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Electronic Supplementary Information (ESI†)

Upconversion Luminescence Enhancement and Temperature Sensing Behavior of F^- Co-doped $Ba_3Lu_4O_9:Er^{3+}/Yb^{3+}$ Phosphors

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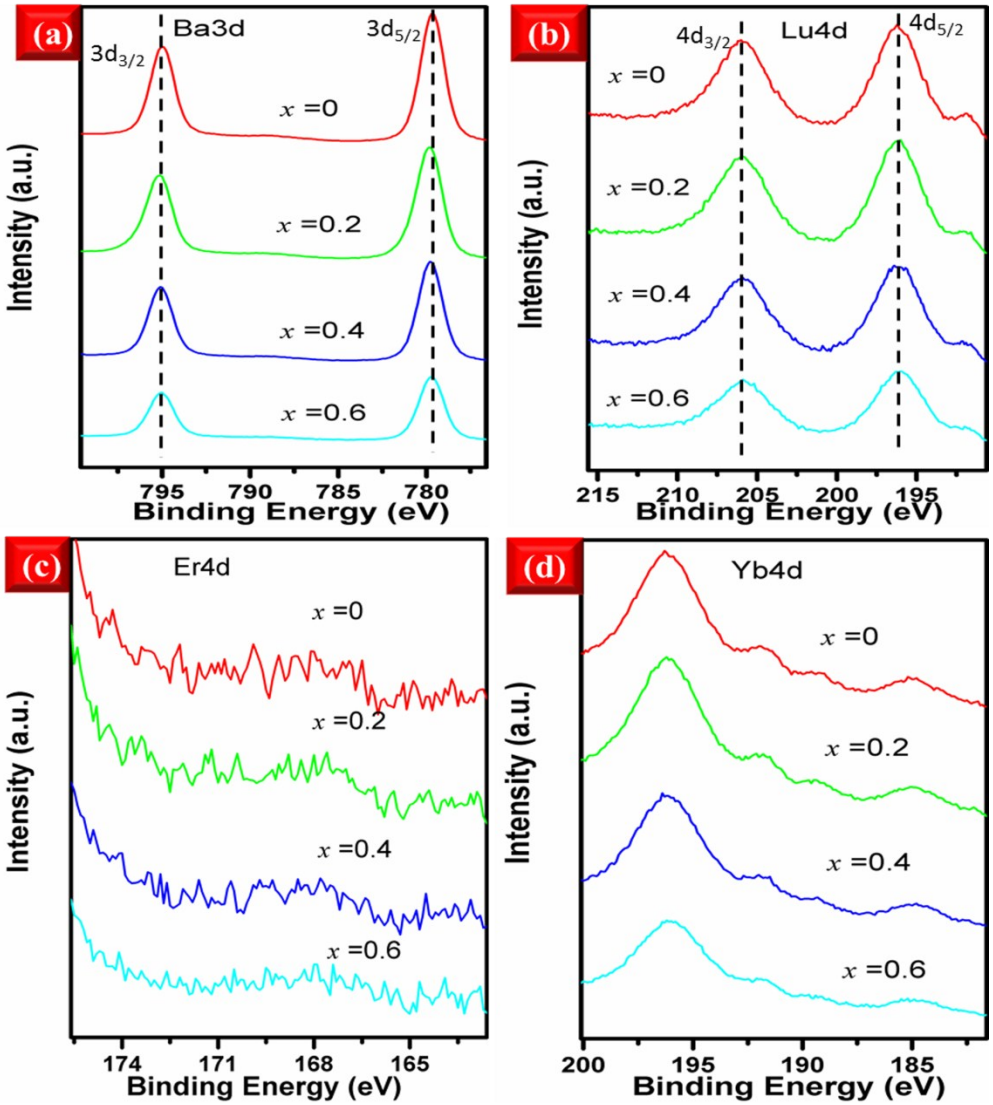

Figure S1. (a) XPS spectrum of Ba3d, (b) XPS spectrum of Lu4d, (c) XPS spectrum of Er4d and (d) XPS spectrum of Yb4d in F^- co-doped EYBLO samples.

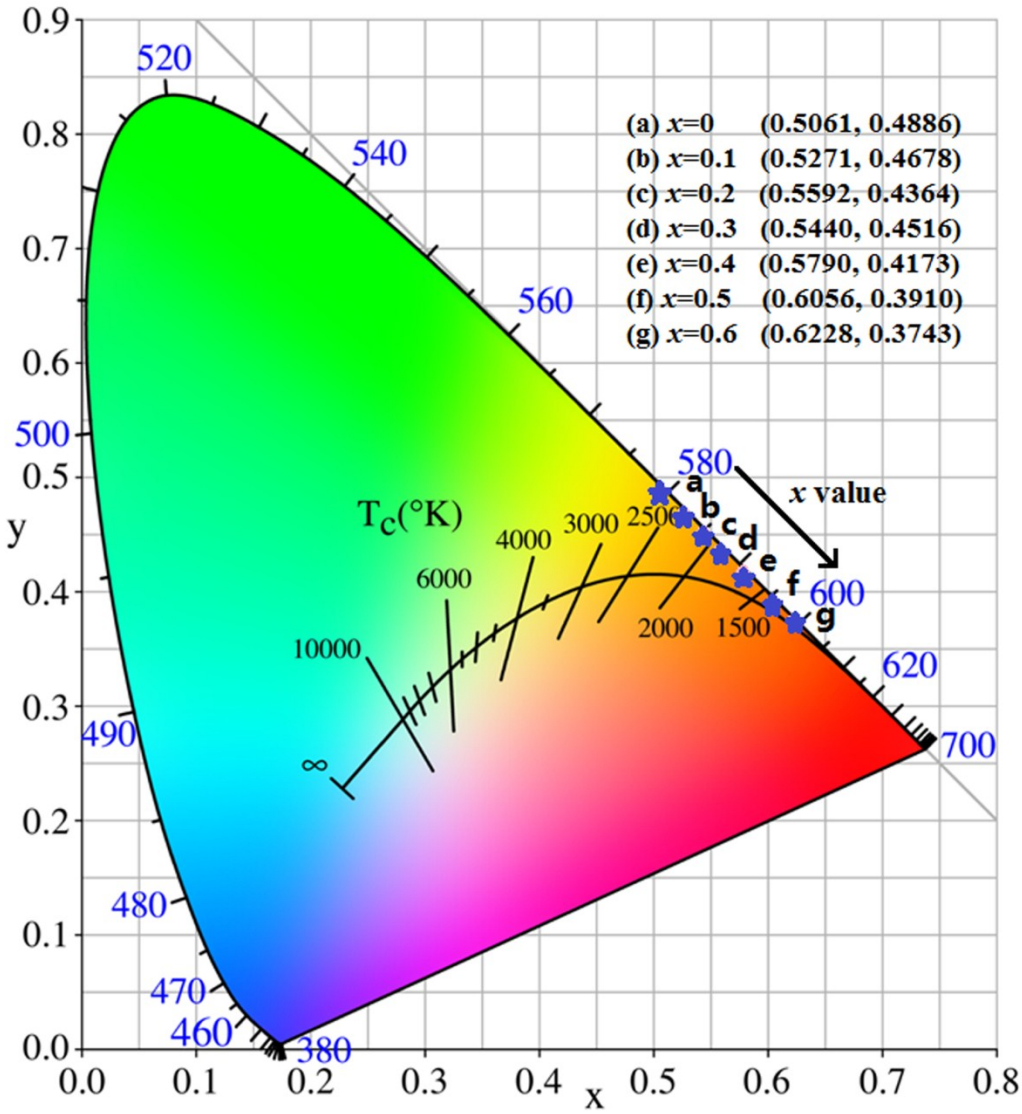

Figure S2. CIE chromaticity diagram with the calculated color coordinates of EYBLO: x F^- samples under 980nm LD excitation with various F- doping concentrations: (a) x =0; (a) x =0; (b) x =0.1; (c) x =0.2; (d) x =0.3; (e) x =0.4; (f) x =0.5; (g) x =0.6.

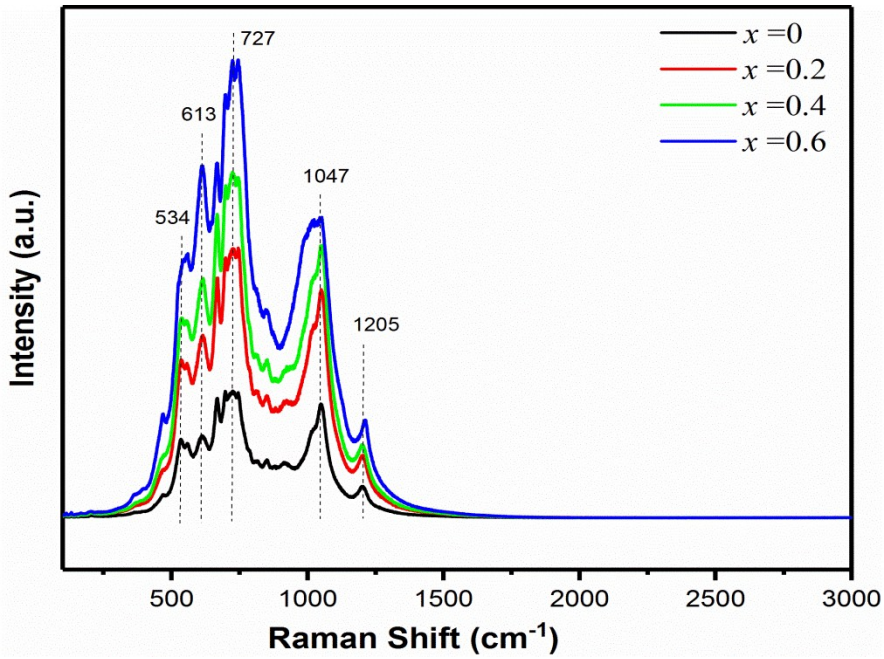

Figure S3. Raman spectra of EYBLO: x F^- samples (x =0, 0.2, 0.4 and 0.6) sintered at 1500℃.

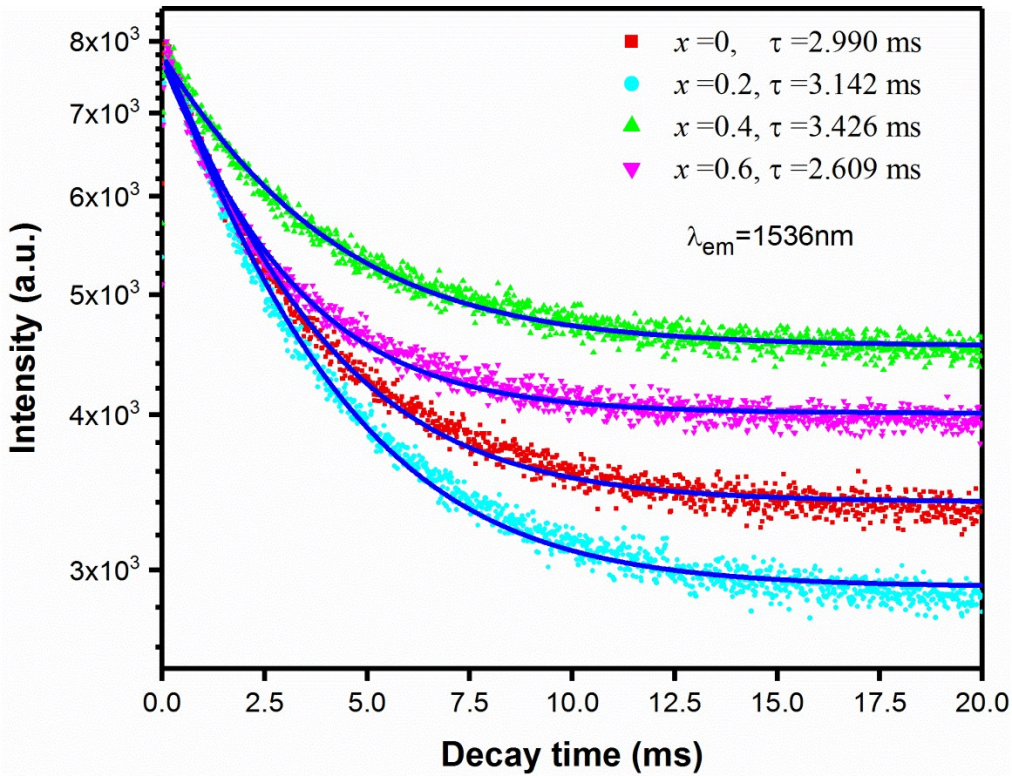

Figure S4. Luminescence decay curves for EYBLO: x F^- samples (x =0, 0.2, 0.4 and 0.6) at the 1536 nm ($^4I_{13/2}\rightarrow{}^4I_{15/2}$) emissions under the excitation of 980 nm LD.

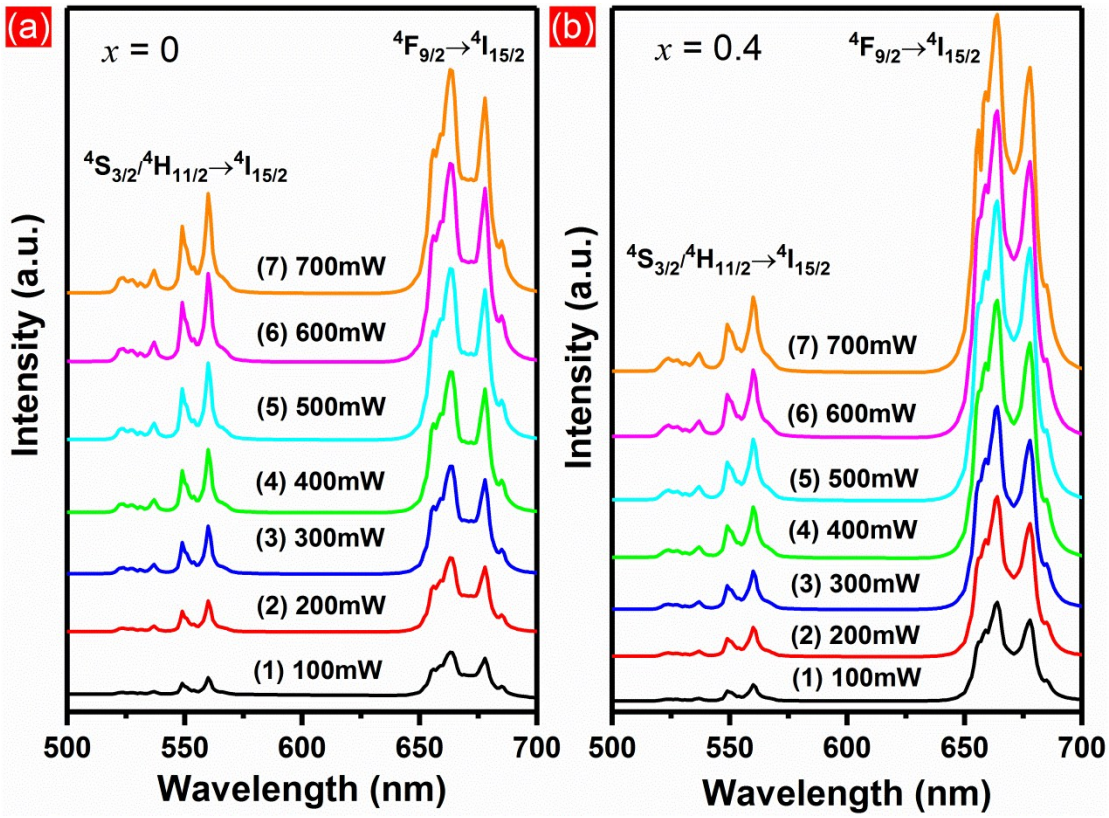

Figure S5. Upconversion luminescence spectra of EYBLO: x F^- samples with (a) x =0 and (b) x =0.4 under different pump-power excitation (λ_{ex}=980 nm): (1) 100 mW; (2) 200 mW; (3) 300 mW; (4) 400 mW; (5) 500 mW; (6) 600 mW; (7) 700mW.

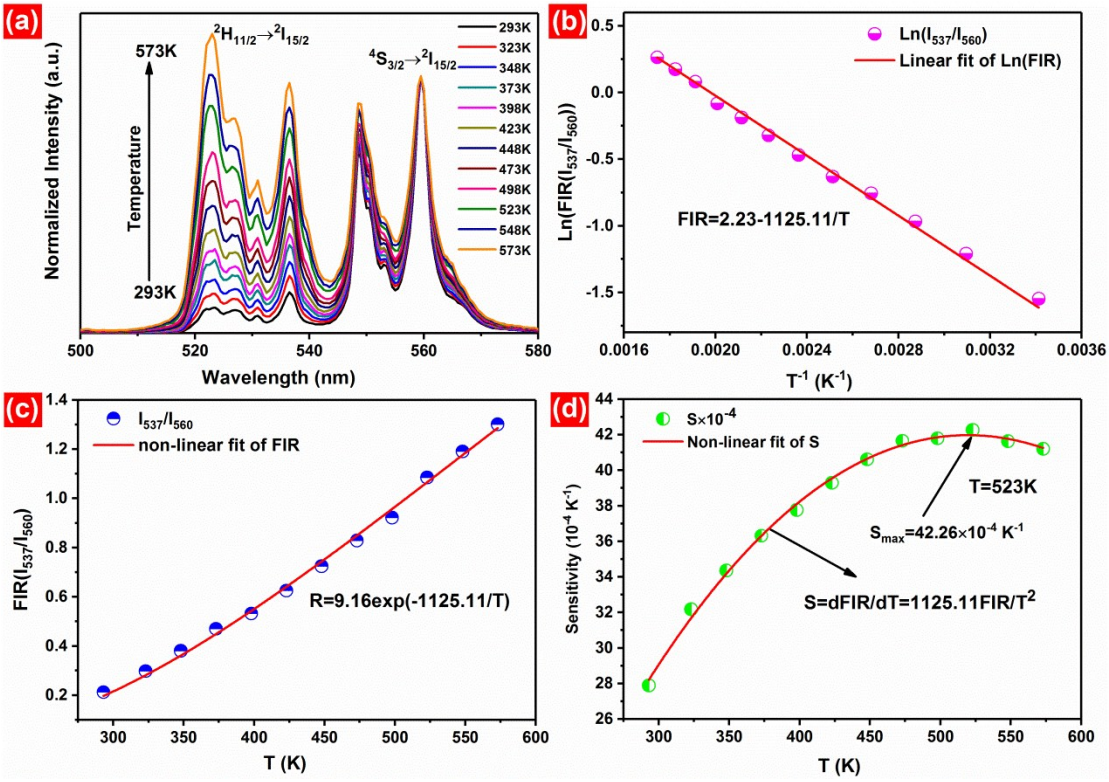

Figure S6. (a) Temperature dependence of the green UC luminescence spectra within

the range from 500nm to 580nm of F^--free EYBLO phosphor under 980 nm excitation (the spectra are normalized to the emission peak at 560 nm). The excitation power density is 3W/cm^2. Upconversion-based temperature-sensing behavior of F^--free EYBLO phosphor: (b) monolog plot of the FIR as a function of the inverse absolute temperature; (c) FIR relative to the temperature; (d) sensor sensitivity as a function of temperature.

Table S1. Summarized the FIR parameters and values of the maximum sensitivity in different Er^{3+}/Yb^{3+} doped oxide materials

Materials	Temperature range (K)	Excitation wavelength (nm)	$\Delta E/k$ (K)	S_{max} ($\times 10^{-4}K^{-1}$)	T (K)	Reference
Phosphate glass	298-438	975	523.1**51**	16	——	[1]
Silicate glass	296-723	978	592.6	33	723	[2]
Oxyfluoride glass	290-450	980	1035	27	513	[3]
Al_2O_3	295-973	978	964.1	51	—	[4]
Y_2O_3	299-673	980	1067.76	30.199	673	[5]
Gd_2O_3	300-900	976	746.4	39	300	[6]
$LiNbO_3$	296-600	980	1250	75	628	[7]
$BaMoO_4$	303-523	980	—	20.6	523	[8]
Y_2SiO_5	273-623	975	817	56	400	[9]
$CaWO_4$	303-873	980	2109.31	73	873	[10]
$NaY(MoO_4)_2$	303-523	980	752.6	96.9	493	[10]
$CaLa_2ZnO_5$	298-513	980	1068.8	59	—	[12]
$Ba_5Gd_8Zn_4O_{21}$	298-573	980	626.32	24	320	[13]
Ga_2S_3:La_2O_3	293-498	1060	928.98	52	443	[14]
$Ba_3Lu_4O_9$	293-573	980	1195.37	44.57	523	This work

Reference

1 X. Yu, F. Song, C. Zou, L. Luo, C. Ming, W. Wang, Z. Cheng, L. Han, T. Sun and J. Tian, *Opt Mater*, 2009, **31**, 1645-1649.

2 C. Li, B. Dong, S. Li and C. Song, *Chem. Phys. Lett.*, 2007, **443**, 426-429.

3 L. Feng, B. Lai, J. Wang, G. Du and Q. Su, *J. Lumin*, 2010, **130**, 2418-2423.

4 B. Dong, D. P. Liu, X. J. Wang, T. Yang, S. M. Miao and C. R. Li, *Appl. Phys. Lett.*, 2007, **90**, 181117.

5 A. Pandey and V. K. Rai, *Dalton Trans.*, 2013, **42**, 11005-11011.

6 S. K. Singh, K. Kumar and S. B. Rai, *Sens Actuat A Phys*, 2009, **149**, 16-20.

7 M. Quintanilla, E. Cantelar, F. Cussó, M. Villegas and A. C. Caballero, *Appl. Phys. Express*, 2011, **4**, 022601.

8 A. K. Soni, A. Kumari and V. K. Rai, *Sens Actuat B Chem*, 2015, **216**, 64-71.

9 N. Rakov and G. S. Maciel, *Sens Actuat B Chem*, 2012, **164**, 96-100.

10 W. Xu, Z. Zhang and W. Cao, *Opt Lett*, 2012, **37**, 4865-4867.

11 X. Yang, Z. Fu, Y. Yang, C. Zhang, Z. Wu, T. Sheng and A. Srivastava, *J. Am. Ceram. Soc.*, 2015, **98**, 2595-2600.

12 L. Li, C. Guo, S. Jiang, D. K. Agrawal and T. Li, *RSC Adv.*, 2014, **4**, 6391-6396.

13 B. Tian, B. Chen, Y. Tian, X. Li, J. Zhang, J. Sun, S. Fu, H. Zhong, X. Zhang, H. Yu and R. Hua, *Mater. Express*, 2013, **3**, 241-246.

14 P. V. dos Santos, M. T. de Araujo, A. S. Gouveia-Neto, J. A. Medeiros Neto and A. S. B. Sombra, *Appl. Phys. Lett.*, 1998, **73**, 578-580.