Supporting Information

Facile Solution Synthesis of Bi3+/Yb3+ ions Co-Doped Cs2Na0.6Ag0.4InCl6 Double Perovskite with Near Infrared Emission

Guodong Zhang,[a,b] Yi Wei,[a,b] Peipei Dang,[a,b] Hui Xiao,[a,b] Dongjie Liu,[a,b] Xinke Li,[a,b] Ziyong Cheng,[*,a,b] Jun Lin[*,a,b]

[a] State Key Laboratory of Rare Earth Resource Utilization, Changchun Institute of Applied Chemistry, Chinese Academy of Sciences, Changchun 130022, P. R. China

[b] University of Science and Technology of China, Hefei, 230026, P. R. China
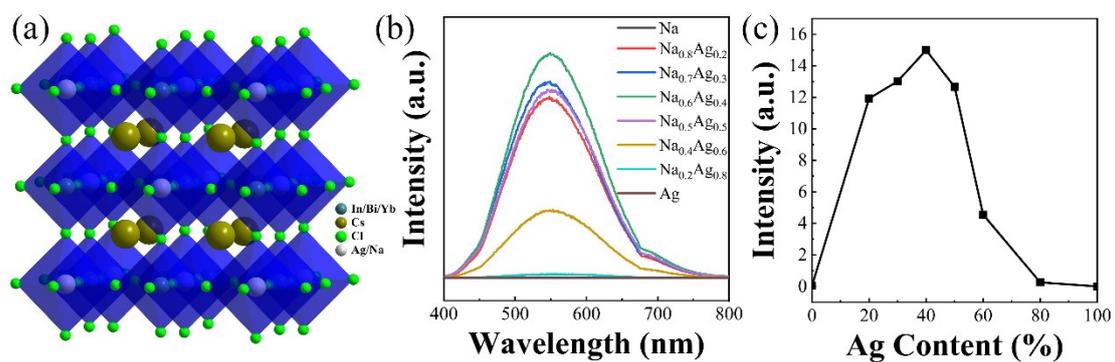
Figure S1. (a) Representation of $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:Bi:Yb lattice. (b) PL emission spectra and (c) PL integrated intensity variation of $Cs_2Na_{1-x}Ag_xInCl_6$ crystals.
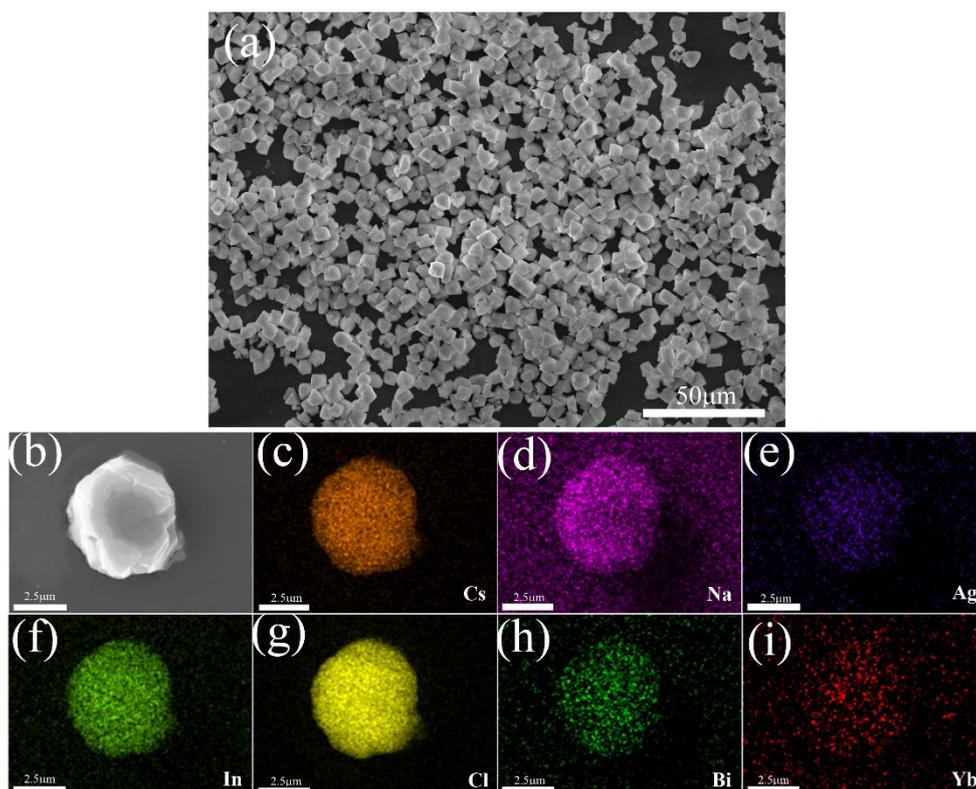
Figure S2. SEM images and corresponding elemental mapping data for Cs, Na, Ag, In, Cl, Bi and Yb elements in $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:Bi:Yb(50%).
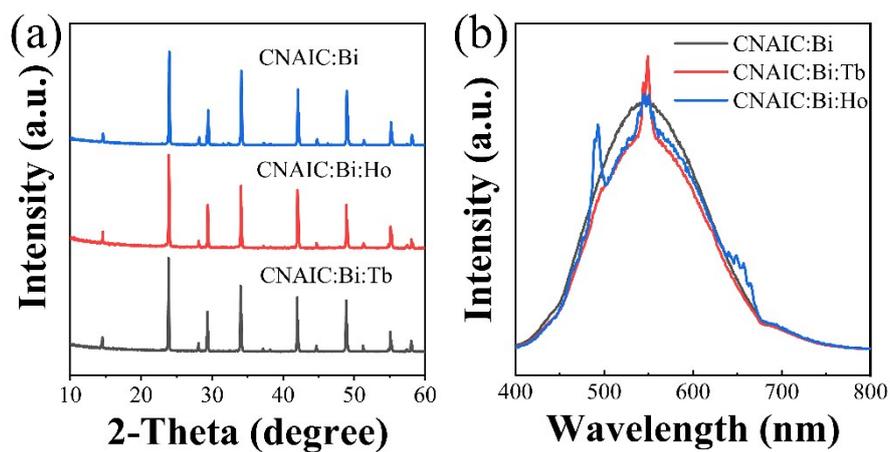
Figure S3. (a) XRD patterns and (b) PL spectra of Bi^{3+} doped, Bi^{3+}-Ho^{3+} co-doped and Bi^{3+}-Tb^{3+} co-doped $Cs_2Na_{0.6}Ag_{0.4}InCl_6$.
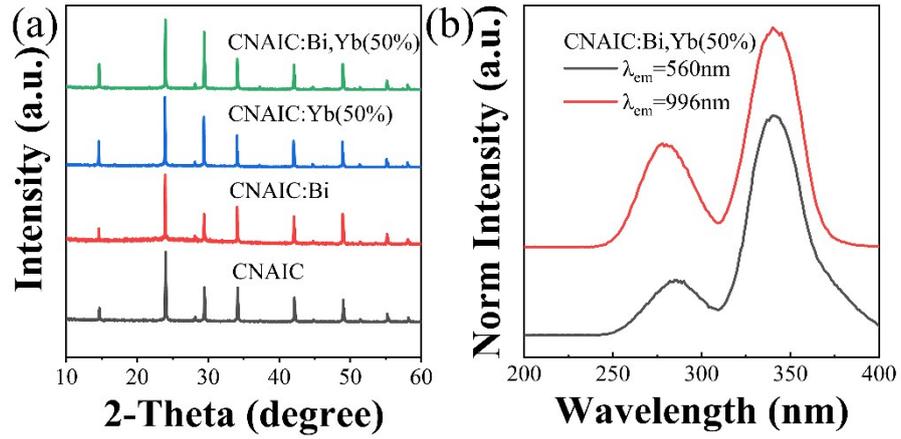
Figure S4. (a) XRD of undoped, Bi^{3+} doped, $Yb^{3+}(50\%)$ doped and Bi^{3+}-$Yb^{3+}(50\%)$ codoped $Cs_2Na_{0.6}Ag_{0.4}InCl_6$. (b) PLE spectra of $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:Bi:Yb(50%) with emission wavelengths at visible (λ_{em}=560 nm) and near-infrared (λ_{em}=996nm) region.
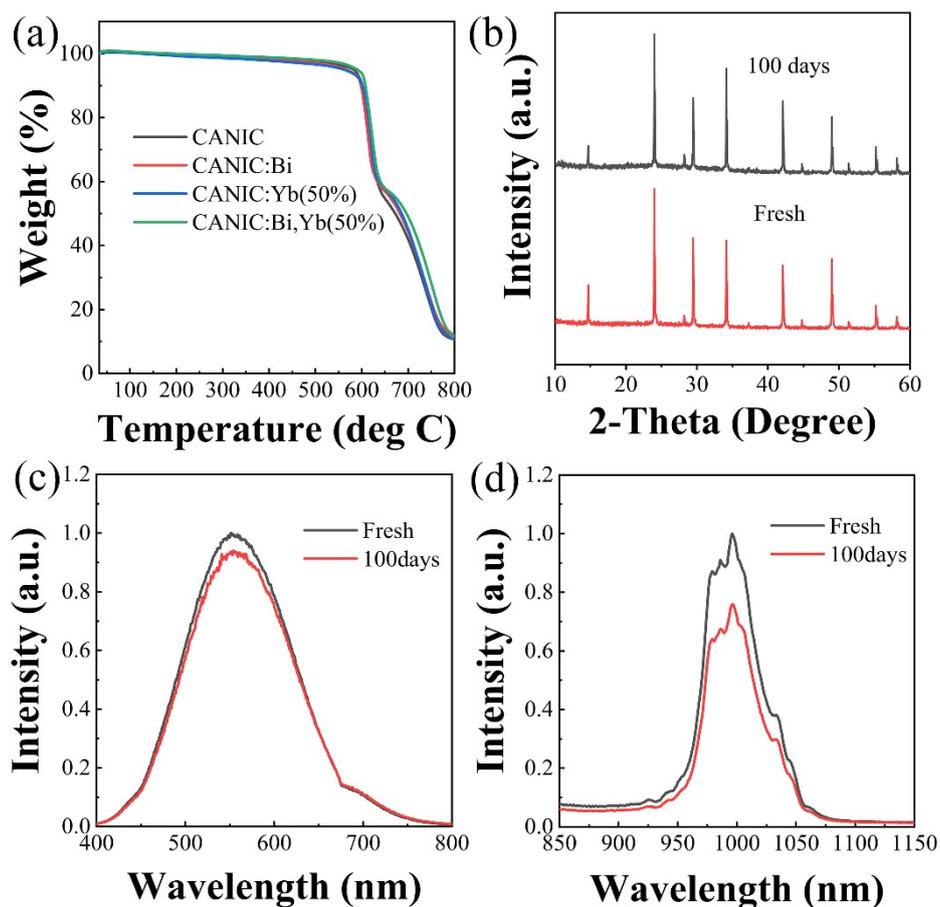
Figure S5. (a) TGA data of undoped, Bi^{3+} doped, Yb^{3+}(50%) doped and Bi^{3+}-Yb^{3+}(50%) codoped $Cs_2Na_{0.6}Ag_{0.4}InCl_6$. (b) XRD patterns, (c) visible emission intensity, and (d) NIR emission intensity of $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:Bi:Yb(50%) crystals recorded at different time intervals from the day one of synthesis. Samples are stored in ambient conditions.
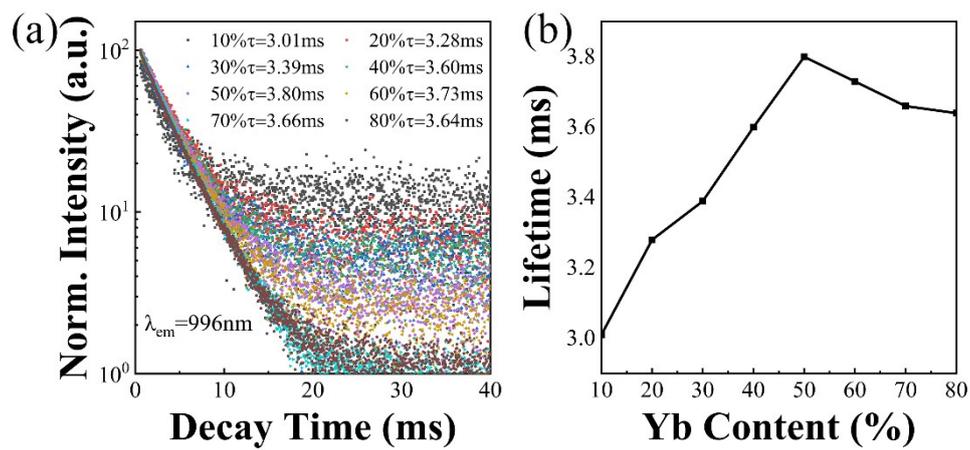
Figure S6. (a) Decay curves of $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:Bi:Yb(10-80%) crystals under excitation at 340 nm and monitoring at 996 nm, and (b) the corresponding lifetime variation.
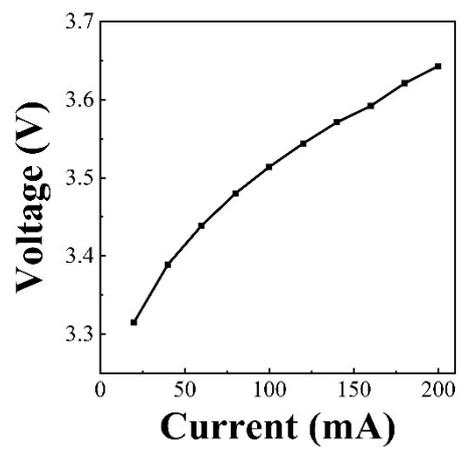
Figure S7. The current-voltage diagram of the pc-LED.

Table S1. Inductively coupled plasma optical emission spectrometer (ICP-OES) data of $Cs_2Ag_xNa_{1-x}InCl_6$. Comparison of Ag concentration added in the reaction mixture with that found in the product. Ag% is calculated following the equation {[Ag]/([Ag] + [Na])} × 100%.

Sample	Precursor		Product(ICP-MS)	
	Na%	Ag%	Na%	Ag%
$Cs_2NaInCl_6$	100%	0	100%	0
$Cs_2Na_{0.8}Ag_{0.2}InCl_6$	80%	20%	89.86%	10.14%
$Cs_2Na_{0.7}Ag_{0.3}InCl_6$	70%	30%	88.58%	11.42%
$Cs_2Na_{0.6}Ag_{0.4}InCl_6$	60%	40%	86.51%	13.49%
$Cs_2Na_{0.5}Ag_{0.5}InCl_6$	50%	50%	78.89%	21.12%
$Cs_2Na_{0.4}Ag_{0.6}InCl_6$	40%	60%	74.15%	25.84%
$Cs_2Na_{0.2}Ag_{0.8}InCl_6$	20%	80%	26.12%	73.87%
$Cs_2AgInCl_6$	100%	0	0	100%

Table S2. ICP-OES data of $Cs_2Na_{0.6}Ag_{0.4}InCl_6$:Bi:Yb(10-80%). Comparison of Yb concentration added in the reaction mixture with that found in the product. Yb% is calculated following the equation $\{[Yb]/([In] + [Bi] + [Yb])\} \times 100\%$.

Sample	Precursor			Product(ICP-MS)		
	Bi%	In%	Yb%	Bi%	In%	Yb%
CNAIC:Bi:Yb(10%)	0.5%	89.5%	10%	1.17%	98.33%	0.49%
CNAIC:Bi:Yb(20%)	0.5%	79.5%	20%	0.99%	98.40%	0.61%
CNAIC:Bi:Yb(30%)	0.5%	69.5%	30%	1.05%	97.91%	1.05%
CNAIC:Bi:Yb(40%)	0.5%	59.5%	40%	1.24%	97.19%	1.58%
CNAIC:Bi:Yb(50%)	0.5%	49.5%	50%	1.51%	96.26%	2.23%
CNAIC:Bi:Yb(60%)	0.5%	39.5%	60%	2.39%	95.09%	2.51%
CNAIC:Bi:Yb(70%)	0.5%	29.5%	70%	2.52%	94.68%	2.80%
CNAIC:Bi:Yb(80%)	0.5%	19.5%	80%	3.01%	93.96%	3.03%