Supporting Information

Warm White-light Emitting Silica Films Prepared Using Lead-free Double Perovskite QDs

Zexin Li[a], Fenglei Sun[a], Haining Song[a], Haifeng Zhou[b,*], Yifei zhou[c], Zhenlei Yuan[a], Peng Guo[a], Guangjun Zhou[a,*], Qianqian Zhuang[d] and Xiaoqiang Yu[a]

[a] State Key Laboratory of Crystal Materials, Shandong University, Jinan 250100, PR China

[b] School of Materials Science and Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, PR China

[c] School of Mechanical, Electrical & Information Engineering, Shandong University, Weihai, 264209, P.R. China.

[d] State Key Laboratory of Biobased Material and Green Papermaking, School of Bioengineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, China.

*** Corresponding Author**

Email: gjzhou@sdu.edu.cn (G. Zhou); hfzhou@qlu.edu.cn (H. Zhou)

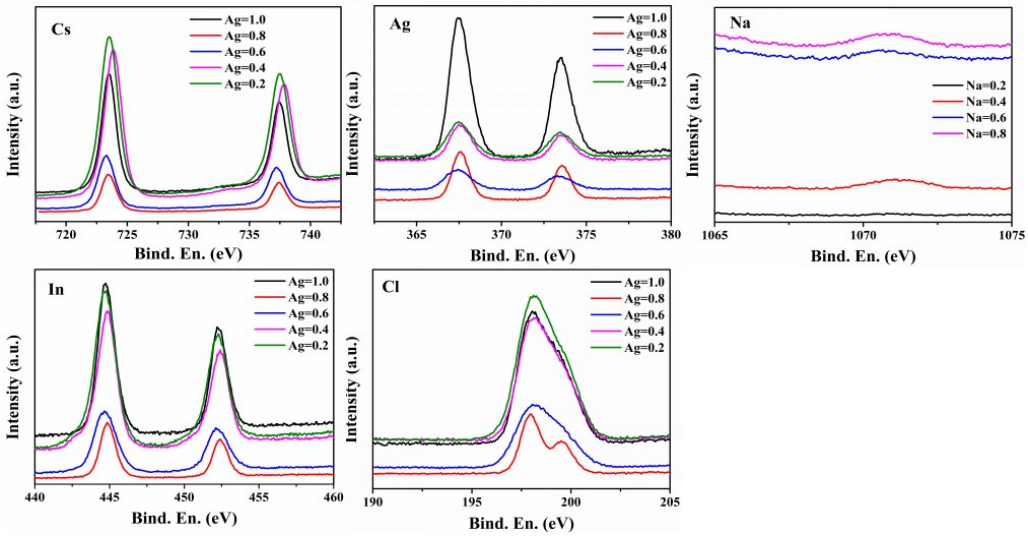

Fig. S1 Representative XPS spectra collected on the sample of Bi-doped $Cs_2Ag_xNa_{1-x}InCl_6$ NCs, from top to bottom, X=1.0, X=0.8, X=0.6, X=0.4 and X=0.2 respectively. Data is shown over the binding energy ranges typical for Cs 3d, In 3d, Ag 3d, Na 1s, Cl 2p.

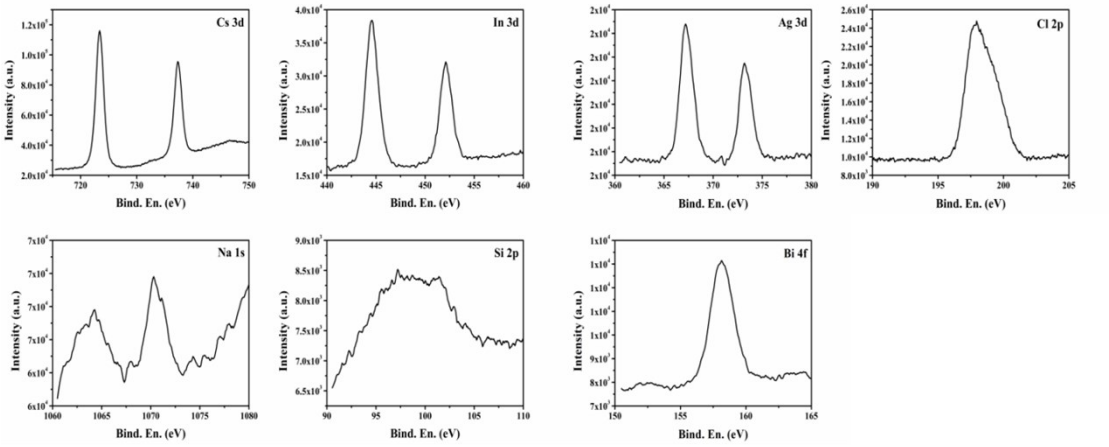

Fig. S2 Representative XPS spectra collected on the sample of $Cs_2Ag_{0.40}Na_{0.60}InCl_6$: Bi-$SiO_2$ thin film. Data is shown over the binding energy ranges typical for Cs 3d, In 3d, Ag 3d, Na 1s, Cl 2p, Bi 4f and Si 2p.

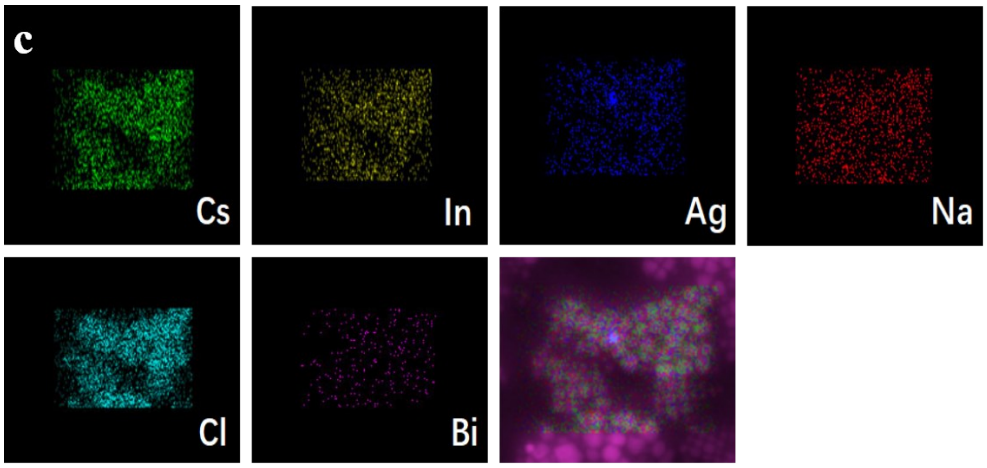

Fig. S3 Mapping images of $Cs_2Ag_{0.40}Na_{0.60}InCl_6$: Bi QDs.

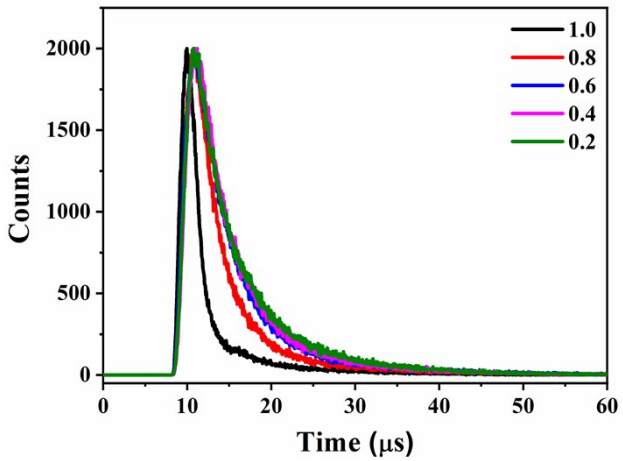

Fig. S4 Luminescence decay curves of $Cs_2Ag_xNa_{1-x}InCl_6$: Bi QDs, x=0.2-0.6 exhibit an obvious longer lifetime (6.89 μs, 6.53 μs, 7.50 μs and 6.59 μs) than that with x=1 (19.21 μs).

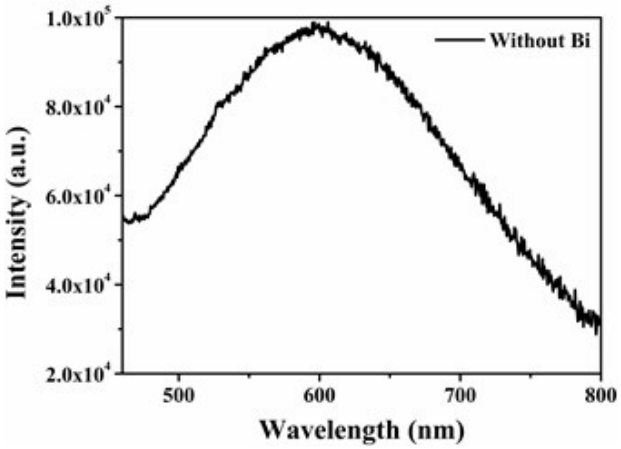

Fig. S5 PL spectrum of $Cs_2Ag_{0.40}Na_{0.60}InCl_6$ quantum dots.

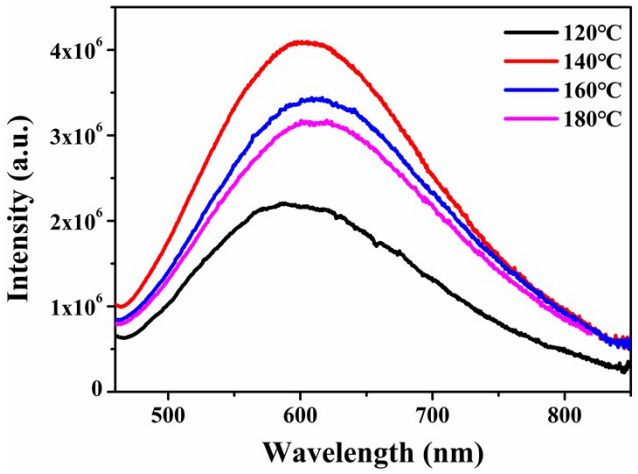

Fig. S6 PL spectra of $Cs_2Ag_{0.40}Na_{0.60}InCl_6$: Bi QDs at 120°C, 140°C, 160°C and 180°C.

Table S1. XPS elemental analyses for Bi-doped $Cs_2Ag_xNa_{1-x}InCl_6$ QDs.

XPS (at%)					
Cs	**Ag**	**Na**	**In**	**Bi**	**Cl**
11.34	5.67	0	5.20	0.82	76.97
13.66	6.37	2.18	7.55	1.09	69.15
14.86	3.65	3.32	7.62	0.95	69.60
20.20	3.46	5.88	8.63	1.25	60.58
19.49	1.48	8.31	9.99	1.31	59.42

Table S2. Relative molar compositions of Bi-doped $Cs_2Ag_xNa_{1-x}InCl_6$ QDs by STEM-EDS.

STEM-EDS (at%)				
Cs	**Ag**	**Na**	**In**	**Cl**
21.49	9.69	0	9.41	63.78
21.72	8.32	2.54	9.52	69.62
23.99	5.44	4.35	9.25	62.70
21.75	4.47	6.58	9.67	64.37
25.41	2.21	7.84	9.82	69.85

Table S3. XPS elemental analyses for $Cs_2Ag_{0.40}Na_{0.60}InCl_6$: Bi-$SiO_2$ thin film.

XPS (at%)						
Cs	**Ag**	**Na**	**In**	**Cl**	**Bi**	**Si**
14.71	5.04	5.84	7.39	40.44	0.94	25.77