

Supporting information

Color manipulation from Bi³⁺-activated CaZnOS under stress with ultra-high efficiency and low threshold for multiple anticounterfeiting

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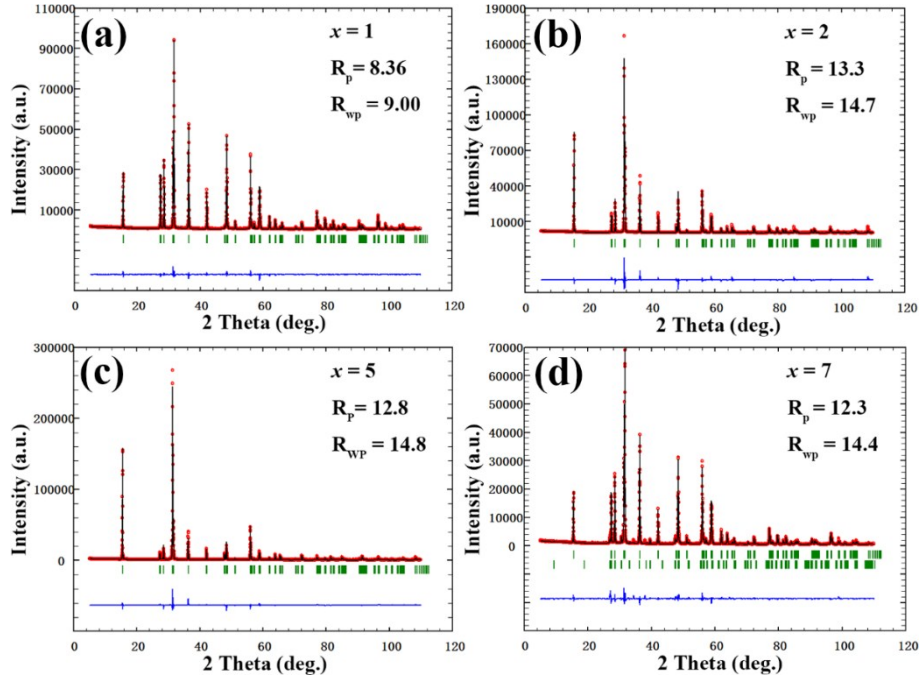


Figure S1. Rietveld refinement of CaZnOS: x % Bi^{3+} , x % Li^{+} (a) $x = 1$, (b) $x = 2$, (c) $x = 5$ and (d) $x = 7$.

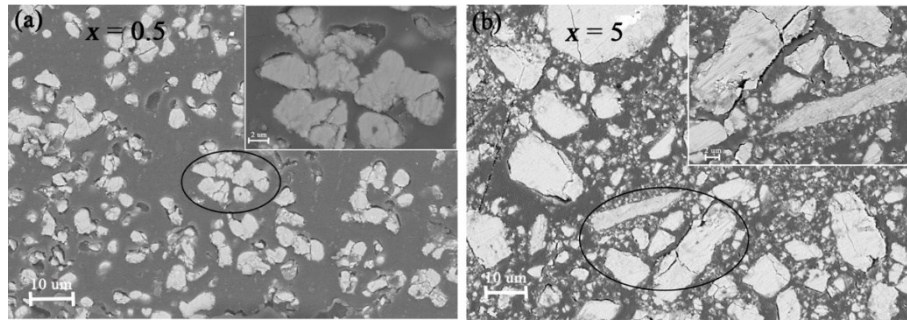


Figure S2. The cross-section SEM of (a) CaZnOS: 0.5 % Bi^{3+} , 0.5 % Li^{+} and (b) CaZnOS: 5 % Bi^{3+} , 5 % Li^{+} phosphors embedded in epoxy resin.

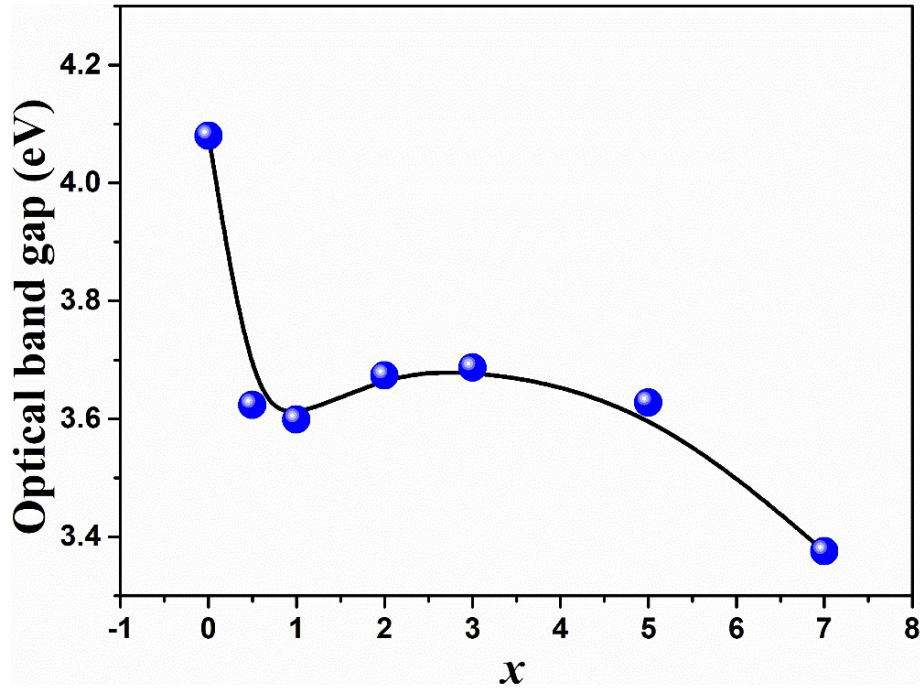


Figure S3. The optical band gaps of CaZnOS: x % Bi^{3+} , x % Li^{+} ($x = 0, 0.5, 1, 2, 3, 5, 7$)

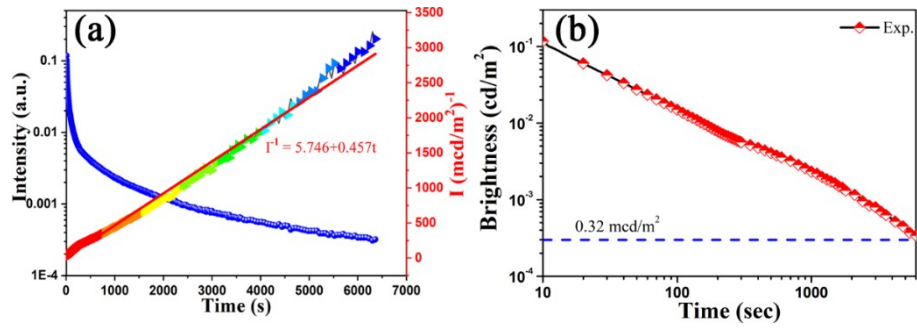


Figure S4. Persistent decay curve and the plots of inverse of long persistent luminescence versus time (a) and log(brightness)-time (b) of CaZnOS: 5 % Bi^{3+} , 5 % Li^{+} .

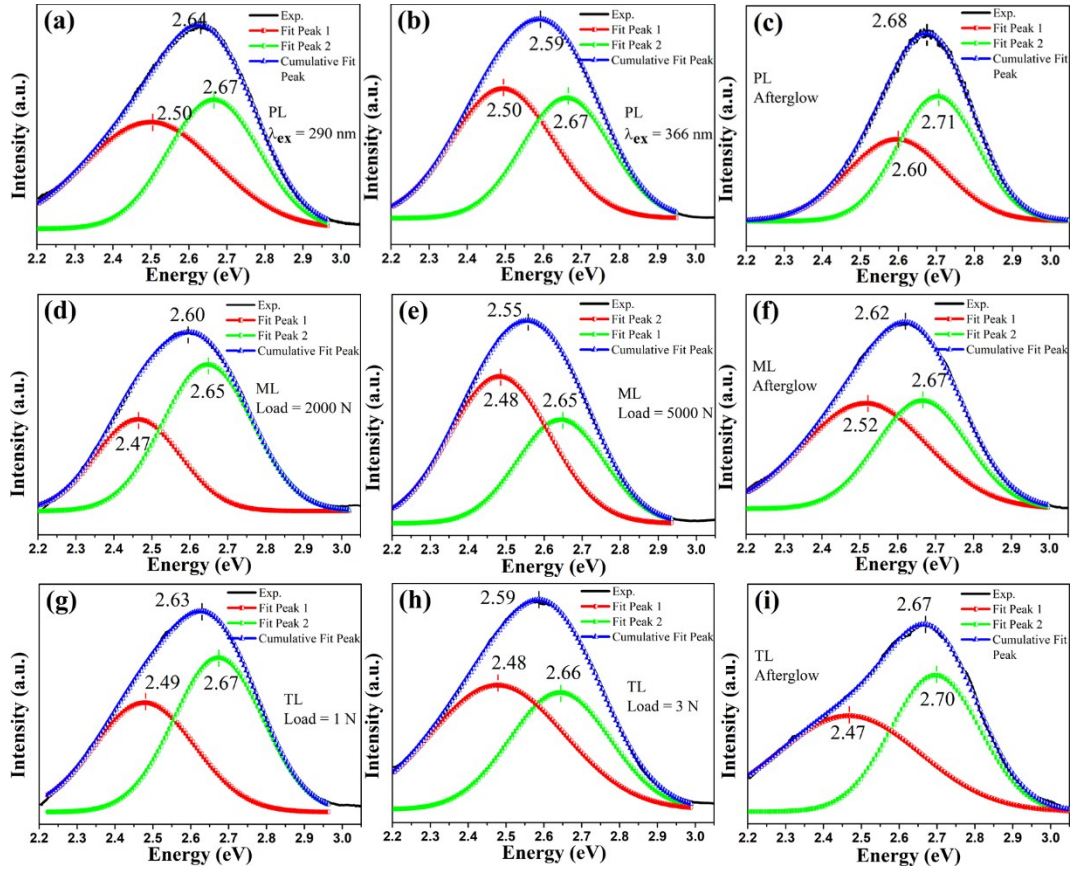


Figure S5. Deconvolution of CaZnOS: 5 % Bi³⁺, 5 % Li⁺ for PL ($\lambda_{\text{ex}} = 290$ (a), 366 nm (b) and afterglow (c)), ML (Load = 2,000 (d), 5,000 N (e) and afterglow (f)) and TL (Load = 1 (g), 3 N (h) and afterglow (i)).

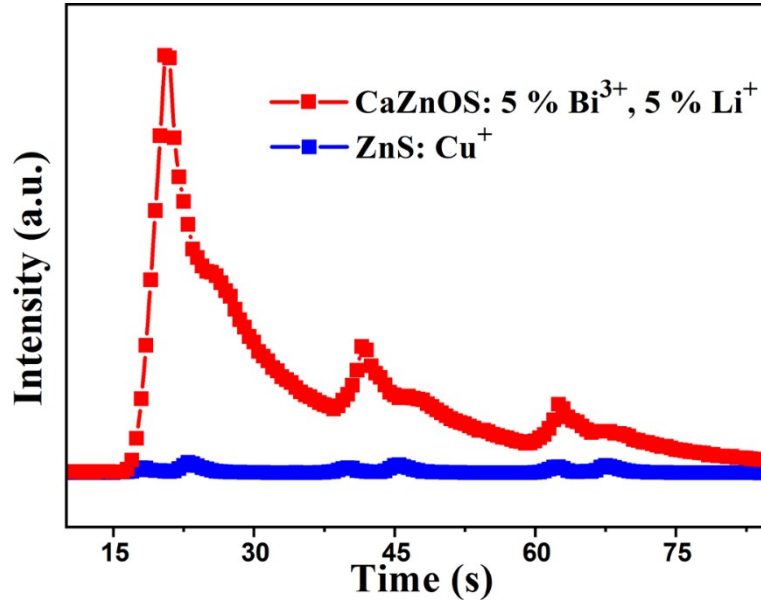


Figure S6. Comparison of ML intensities for the CaZnOS: 5 %Bi³⁺, 5 %Li⁺ and ZnS: Cu⁺ sheet for 3 times during the load range from 0 to 2,000 N.

Table S1. Lifetimes ($\lambda_{\text{ex}} = 366 \text{ nm}$, $\lambda_{\text{em}} = 485 \text{ nm}$) of CaZnOS: 5 %Bi³⁺, 5 %Li⁺ measured within 80 – 480 K

Temperature (K)	τ_1 (ns)	A ₁	τ_2 (ns)	A ₂	τ (ns)
80	53070	7600	89110	2569	66119
120	45985	9537	81.402	1133	52139
160	22053	10519	99320	20	22715
200	6762	5731	12526	4711	10241
240	261	215	1865	611	1790
280	415	154	1240	717	1184
300	467	210	916	684	855
320	225	113	761	612	733
360	99	129	590	699	576
400	143	193	390	647	365
440	64	453	209	227	154
480	13	569	80	76	44

Table S2. Calculated trap depths (E) and related frequency factor (S) of CaZnOS: 5 % Bi³⁺, 5 %

Li⁺ with wavelength at 487 nm

Peak number	$E(\text{eV})$	$S(\text{s}^{-1})$	$n_0(\text{cm}^{-3})$	b
Peak 1	0.68	9.87×10^9	4.13×10^7	2
Peak 2	0.77	10^{10}	4.66×10^7	2
Peak 3	0.91	1.01×10^{10}	2.98×10^7	2
Peak 4	1.20	1.22×10^{10}	6.24×10^6	2