SUPPORTING INFORMATION

Two-Step Design of a Single-Doped White Phosphor with High Color Rendering

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Materials and Methods:

Synthesis. The phosphors were prepared by sol-gel method. Eu_2O_3 was dissolved in HNO_3 to obtain $Eu(NO_3)_3$. Then, stoichiometric amounts of $Eu(NO_3)_3$, $NaNO_3$, $Ca(NO_3)_2$, $Mg(NO_3)_2$ and $Sc(NO_3)_3$ were dissolved in ethanol. Stoichiometric amount of $Si(OC_2H_5)_4$ was added and the mixtures were stirred at 80°C for 30 min. The gels were dried at 120°C for 12h, ground, heated at 800°C for 20h in air, ground and sintered at 1200°C for 5h under forming gas. Then, the samples were cooled down from 1200°C to room temperature during 12h.

Controlled Reduction of Dopants. The controlled reduction of the dopants was carried out from 600°C to 900°C using Titanium as oxygen getter. In a glove box, a silica tube was filled with a crucible in stumatite containing 500 mg of Ti in one compartment and 40 mg of powder to be reduced in the others. The samples were placed under a temperature gradient in order to find the temperature range for which the oxidation states of the dopants could be finely controlled. The reductions were carrying out for one hour (vacuum maintained by pumping).

Characterization. Quantum efficiency was measured using the integrating sphere on a FLS920 fluorescence spectrophotometer (Edinburgh Instruments Ltd., U.K.). The temperature dependent photoluminescent measurements were carried out in a Labram HR-800 (Horiba Jobin-Yvon) equipped with a HFS600E-P probe stage from Linkam. The excitation at 325nm is provided by a He-Cd laser from Kimmon.

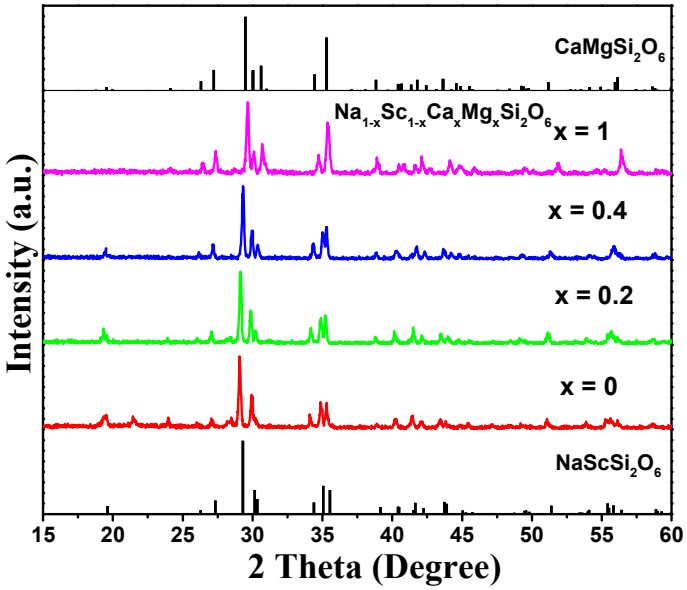

Figure S1. XRD patterns of $(Na_{1-x}Sc_{1-x})(Ca_xMg_x)Si_2O_6:0.03Eu^{2+}$ phosphors with different x values (x = 0, 0.2, 0.4 and 1)

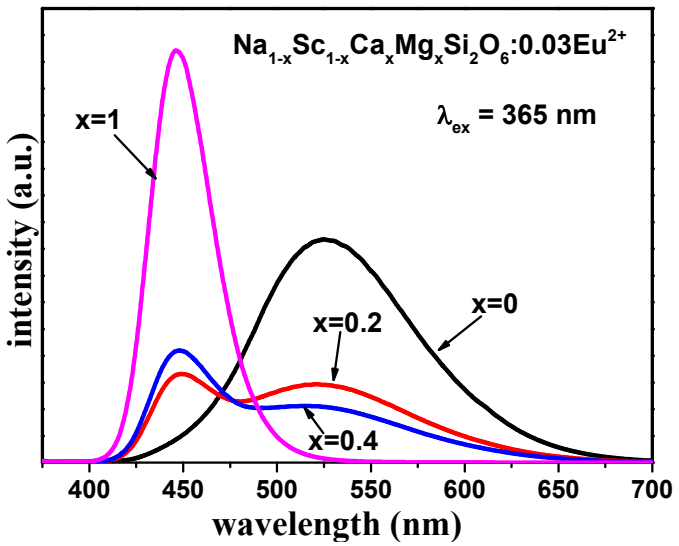

Figure S2. PL spectra (λ_{ex} = 365 nm) of $(Na_{1-x}Sc_{1-x})(Ca_xMg_x)Si_2O_6:0.03Eu^{2+}$ phosphors with different x values (x = 0, 0.2, 0.4 and 1)

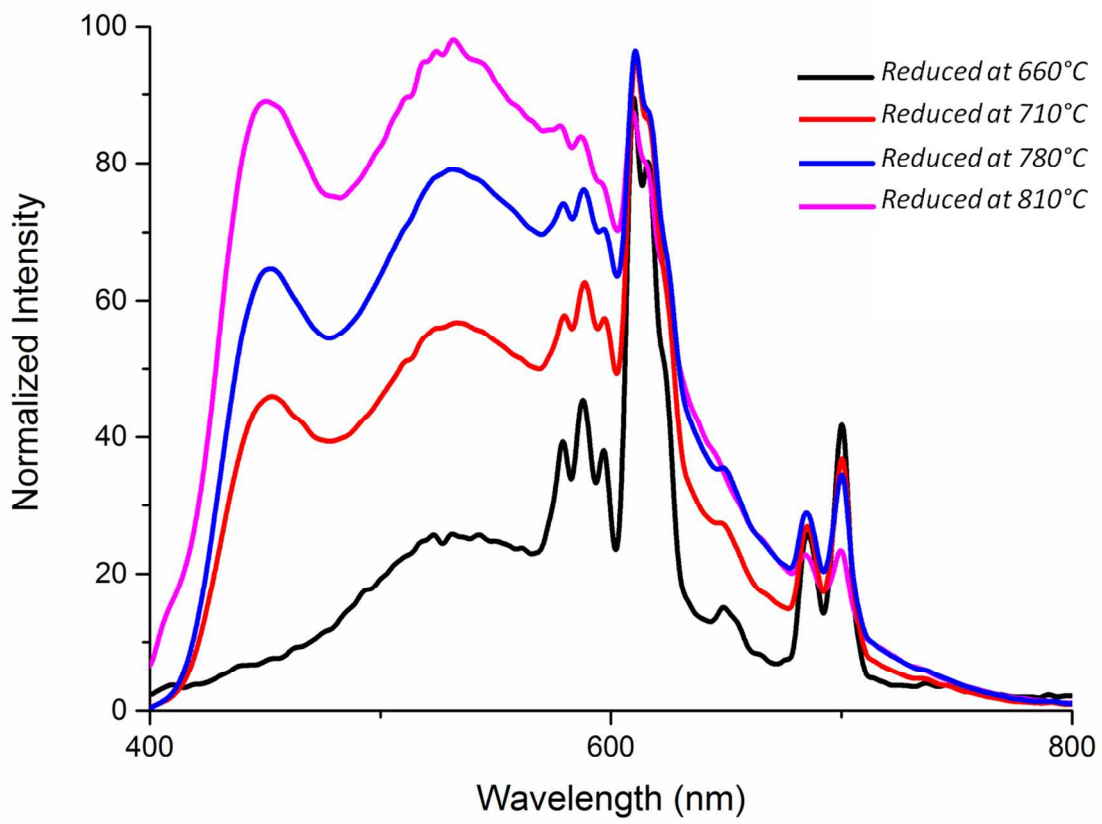

Figure S3. PL spectra (λ_{ex} = 365 nm) of $(Na_{1-x}Sc_{1-x})(Ca_xMg_x)Si_2O_6$:0.03Eu phosphor for x= 0.2 with different ratio Eu^{3+}/Eu^{2+}.

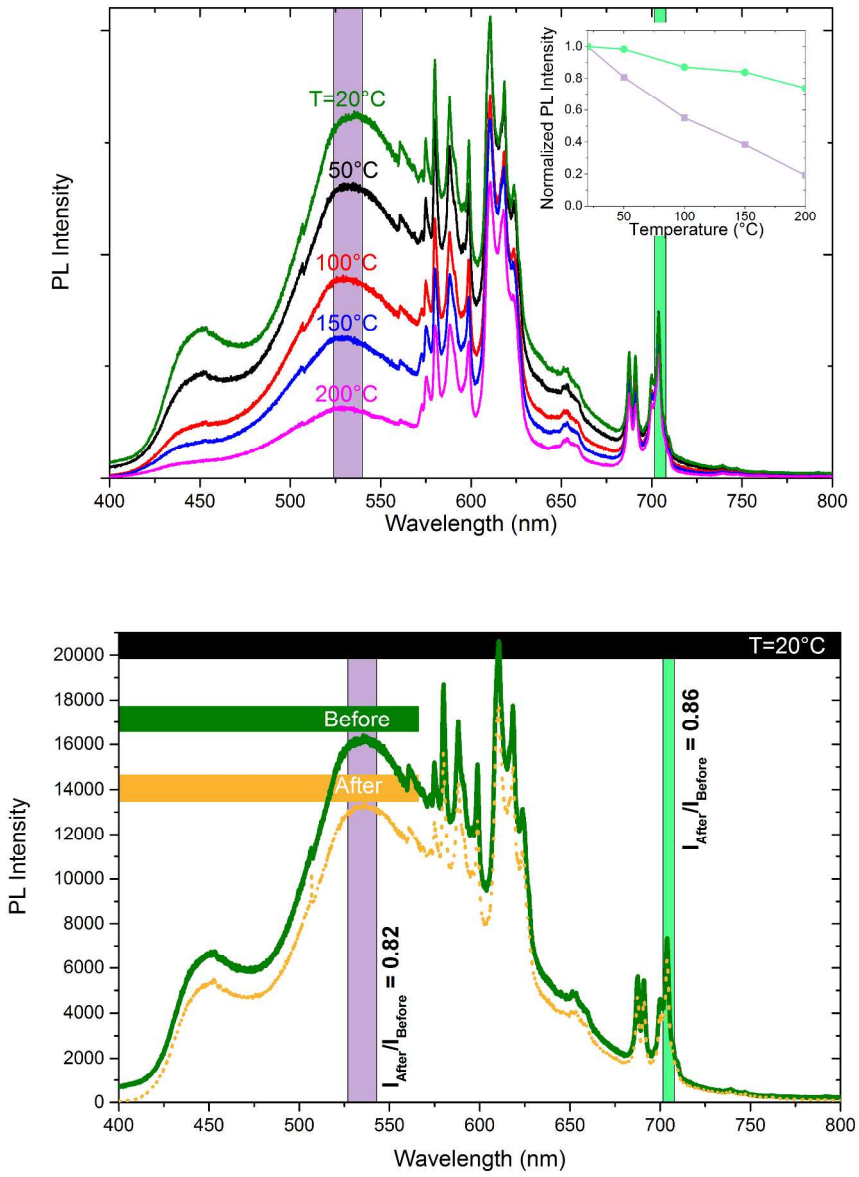

Figure S4. (Top) PL spectra (λ_{ex} = 325 nm) vs. Temperature for the white phosphor $Na_4CaMgSc_4Si_{10}O_{30}$:Eu and (Bottom) PL spectra (λ_{ex} = 325 nm) before and after heating at 200° C. The ratio I_{After}/I_{Before} of the emission bands corresponding to Eu^{3+} and Eu^{2+} remains similar.