## **Electronic Supplementary Information**

## Tuning luminescence thermal quenching performance of $K_xMg_xSc_{1.95-}$ <sub>x</sub>Mo<sub>3</sub>O<sub>12</sub>:5%Eu<sup>3+</sup> phosphor via synergistic negative thermal expansion and

## charge compensation effects

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Fig. S1. (a) XPS survey spectrum and detailed XPS spectra of (b) K 2p, (c) Mg 1s, (d) Sc 2p, (e) Mo 4d, and (f) Eu 3d of the KSME4 phosphor.



Fig. S2. Temperature-dependent SXRD diffraction patterns of the (a) KMSE7 and (b) KMSE10 phosphors.



Fig. S3. Variation of the unit cell parameters *a*, *b* and *c* of the (a) KMSE7 and (b) KMSE10 phosphors.



Fig. S4. Temperature-dependent Raman spectra of KMSE4.



**Fig. S5.** The KMSE7 control sample: (a) Temperature-dependent PLE spectra. (b) Normalized PLE integral intensity of (a) at 395, 465 and 536 nm. The KMSE10 control sample: (c) Temperature-dependent PLE spectra. (d) Normalized PLE integral intensity of (c) at 395, 465 and 536 nm.



**Fig. S6.** (a) Temperature-dependent SXRD diffraction patterns of the SMOE phosphor from 300 to 700K. (b) Rietveld refinement results of the SXRD pattern of the SMOE sample at 300K. Variation of unit cell parameters of (c) a, b and c and (d) V of the SMOE phosphor with temperature in the range of 300 to 700K.



**Fig. S7.** The SMOE control sample: (a) Temperature-dependent PLE spectra. (b) Normalized PLE integral intensity of (a) at 395, 465 and 536 nm. (c) Temperature-dependent PL spectra. (d) Normalized PL integral intensity of (c) at 593, 613, 652 and 705 nm.



Fig. S8. Temperature-dependent PL spectra of the (a) KMSE7, and (c) KMSE10 samples at  $\lambda_{ex} = 277$  nm. The normalized integral emission intensity of the (b) KMSE7, and (d) KMSE10 samples with the four peaks at 593, 613, 652, and 705 nm as a function of temperature.



**Fig. S9.** The ratio of the integral intensities of the red (600 - 630 nm) and orange (575 - 600 nm) PL emission of the series of KSME and SOME samples.



Fig. S10. Variation of lifetime with temperature for the KMSE4, KMSE7, and KMSE10 samples.



Fig. S11. (a) Temperature-dependent lifetime decay curves of the SMOE sample. (b) The relevant variation of decay time with temperature.



Fig. S12. Variation curves of  $[hvF(A)]^2$  with hv for the (a) KSME4, (b) KSME7, (c) KSME10, and (d) SMOE phosphors.



Fig. S13. CIE coordinate diagrams for the (a) KSME4, (b) KSME7, (c) KSME10, and (d) SMOE phosphors.