Supplementary Information

A Novel Broadband Near-infrared Fluoride Phosphor with Nearly 100% Internal Quantum Efficiency by Cationic Substitution Strategy

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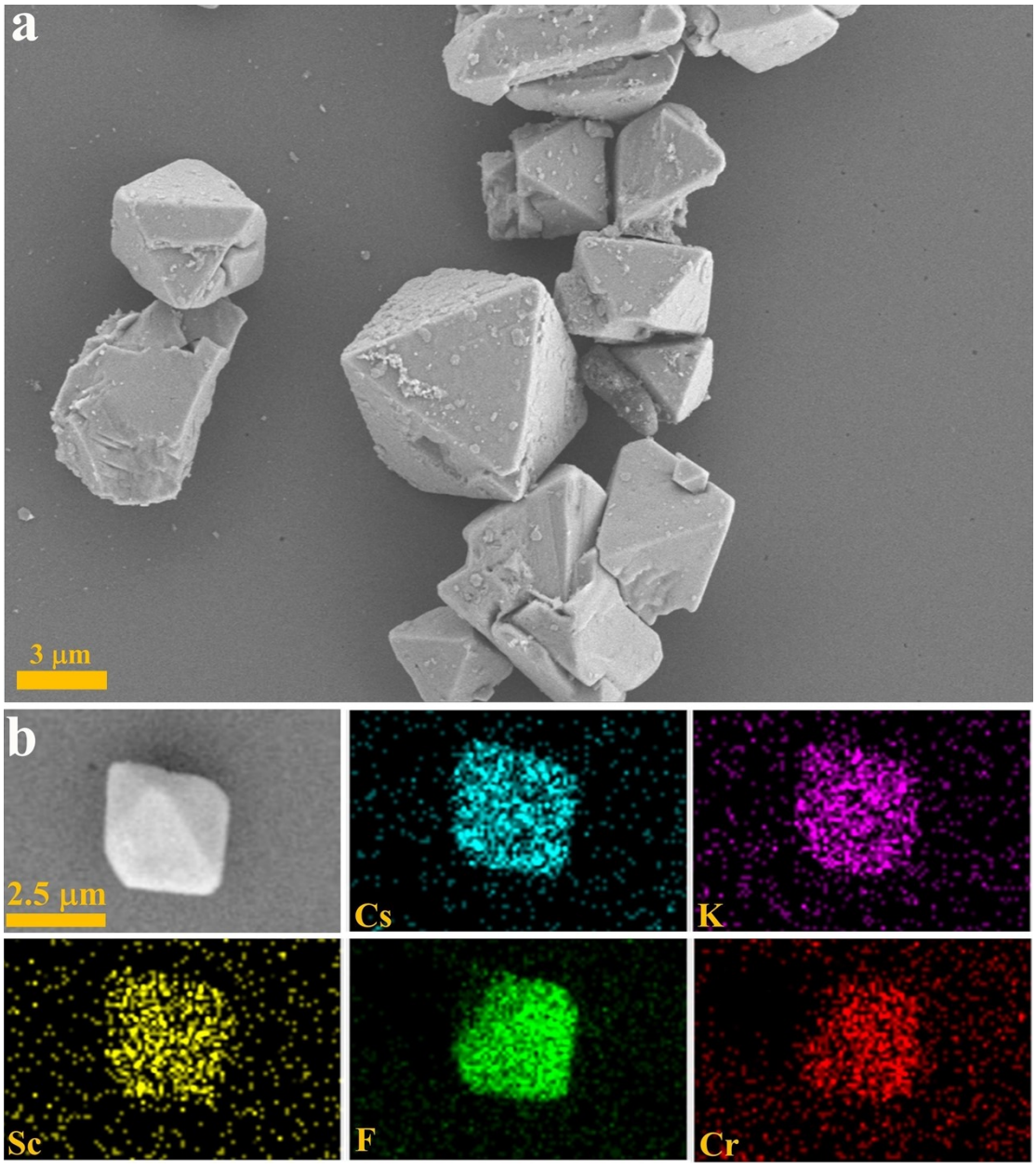

Figure S1. (a) SEM image of CKSF:0.07Cr^{3+}. (b) SEM image of a single crystal and the component elemental maps of a CKSF:0.07Cr^{3+}.

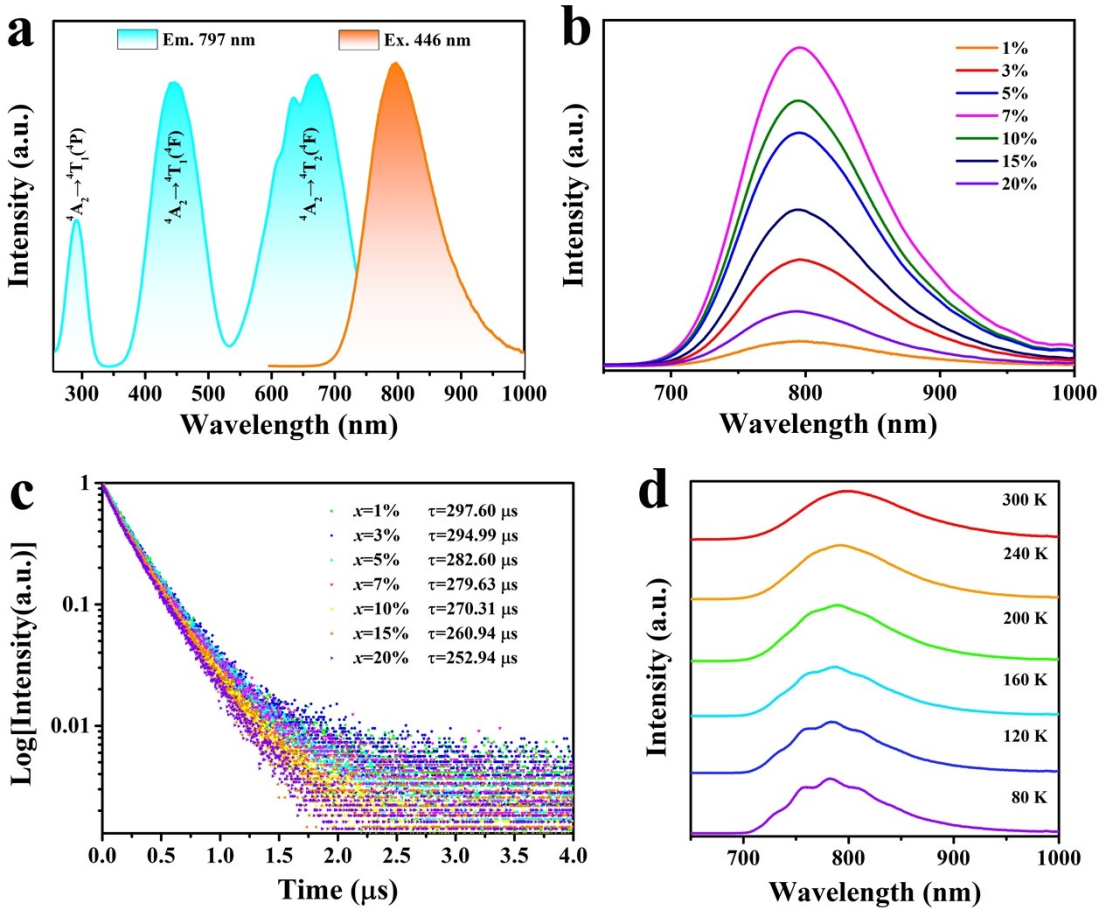

Figure S2. (a) Excitation/emission spectra of CKSF:0.07Cr^{3+}. (b) The concentration-dependent emission spectra of CKSF:x0.07Cr^{3+} (x=0.01-0.20). (c) Decay curve of CKSF:x0.07Cr^{3+} (x=0.01-0.20). (d) CKSF:0.07Cr^{3+} emission spectra at low temperatures (80-300 K).

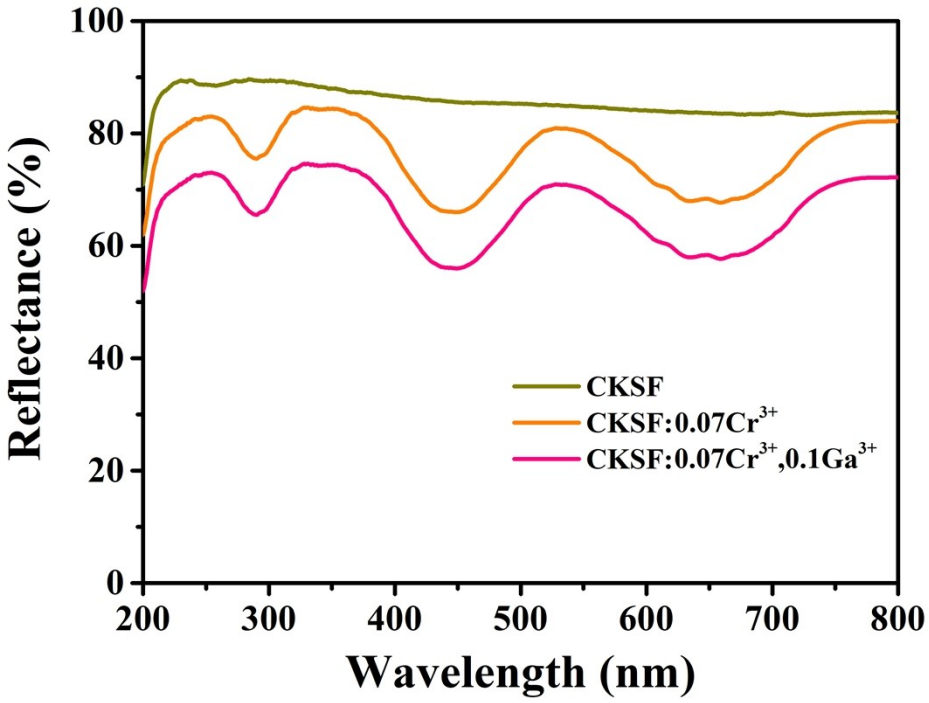

Figure S3. Diffuse reflectance spectroscopy of CKSF, CKSF:0.07Cr^{3+}, and $CKS_{0.83}G_{0.1}F$:0.07Cr^{3+}.

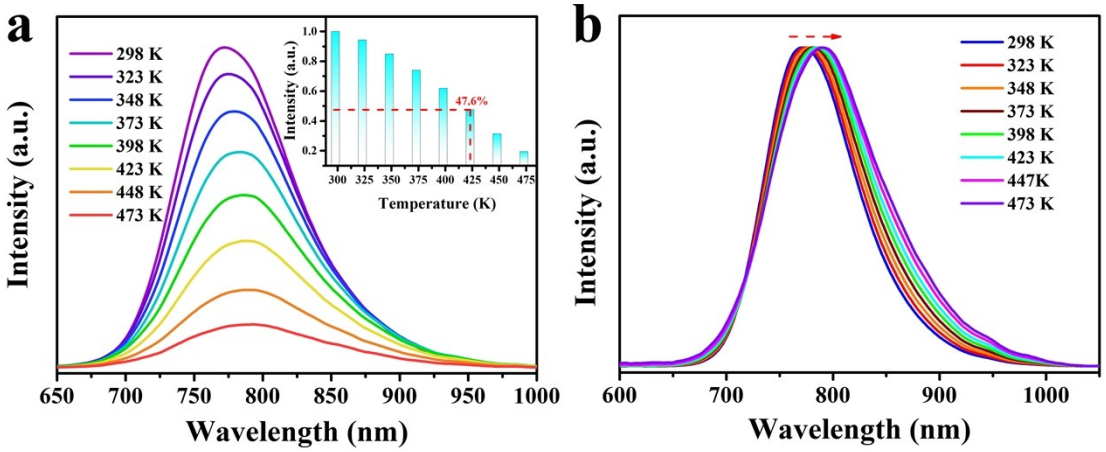

Figure S4. (a) Temperature-dependent emission spectra of CKSF:0.07Cr^{3+}. Inset: dependence of temperature dependent integrated intensity. (b)Normalized temperature-dependent emission spectra of CKSF:0.07Cr^{3+}.

Table S1 PL properties of some Cr^{3+}-activated phosphors and photoelectric properties of the fabricated NIR pc-LEDs.

Phosphor	λ_{ex} (nm)	λ_{em} (nm)	$I_{150°C}$ (%)	IQE (%)	Input power (mW)	NIR output power (mW)@photoelectric efficiency	Ref
$BaMgAl_{10}O_{17}:Cr^{3+}$	398	762	63	94	-	3.4@-	1
$InBO_3:Cr^{3+}$	480	820	50	46.3	360	37.5@10.42%	2
$LiScP_2O_7:Cr^{3+}$	470	880	20	38	300	19@7%	3
$YAl_3(BO_3)_4:Cr^{3+},Yb^{3+}$	450	-	80	-	300	26@8.6%	4
$Ca_2LuZr_2Al_3O_{12}:Cr^{3+}$	460	754	60	69	60	2.448@4.1%	5
$NaInGe_2O_6:Cr^{3+}$	480	900	25	34	-	25@4.85%	6
$Ca_9Ga(PO_4)_7:Cr^{3+}$	440	735	68.5	55.7	-	-	7
$Ca_{3-x}Lu_xGa_{2+x}Ge_{3-x}O_{12}:Cr^{3+}$	460	803	90	-	300	27.1@16.3%	8
$ScBO_3:Cr^{3+}$	450	800	51	65	371	26@7%	9
$Ca_3Sc_2Si_3O_{12}:Cr^{3+}$	460	770	97.4	92.3	2892	109.9@3.8%	10
$K_3GaF_6:Cr^{3+}$	442	750	-	28	1050	8@<1%	11
$K_3ScF_6:Cr^{3+}$	432	770	87.3	71.7	350	32.56564@9.315	12
$Cs_2KGaF_6:Cr^{3+}$	439	782	88.7	90.2	277.5	61.18@22.05%	13
$K_2NaScF_6:Cr^{3+}$	435	765	89.6	74	1094	159.72@14.6%	14
$K_2NaInF_6:Cr^{3+}$	439	774	78.3	70.2	817.1	72.97@8.93%	15
$Cs_2KIn_{0.8}Al_{0.1}F_6:Cr^{3+}$	447	794	71.6	88.06	1026	215.88@21.04%	16
$ScF_3:Cr^{3+}$	468	853	85.5	45	110	3.51@3.19%	17
$Na_3ScF_6:Cr^{3+}$	436	774	30	91.5	-	699.8@15.46%	18
$Na_3GaF_6:Cr^{3+},Li^+$	429	758	84.9	95.8	-	974.12@20.9%	19
$Cs_2KSc_{0.83}Ga_{0.1}F_6:Cr^{3+}$	**439**	**782**	**88.7**	**90.2**	**277.5**	**61.18@22.05%**	**This work**

Table S3 Results of Dq/B of $CKS_{0.83-y}G_yF:0.07Cr^{3+}$ (y=0,0.1).

Ga^{3+} content	$^4A_2 \rightarrow {}^4T_1(^4F)$ λ (nm)	$^4A_2 \rightarrow {}^4T_2(^4F)$ λ (nm)	*Dq*/B
0	673	446	1.75
0.1	667	446	1.83

Table S3 Some photoelectric parameters of the fabricated NIR pc-LED under various driven currents.

Current (mA)	Input electrical power (mW)	NIR output power (mW)	Photoelectric conversion efficiency (%)
20	53	16.27	30.70
40	106	33.35	31.46
60	161	50.33	31.26
80	220	67.40	30.63
100	281	84.04	29.91
120	339	101.06	29.81
160	494	136.44	27.62
200	584	160.43	27.47
240	716	190.32	26.58
280	936	226.30	24.18
320	1017	252.11	24.79

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