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Supporting Information

Admirable Stability Achieved by ns^2 Ions Co-doping for All-inorganic Metal Halide towards Optical Anti-counterfeiting

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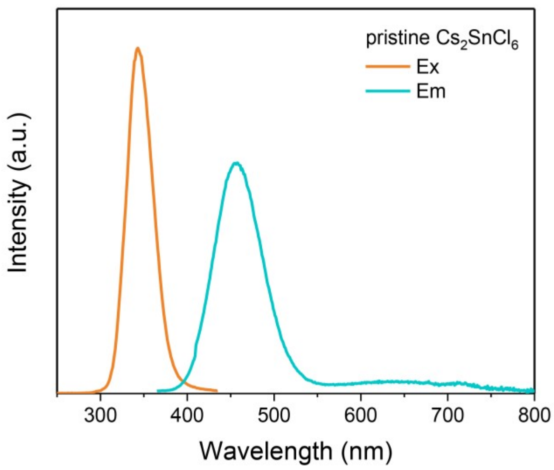

Figure S1. The PL and PLE spectra of pristine Cs_2SnCl_6.

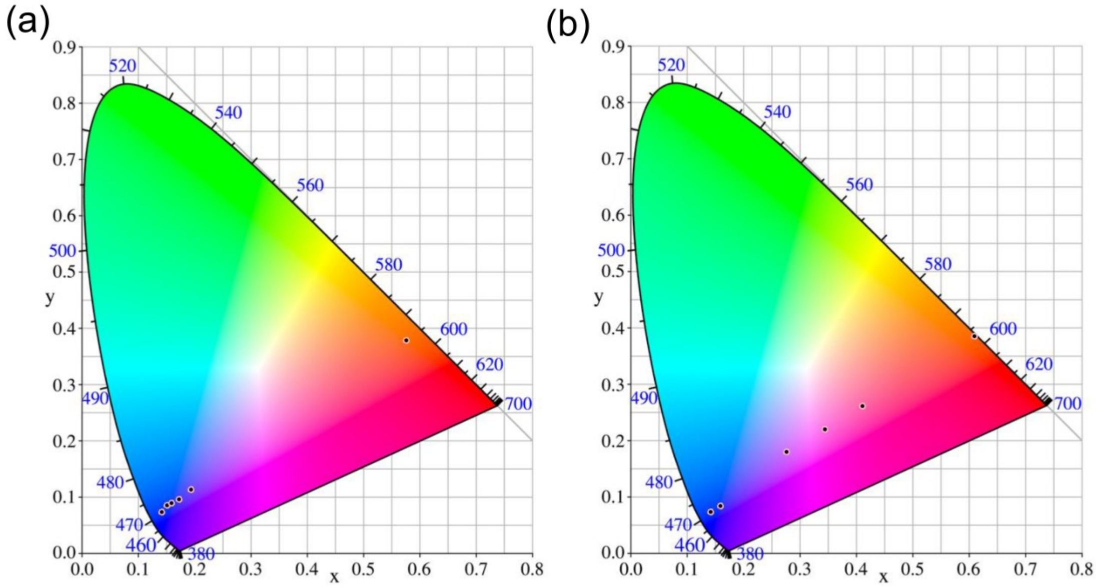

Figure S2. (a) CIE chromaticity coordinates of Cs_2SnCl_6: $Bi_{0.2-x}Sb_x$ sample excited at 365 nm. (x= 0, 0.04, 0.08, 0.12, 0.16, 0.2) (b) CIE chromaticity coordinates of Cs_2SnCl_6: $Bi_{0.2-x}Sb_x$ sample excited at 395 nm. (x= 0, 0.04, 0.08, 0.12, 0.16, 0.2)

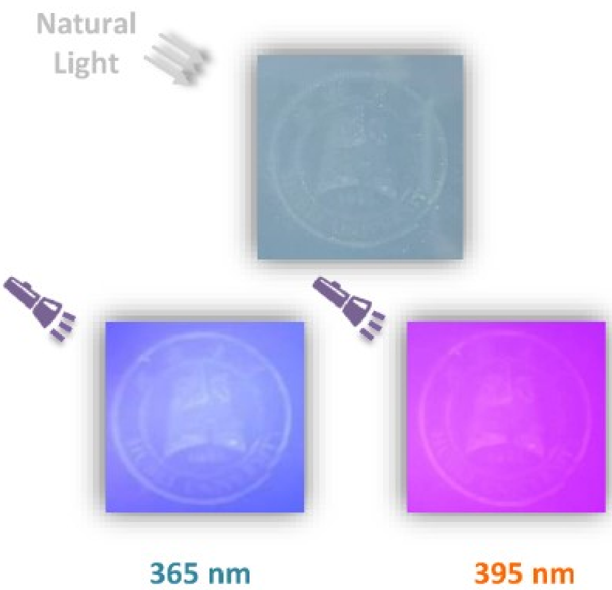

Figure S3 Photograph of pattern made by anti-counterfeiting ink composed of Cs_2SnCl_6: $Bi_{0.08}Sb_{0.12}$ at natural light and irradiated by a UV lamp at 365 nm and 395 nm

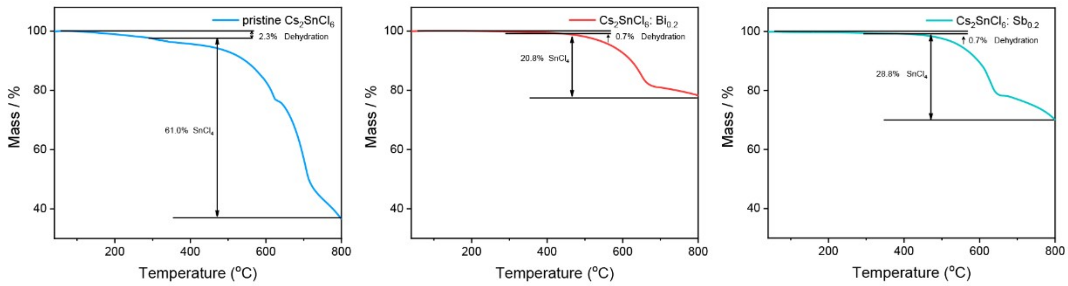

Figure S4. The thermogravimetric analysis of pristine Cs_2SnCl_6, Cs_2SnCl_6: $Bi_{0.2}$ and Cs_2SnCl_6: $Sb_{0.2}$.

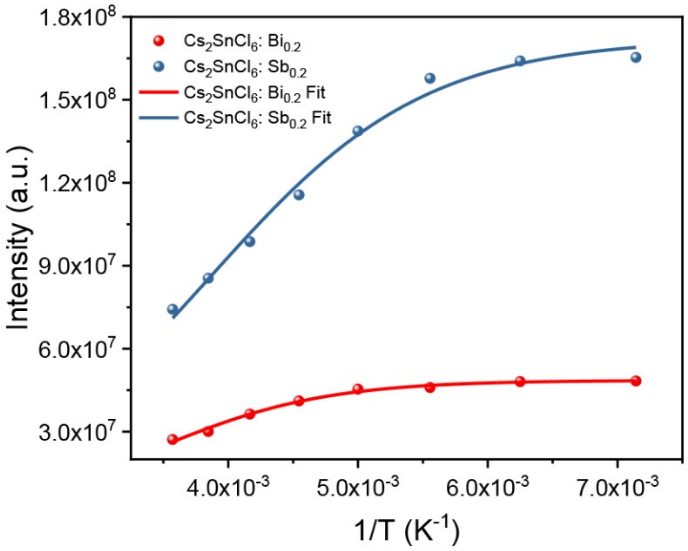

Figure S5 Integrated PL intensity as a function of temperature for Cs_2SnCl_6: $Bi_{0.2}$ and Cs_2SnCl_6: $Sb_{0.2}$ crystals crystals. The line represents fit curve of binding energies.

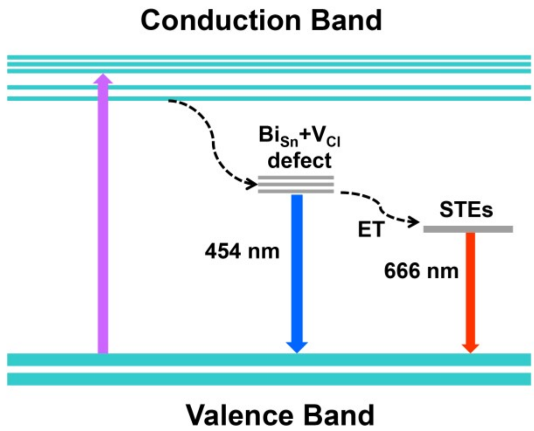

Figure S6. The schematic representation of the luminescent emission mechanism of Bi^{3+} and Sb^{3+} co-doped Cs_2SnCl_6.

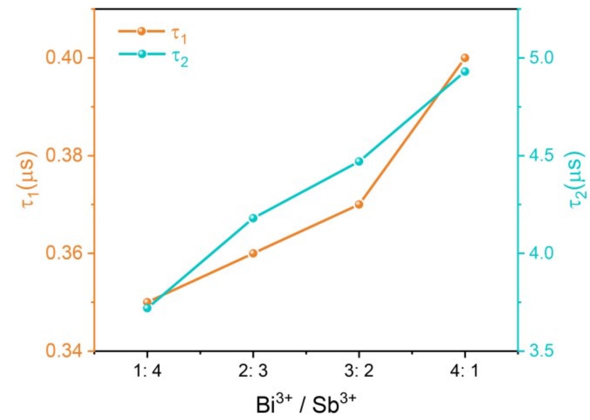

Figure S7. Broken line of photoluminescence lifetime at 666nm with different Bi^{3+}/Sb^{3+} codoping contents.

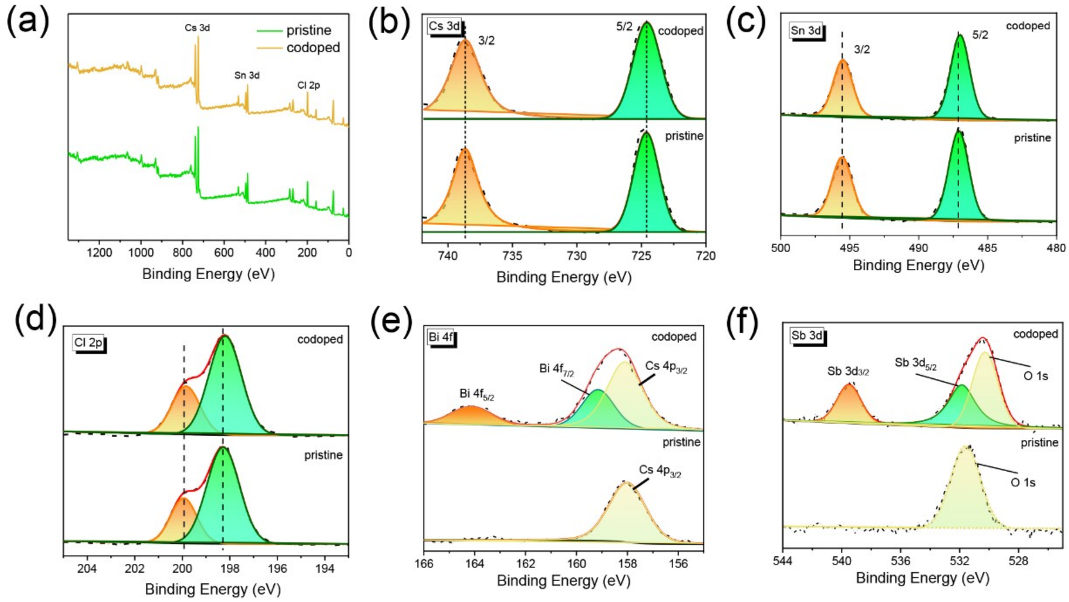

Figure S8 (a) Full range of XPS of pristine Cs_2SnCl_6 and Cs_2SnCl_6: $Bi_{0.08}Sb_{0.12}$. **(b-f)** High-resolution XPS of Cs ($3d_{3/2}$, $3d_{5/2}$), Sn ($3d_{3/2}$, $3d_{5/2}$), Cl ($2p_{1/2}$, $2p_{3/2}$), Bi ($4f_{5/2}$, $4f_{7/2}$) and Sb ($3d_{3/2}$, $3d_{5/2}$) in pristine Cs_2SnCl_6 and Cs_2SnCl_6: $Bi_{0.08}Sb_{0.12}$.

Table S1. Comparison of Bi^{3+} and Sb^{3+} concentrations obtained from ICP-MS of Cs_2SnCl_6: $Bi_{0.2-x}Sb_x$ (x= 0, 0.04, 0.08, 0.12, 0.16, 0.2). Bi% is calculated following the equation ([Bi]/[Sn])×100%. Sb% is calculated following the equation ([Sb]/[Sn])×100%.

Sample Category	Precursor		Product (ICP-MS)	
	Bi %	Sb %	Bi %	Sb %
Cs_2SnCl_6: $Bi_{0.2}$	20	0	4.55	0
Cs_2SnCl_6: $Bi_{0.16}Sb_{0.04}$	16	4	4.49	3.34
Cs_2SnCl_6: $Bi_{0.12}Sb_{0.08}$	12	8	3.82	6.31
Cs_2SnCl_6: $Bi_{0.08}Sb_{0.12}$	8	12	2.30	7.47
Cs_2SnCl_6: $Bi_{0.04}Sb_{0.12}$	4	16	1.40	14.07
Cs_2SnCl_6: $Sb_{0.2}$	0	20	0	14.89

Table S2. The lifetime (μs) of Cs_2SnCl_6: $Bi_{0.2-x}Sb_x$ (x = 0, 0.04, 0.08, 0.12, 0.16, 0.2) at 454 and 666 nm.

Emission Peak	τ(μs)	Cs_2SnCl_6: $Bi_{0.2}$	Cs_2SnCl_6: $Bi_{0.16}Sb_{0.04}$	Cs_2SnCl_6: $Bi_{0.12}Sb_{0.08}$	Cs_2SnCl_6: $Bi_{0.08}Sb_{0.12}$	Cs_2SnCl_6: $Bi_{0.04}Sb_{0.16}$	Cs_2SnCl_6: $Sb_{0.2}$
454 nm	τ	0.3819	0.3425	0.3276	0.3087	0.3064	—
666 nm	τ_1	—	0.40	0.37	0.36	0.35	0.34
	τ_2	—	4.93	4.47	4.18	3.72	3.84