Electronic Supplementary Material (ESI) for Journal of Materials Chemistry C.

Highly efficient broadband NIR phosphor $Y_2CaHfScAl_3O_{12}$:Cr^{3+},Yb^{3+} with superior thermal stability for spectroscopy applications

Pengcheng Luo [a,b], Dashuai Sun [*b], Zeyu Lyu [b], Sida Shen [b], Zheng Lu [b], Zhijun Li [a,b], Zhihang Yue [b], Chengliang Lyu [b], and Hongpeng You [*a, b, c]

[a] School of Chemistry and Chemical Engineering, Nanchang University, Nanchang 330031, P.R. China

[b] Ganjiang Innovation Academy, Chinese Academy of Sciences, Ganzhou 341000, P. R. China

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

* Corresponding author. Fax: +86 431 85698041.

E-mail address: hpyou@ciac.ac.cn (Hongpeng You), dssun@gia.cas.cn (Dashuai Sun)

Figures and Figure Captions

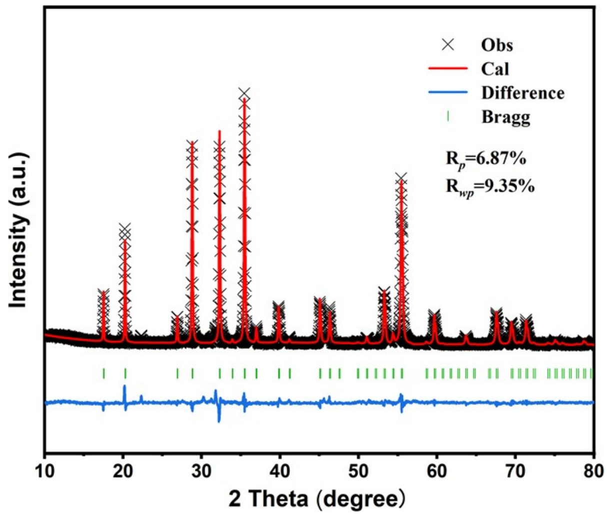

Fig. S1 Rietveld refinement XRD pattern of undoped YCHSA.

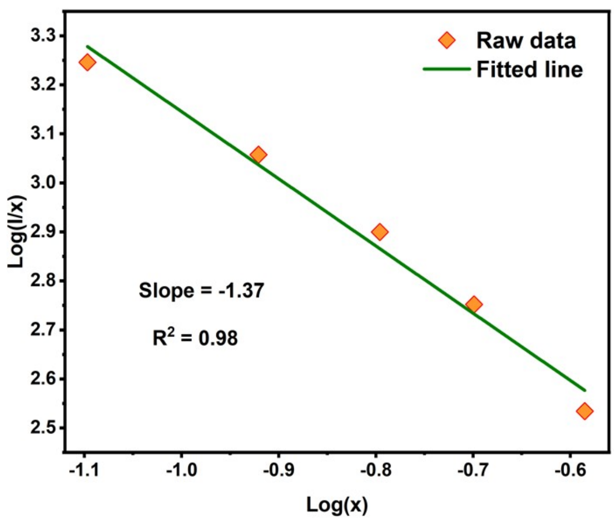

Fig. S2 Relationship of log(I/x) versus log(x) in YCHSA:xCr^{3+} (x = 0.08 to 0.34).

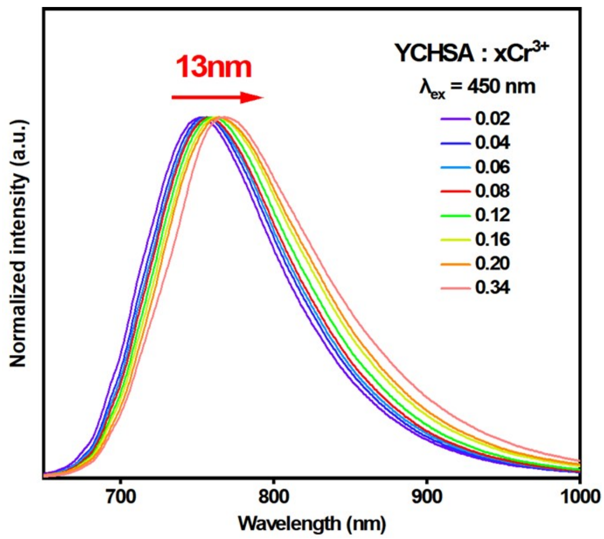

Fig. S3 Normalized PL spectra of YCHSA:xCr^{3+} (x = 0.02 to 0.34).

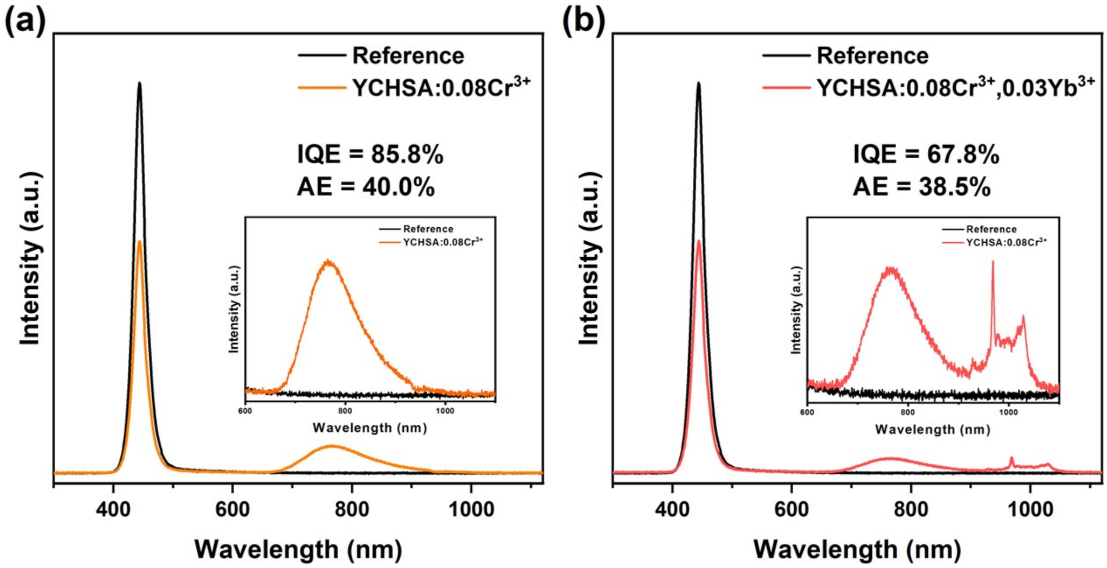

Fig. S4 The quantum efficiency graphs of YCHSA:0.08Cr^{3+} and YCHSA:0.08Cr^{3+},0.03Yb^{3+} samples.

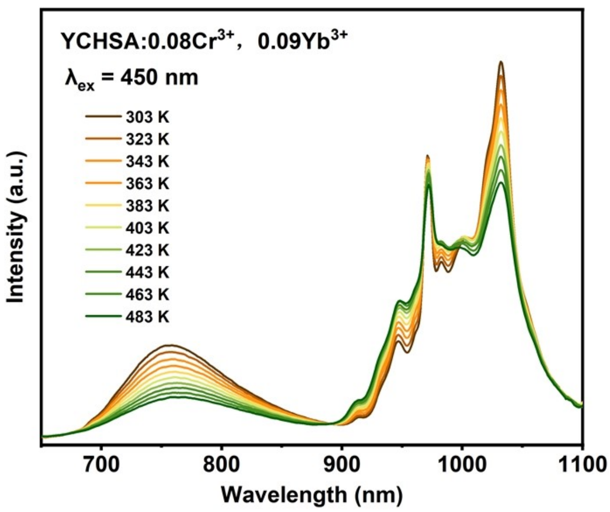

Fig. S5 Temperature-dependent emission spectra of YCHSA:0.08Cr^{3+},0.09Yb^{3+}

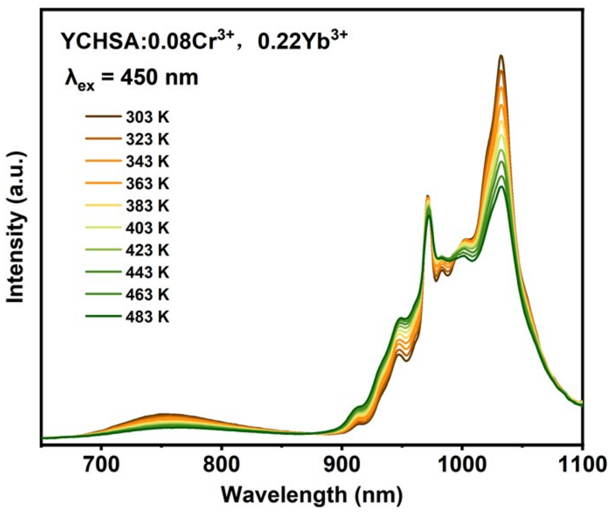

Fig. S6 Temperature-dependent emission spectra of YCHSA:$0.08Cr^{3+}$,$0.22Yb^{3+}$

Tables and Table Captions

Table S1. Refined Structure Parameters of compound undoped $Y_2CaHfScAl_3O_{12}$

atom	site	x	y	z	occ.
Y1	24c	0.25	0.625	0	0.66
Ca1	24c	0.25	0.625	0	0.34
Hf1	16a	0.25	0.75	0.25	0.5
Sc1	16a	0.25	0.75	0.25	0.5
Al1	24d	0.25	0.375	0	1
O1	96h	0.34527	0.46656	0.05219	1

Symmetry, Cubic; space group, *Ia*Error!*d*; a = b = c = 12.3902 Å, V = 1902.11 Å^3; R_{wp} = 9.35%, R_p = 6.87%, χ^2 = 3.38; R_{brag} = 5.00%, R_f = 4.77%

Table S2. Refined Structure Parameters of compound $Y_2CaHfScAl_3O_{12}$:0.08Cr^{3+},0.03Yb^{3+}.

atom	site	x	y	z	occ.
Y1	24c	0.25	0.625	0	0.63
Ca1	24c	0.25	0.625	0	0.34
Hf1	16a	0.25	0.75	0.25	0.5
Sc1	16a	0.25	0.75	0.25	0.42
Al1	24d	0.25	0.375	0	1
O1	96h	0.34527	0.46656	0.05344	1
Cr1	16a	0.25	0.75	0.25	0.08
Yb1	24c	0.25	0.625	0	0.03
Symmetry, Cubic; space group, *Ia***Error!***d*; a = b = c = 12.3742 Å, V = 1894.75 Å^3; R_{wp} = 9.68%, R_p = 7.07%, χ^2 = 3.42, R_{brag} = 5.52%, R_f = 5.79%					

Table S3. PL lifetime of Cr^{3+} ion in YCHSA:0.08Cr^{3+},yYb^{3+} with increasing concentration of Yb^{3+} ions.

y (concentration of Yb^{3+})	PL lifetime of Cr^{3+} (μs)
0	73.55
0.01	59.98
0.03	50.41
0.06	33.46
0.12	25.14
0.16	22.68

Table S4. Energy transfer efficiency in YCHSA:0.08Cr^{3+},yYb^{3+} with increasing concentration of Yb^{3+} ions.

y (concentration of Yb^{3+})	Energy transfer efficiency (%)
0	0
0.01	18.45
0.03	31.46
0.06	54.51
0.12	65.82
0.16	69.16

Table S5. Photoelectric conversion efficiency and output power of NIR pc-LED.

Current (mA)	NIR Efficiency (%)	Total Efficiency (%)	NIR output power (mW)	Total output power (mW)
10	26.128	29.685	6.893	7.8312
20	24.67492	28.30958	13.435	15.414
40	22.88671	25.89741	25.656	29.031
60	21.12094	24.25887	36.535	41.963
80	19.8172	22.62533	46.725	53.346
100	18.59893	21.1992	55.834	63.64
120	17.37094	19.76564	63.595	72.362
140	16.21398	18.49336	70.5	80.411
160	15.32216	17.43126	77.239	87.871
180	14.4997	16.34928	83.482	94.131
200	13.53173	15.3646	87.737	99.621
250	11.59778	13.12985	97.085	109.91
300	9.80021	11.10897	101.54	115.1