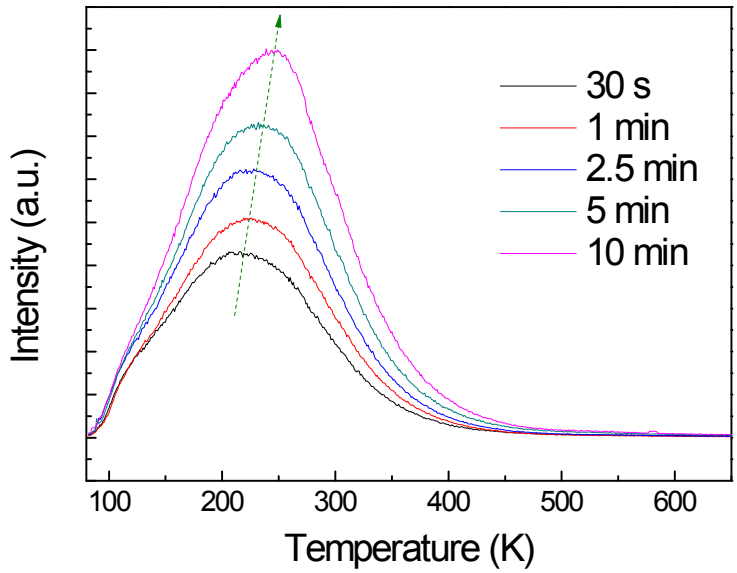

Figure S6. Excitation time dependent TL glow curves of the $Lu_2CaMg_2Si_1Ge_2O_{12}$:0.01Ce^{3+} at a heating rate of 1 K/s (λ_{ex}=460 nm, λ_{em}=580 nm).