Supporting Information

Rapid aqueous-phase synthesis of highly stable $K_{0.3}Bi_{0.7}F_{2.4}$ upconversion nanocrystalline particles at low temperature

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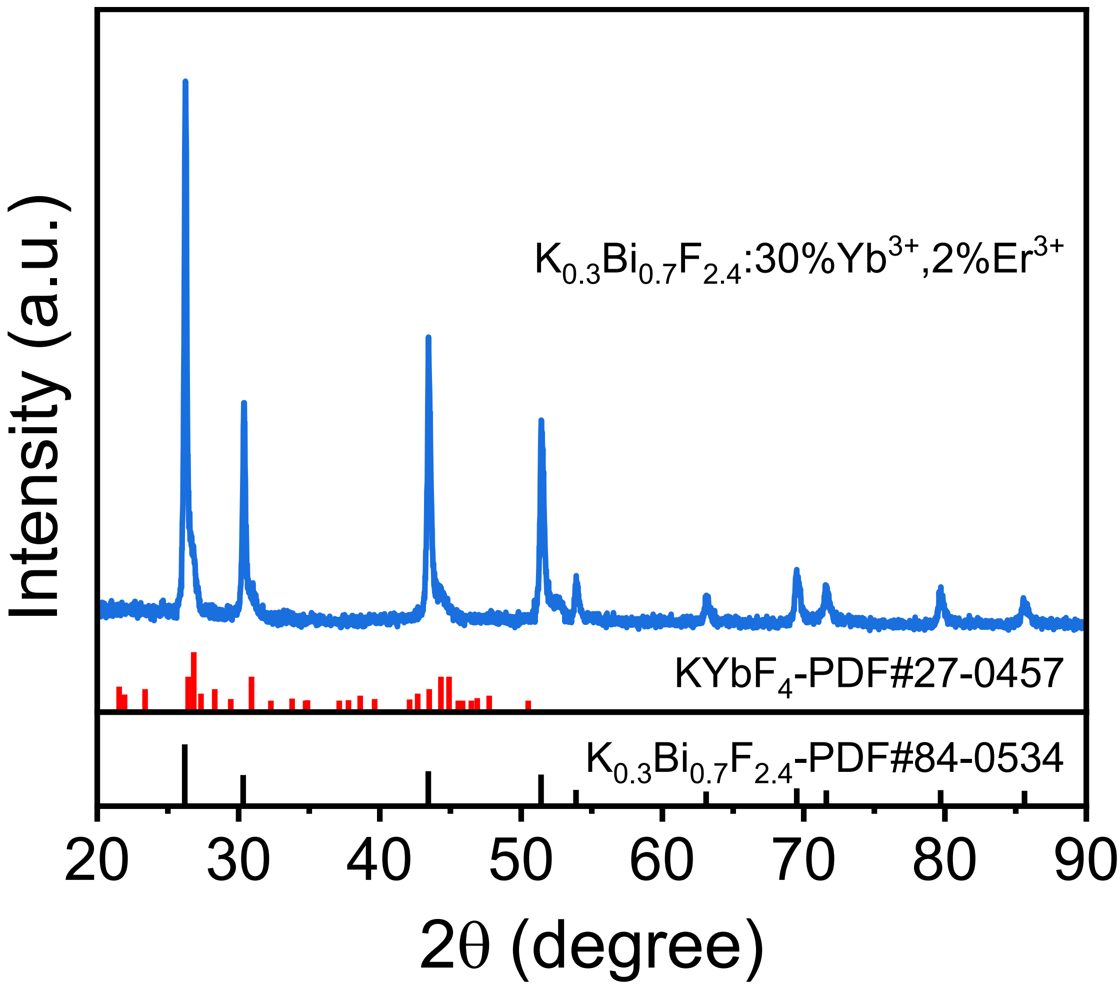

Fig. S1 XRD patterns of KBF:30%Yb^{3+},2%Er^{3+} nanocrystalline particles.

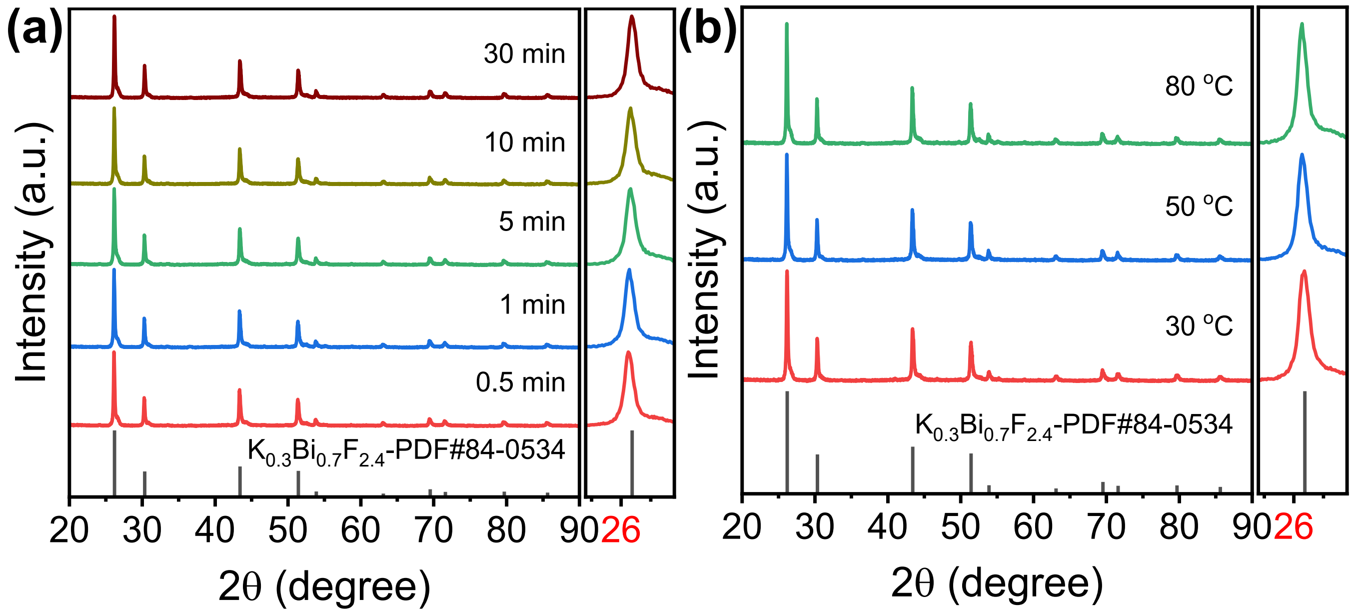

Fig. S2 XRD patterns of KBF:Yb,Er samples synthesized at different reaction times (a) and temperatures (b).

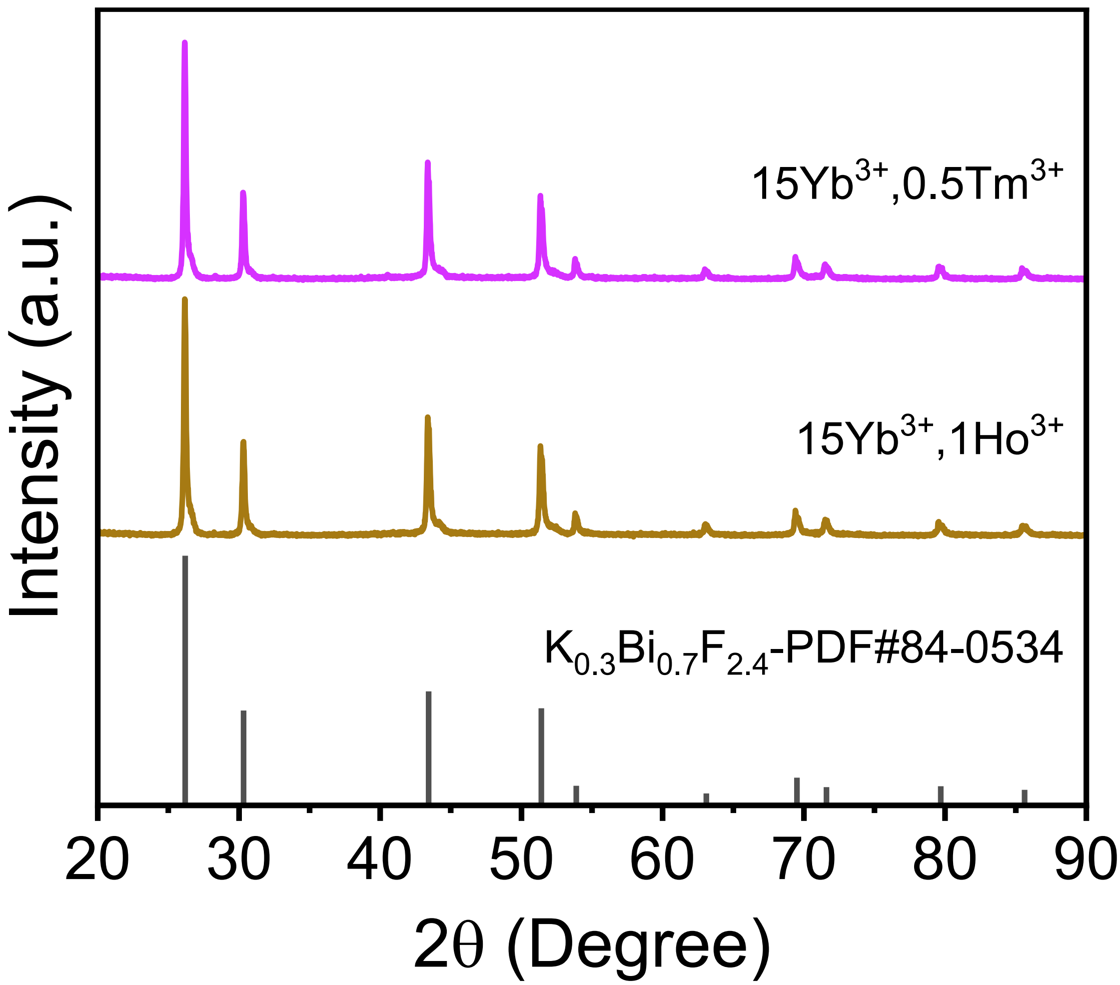

Fig. S3 XRD patterns of KBF:Yb,Ho and KBF:Yb,Tm nanocrystalline particles.

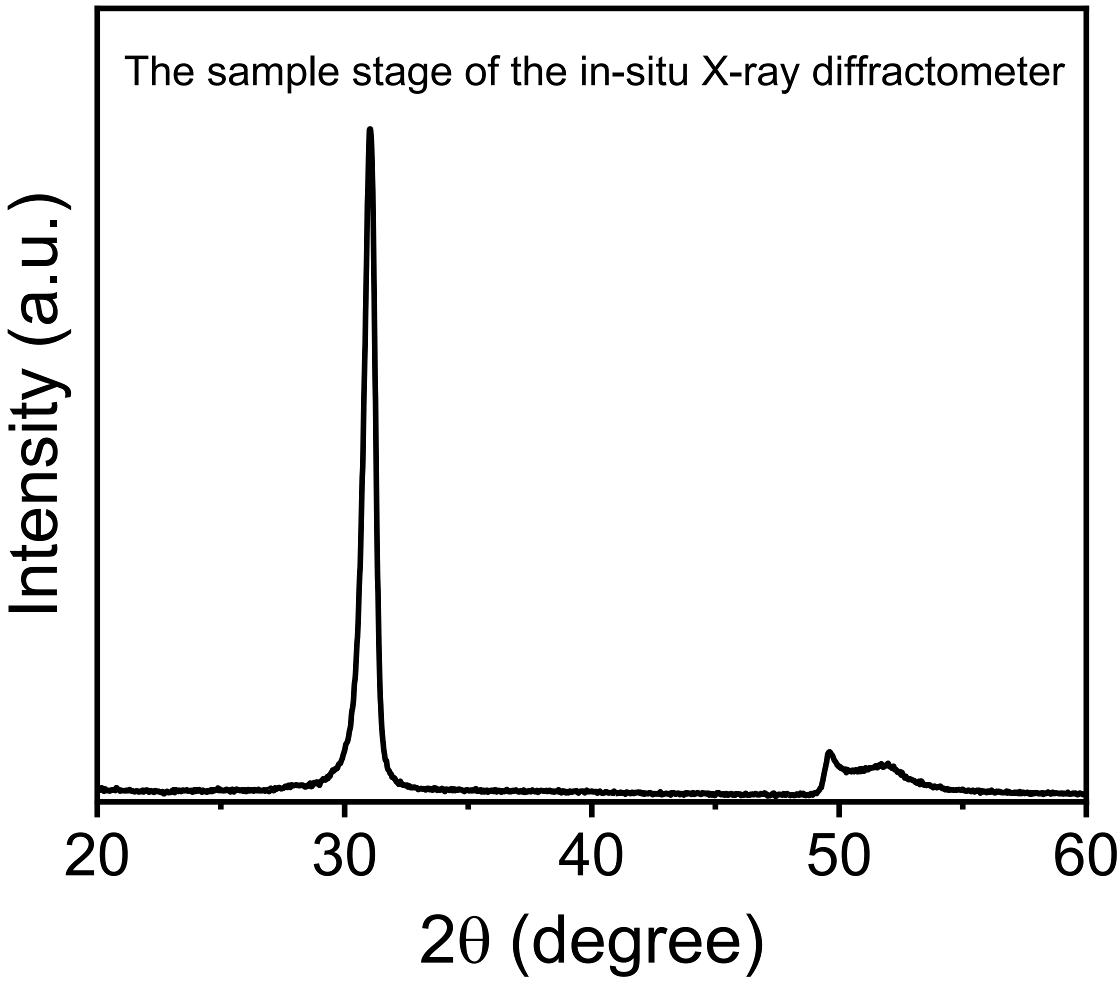

Fig. S4 XRD pattern of the sample stage of the in-situ X-ray diffractometer.

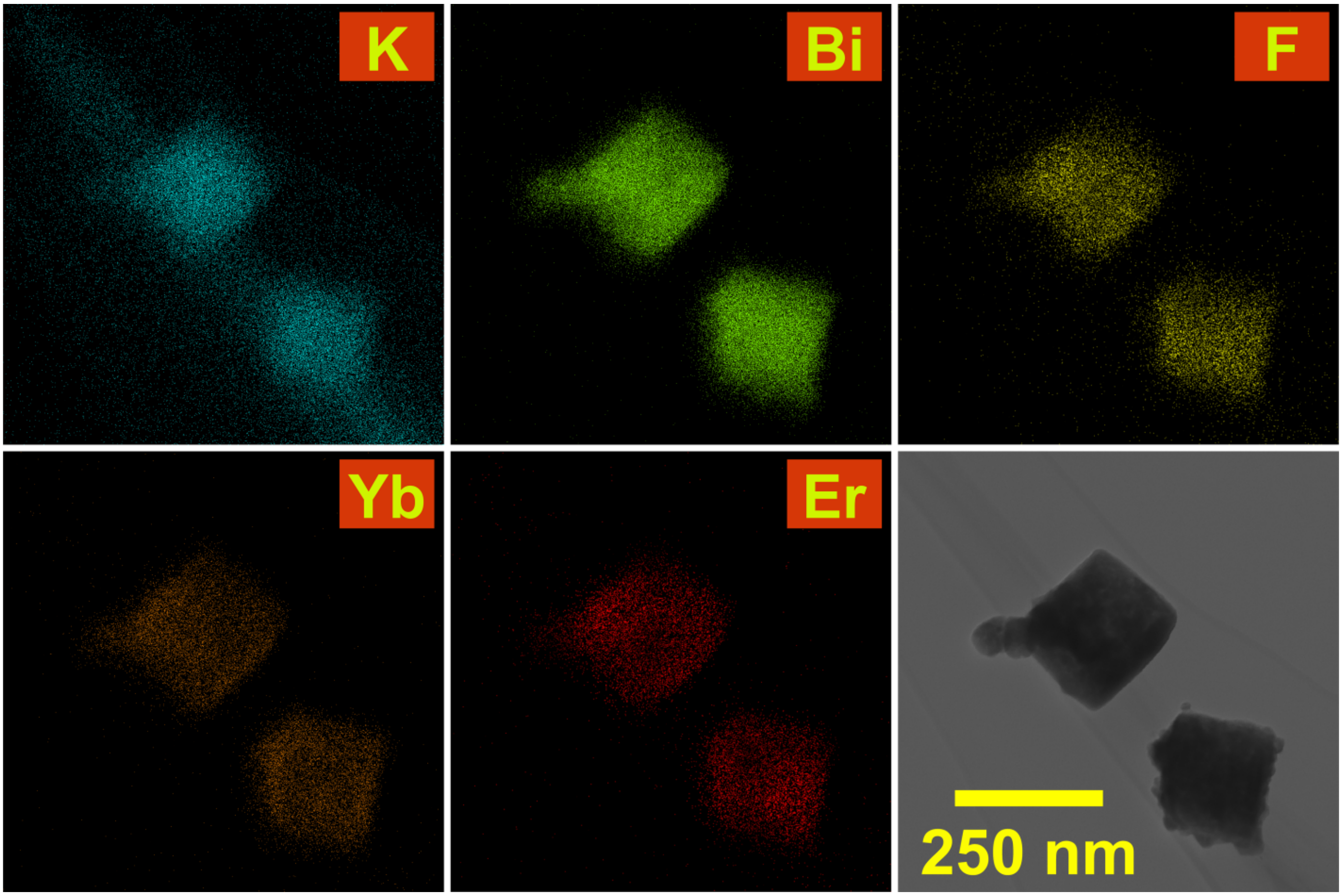

Fig. S5 TEM-EDX elemental mapping of the KBF:Yb,Er nanocrystalline particles.

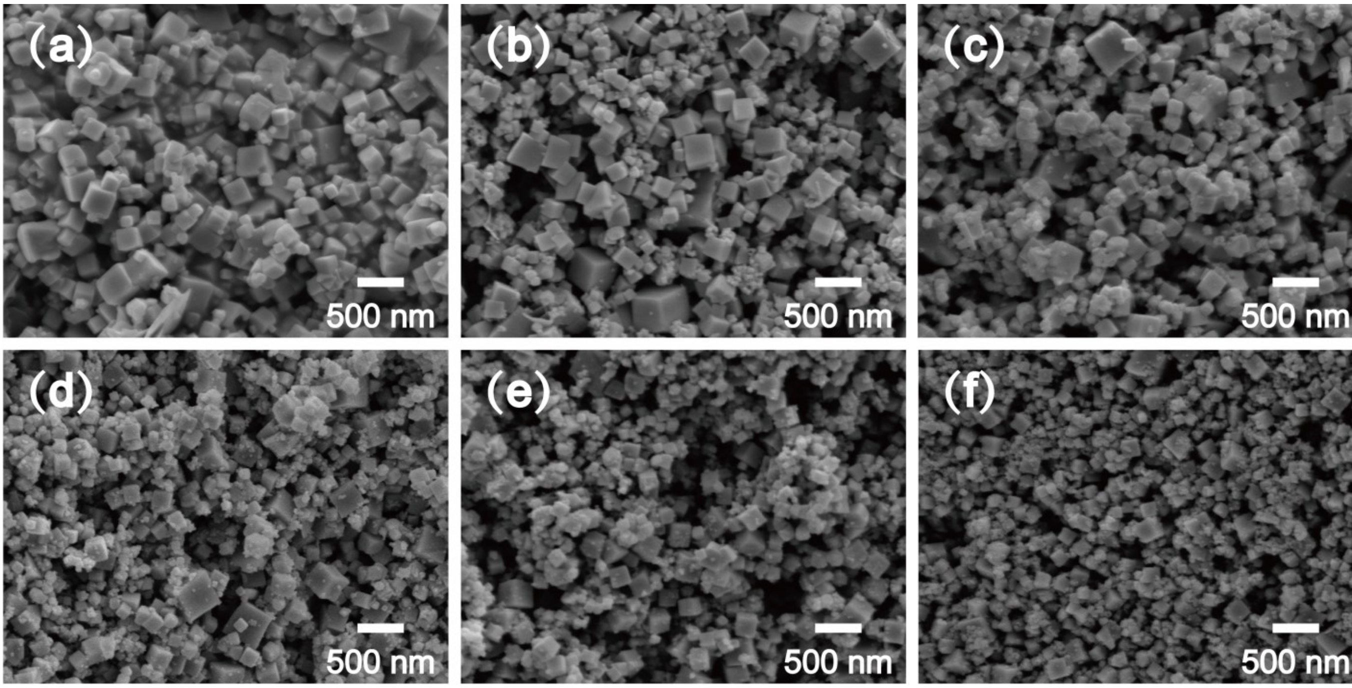

Fig. S6 SEM images of KBF:x%Yb,2%Er particles with different doping concentrations of Yb (x=0, 5, 10, 15, 20, 30).

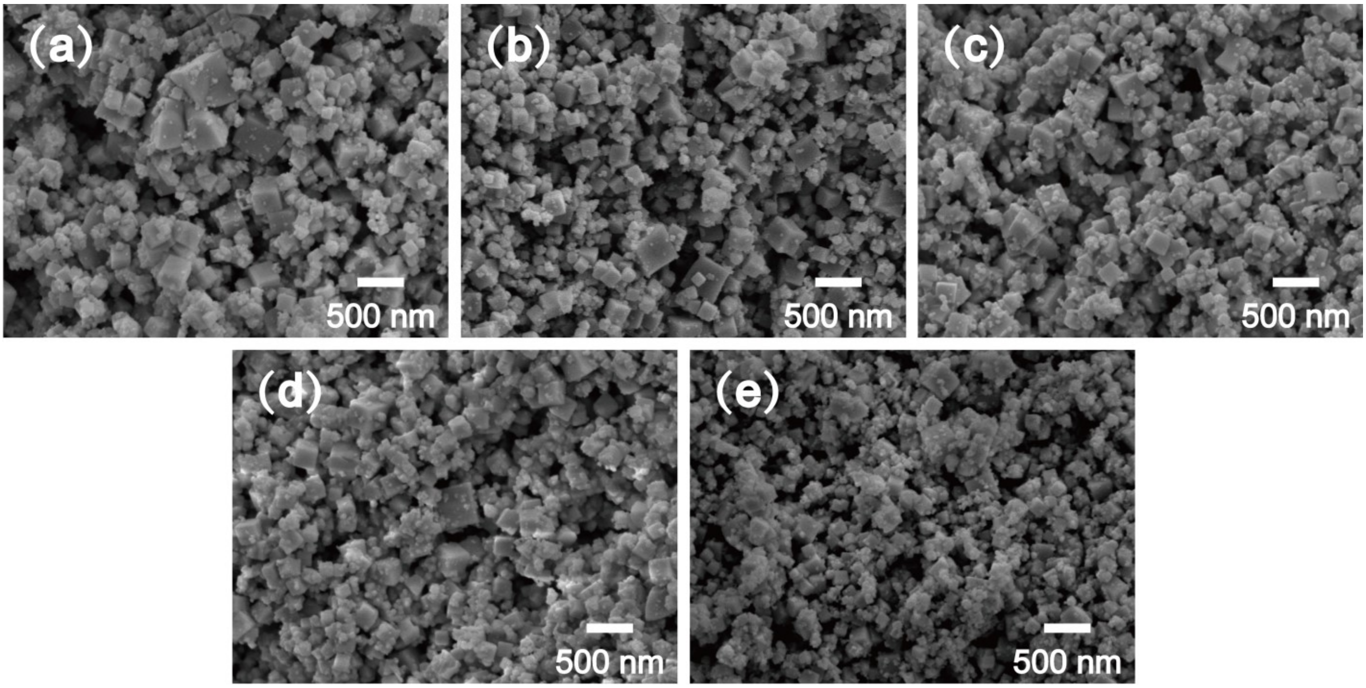

Fig. S7 SEM images of KBF:Yb,Er particles obtained at 80 ºC for different reaction times (0.5, 1, 5, 10, 30 min), respectively.

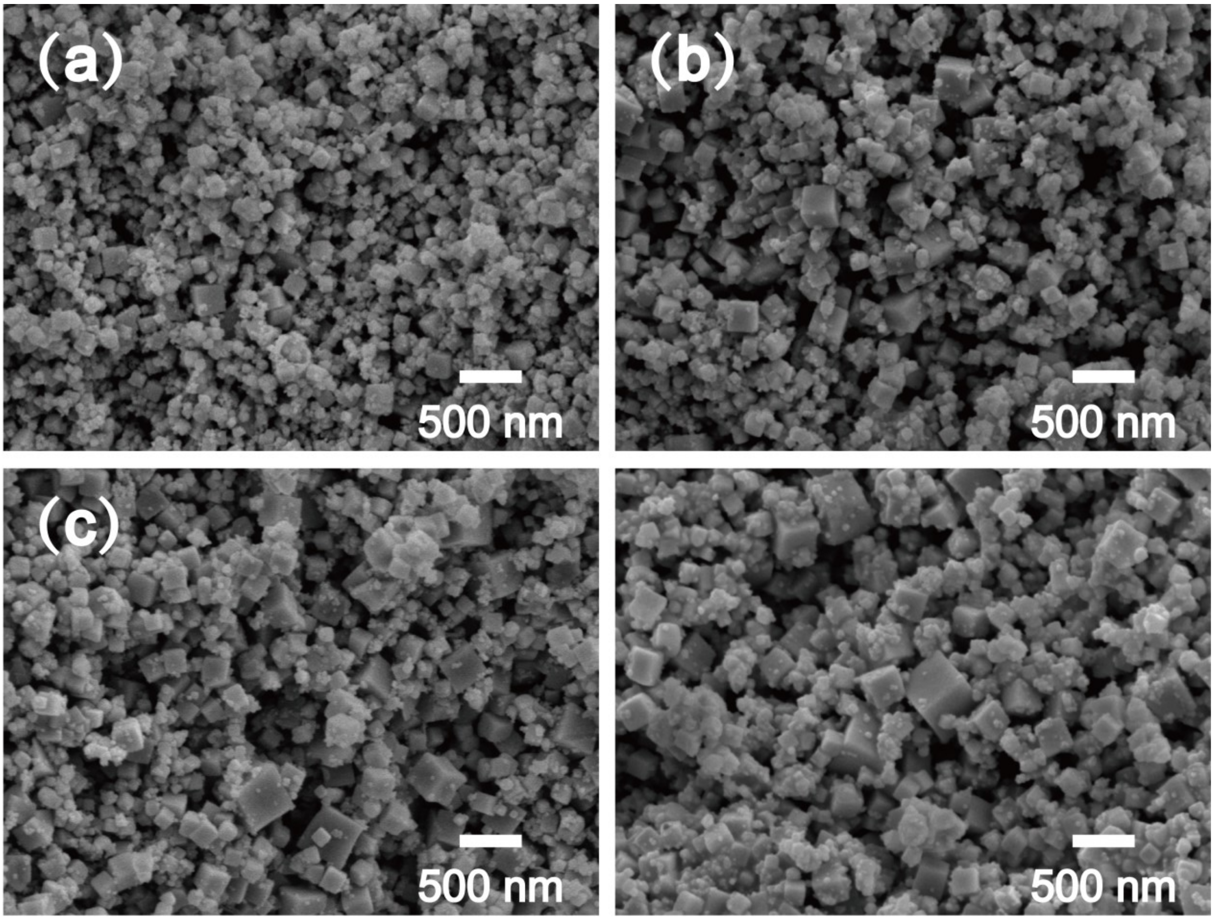

Fig. S8 SEM images of KBF:Yb,Er particles synthesized at (a) 30 ºC, (b) 50 ºC, (c) 80 ºC and (d) 90 ºC for 1min, respectively.

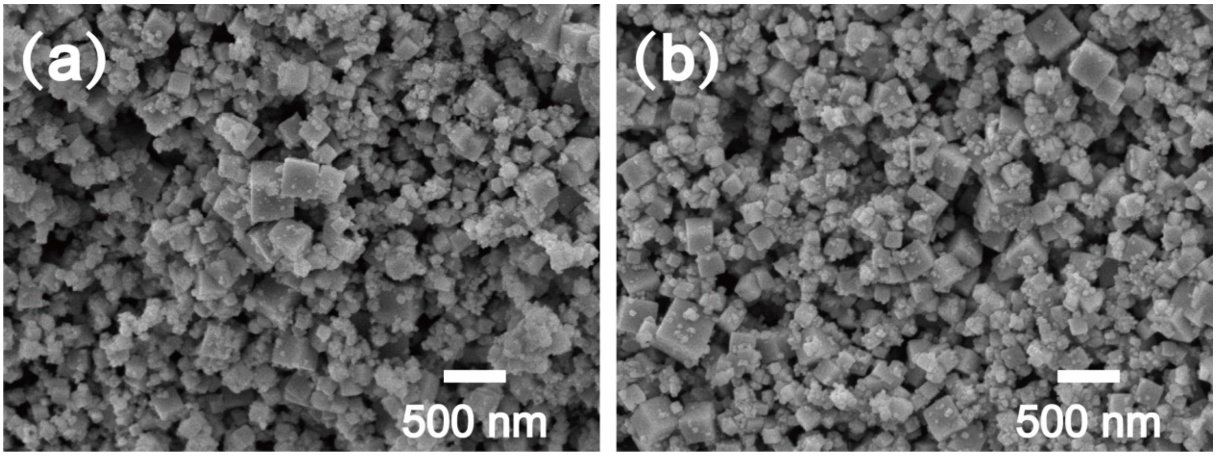

Fig. S9 SEM images of KBF:Yb,Ho (a) and KBF:Yb,Tm (b) nanocrystalline particles.

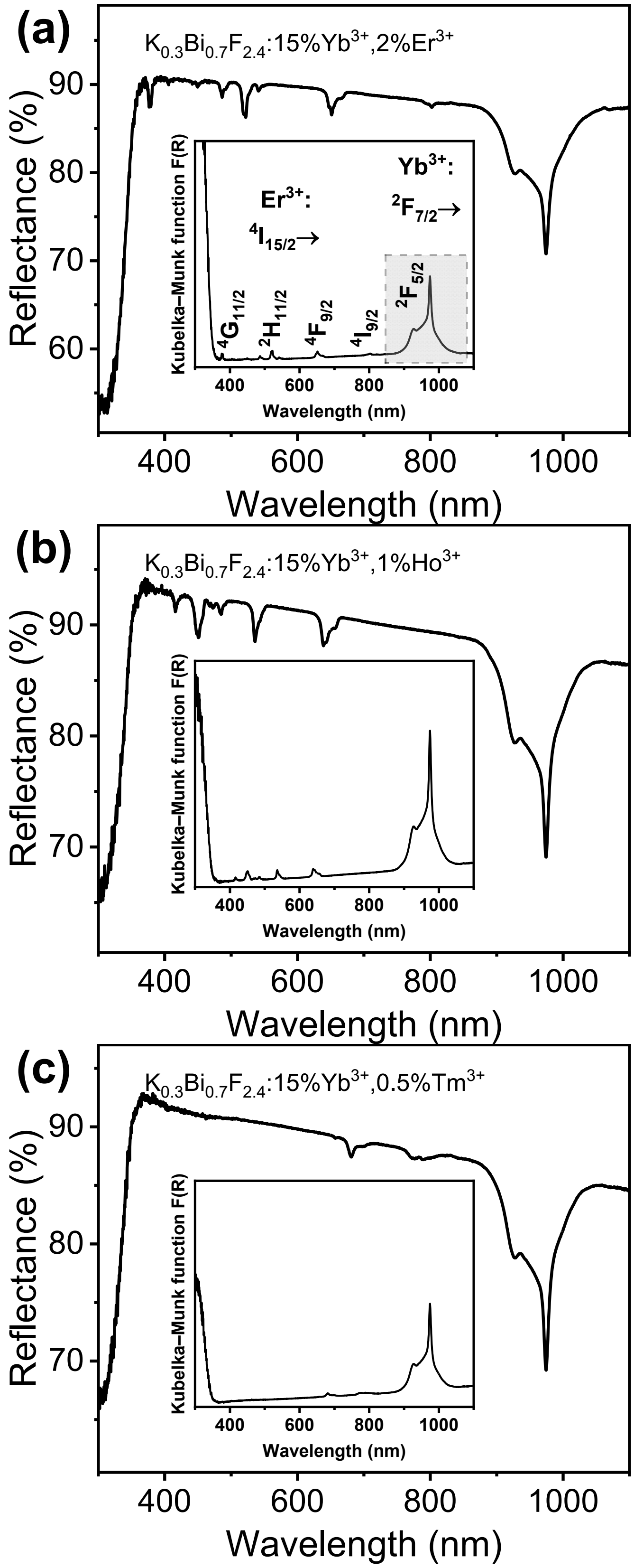

Fig. S10 Diffuse reflectance spectrum and the Kubelka–Munk function (inset) of KBF:Yb,Er (a), KBF:Yb,Ho (b) and KBF:Yb,Tm (c) nanocrystalline particles.

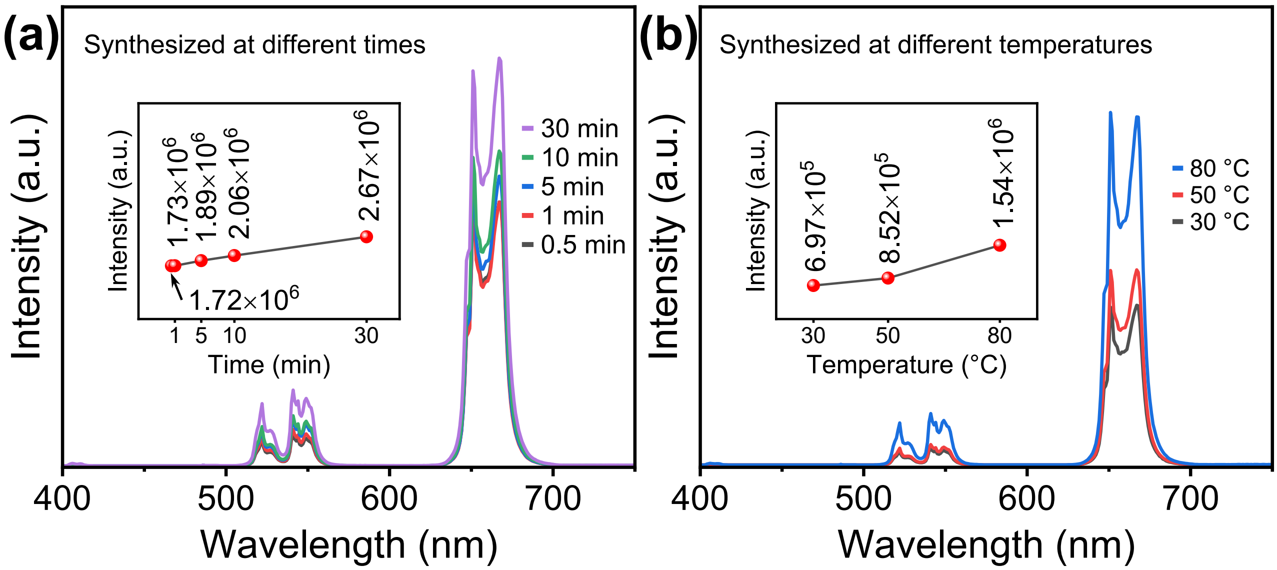

Fig. S11 Upconversion luminescence spectra of KBF:Yb,Er nanocrystalline particles synthesized at different times (a) and temperatures (b).

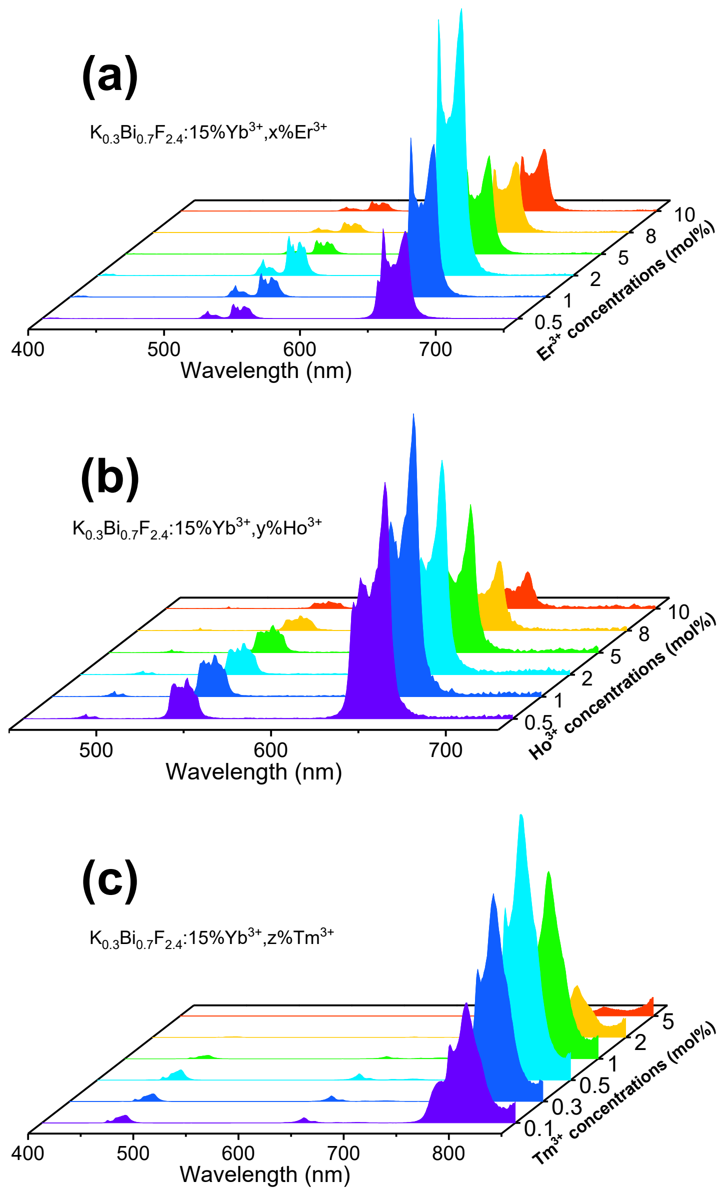

Fig. S12 Upconversion luminescence spectra of (a) KBF:15%Yb,x%Er (x = 0.5, 1, 2, 5, 8, 10), (b) KBF:15%Yb,y%Ho (y = 0.5, 1, 2, 5, 8, 10) and (c) KBF:15%Yb,z%Tm (z = 0.1, 0.3, 0.5, 1, 2, 5).

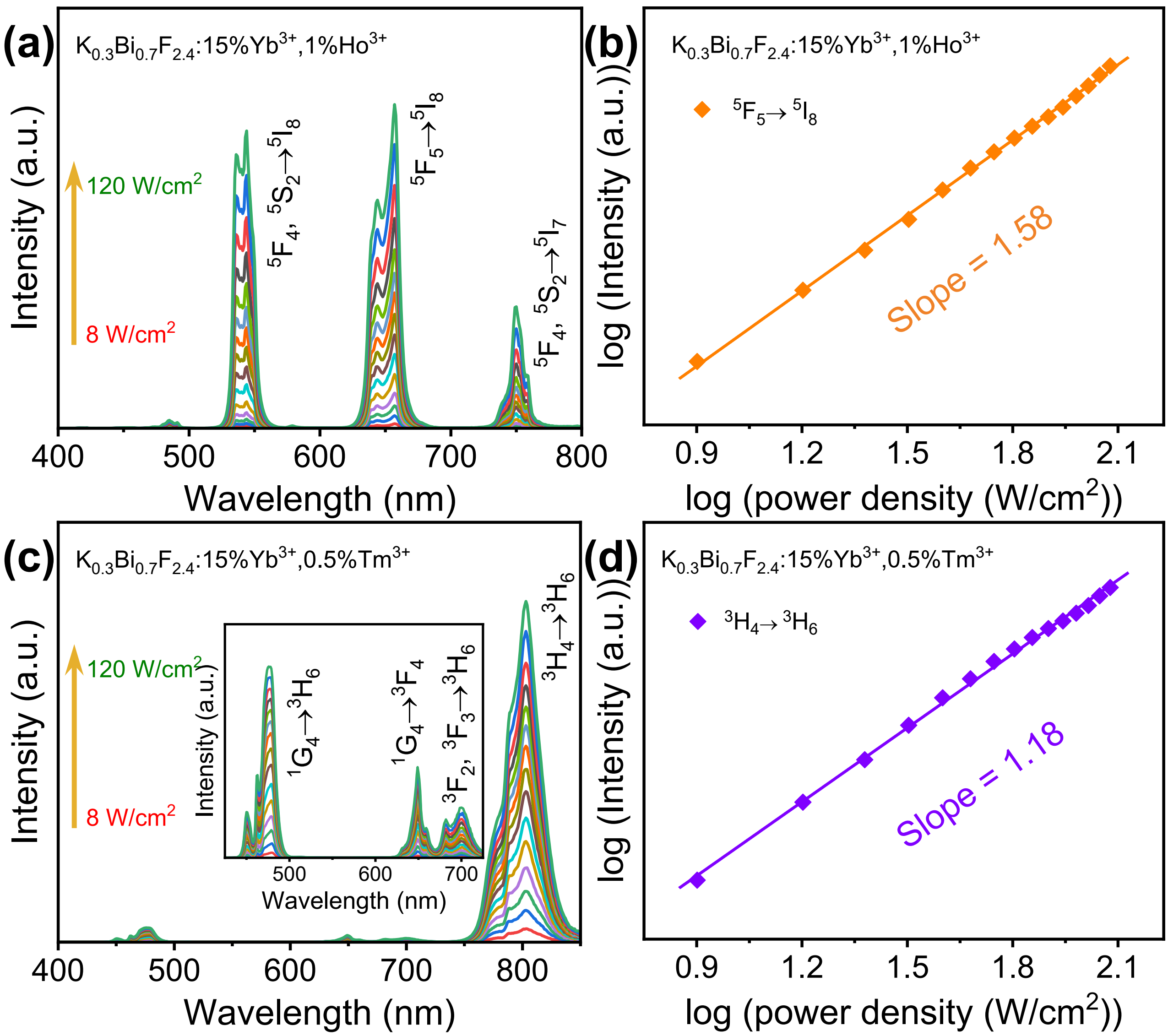

Fig. S13 (a, c) Upconversion luminescence spectra and (b, d) power dependence of red upconversion emissions of KBF:Yb,Ho and KBF:Yb,Tm samples when exciting by 980 nm laser with different output power between 8 W/cm^2 and 120 W/cm^2.

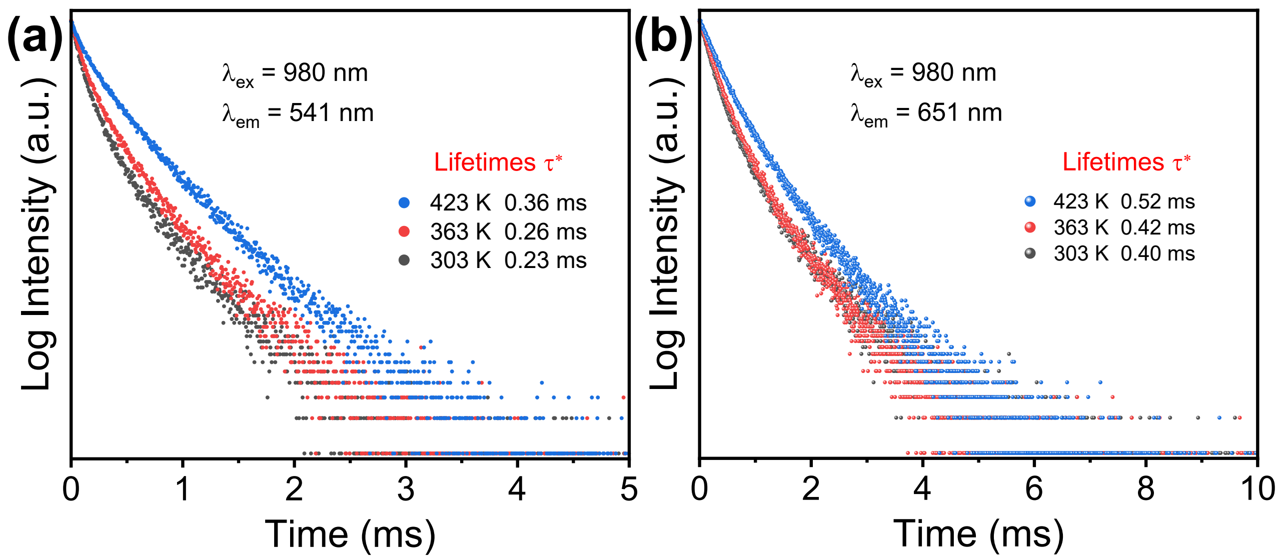

Fig. S14 Temperature-dependent decay curves of KBF:Yb,Er particles monitored at 451 nm (a) and 651 nm (b) in the temperature range of 303–423 K.

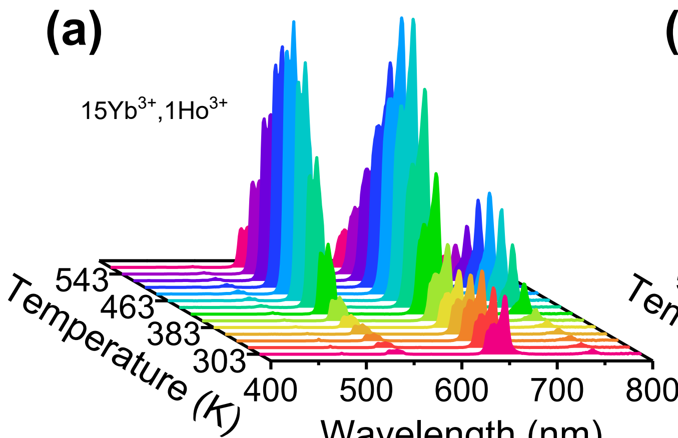

Fig. S15 Upconversion luminescence spectra of KBF:Yb,Ho (a) and KBF:Yb,Tm (b) as a function of temperature under 980 nm laser excitation.

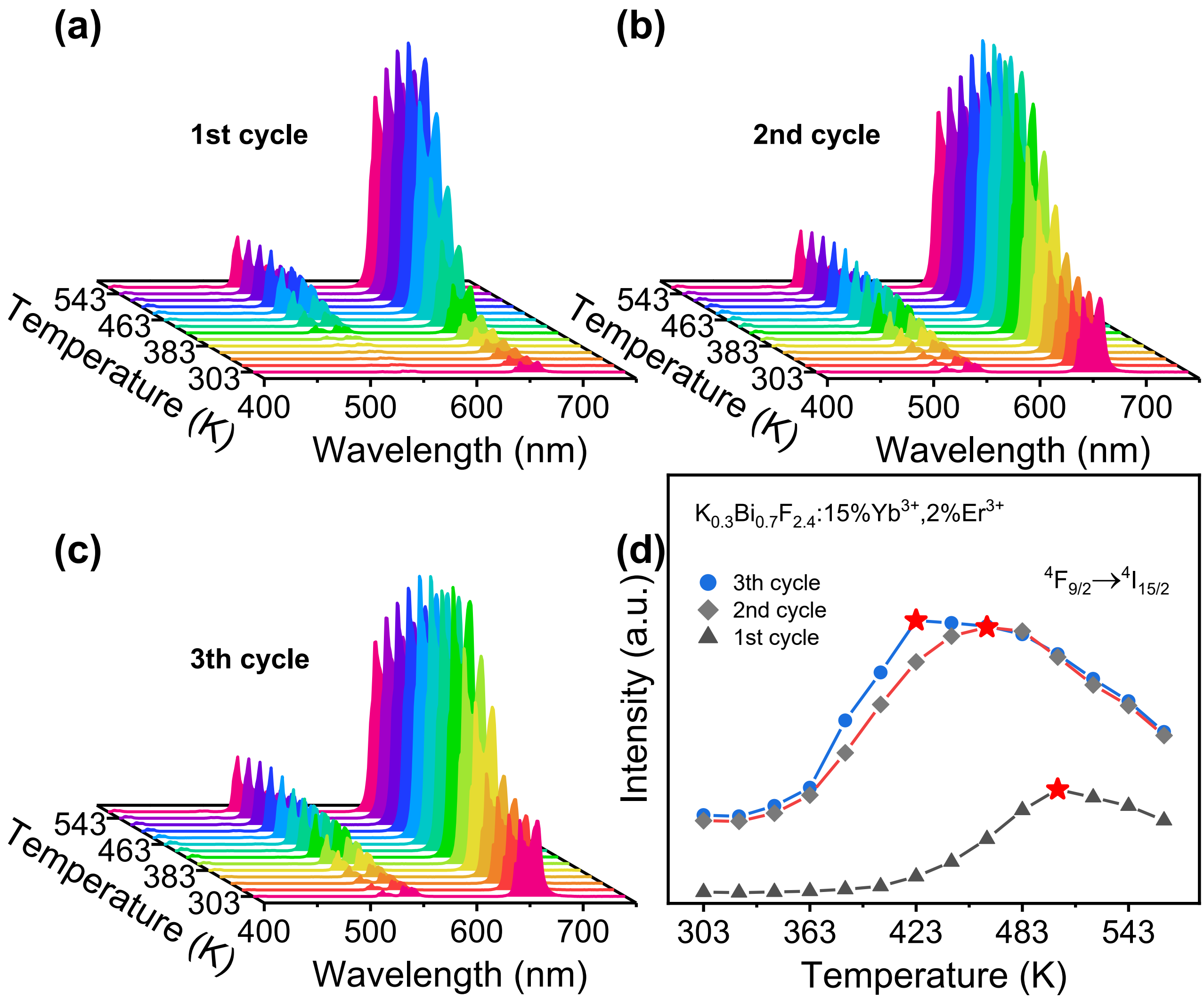

Fig. S16 Upconversion luminescence behavior of KBF:Yb,Er sample as a function of temperature in three continuous cycles. (a) 1st cycle, (b) 2nd cycle, (c) 3th cycle, (d) emission intensity of Er^{3+} at 668 nm as a function of temperature under 980 nm excitation.

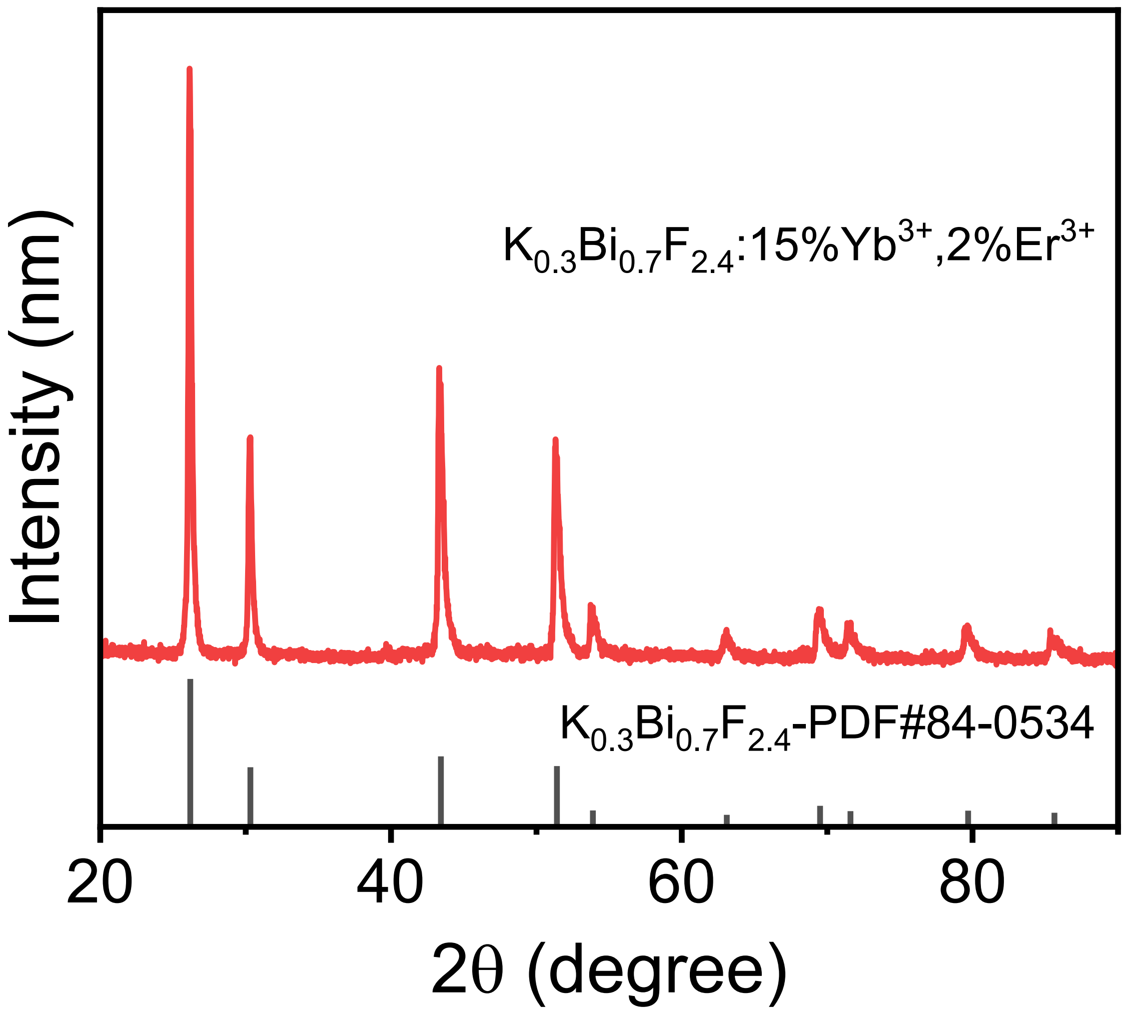

Fig. S17 XRD patterns of KBF:15%Yb^{3+},2%Er^{3+} nanocrystalline particles after three continuous heating cycles.

Table S1. Calculated lattice parameters for the standard KBF host lattice and KBF:Yb,Er nanocrystalline particles.

Parameters	Compounds			
	$K_{0.3}Bi_{0.7}F_{2.4}$ (JCPDS No. 84-0534)	$K_{0.3}Bi_{0.7}F_{2.4}$: 5%Yb^{3+},2%Er^{3+}	$K_{0.3}Bi_{0.7}F_{2.4}$: 15%Yb^{3+},2%Er^{3+}	$K_{0.3}Bi_{0.7}F_{2.4}$: 30%Yb^{3+},2%Er^{3+}
a=b=c(Å)	5.8895	5.88993	5.88981	5.88967
V (Å³)	204.28	204.33	204.32	204.30
$\alpha = \beta = \gamma$	90 °	90 °	90 °	90 °
Z	4	4	4	4
R_P	—	7.72 %	6.33 %	6.70 %
R_{WP}	—	9.85 %	8.99 %	8.85 %
χ^2	—	3.899	4.107	3.537

Table S2. The ICP analysis of KBF:Yb,Er samples.

Element	Sample weight/g	Solution volume/ml	Dilution factor	Test Indicating value/mg/L	Element concentration/ mg/kg	Element weight fraction/wt%	Element mole fraction/mol%	Doping concentration/ mol%
K	0.122	25	50	5.71848	58590.98361	5.86	8.87	
Bi	0.122	25	50	62.02075	635458.5041	63.55	17.99	
Yb	0.122	25	50	6.94177	71124.69262	7.11	2.43	11.73
Er	0.122	25	50	0.84997	8708.709016	0.87	0.31	1.49
F	Calculated				226117.1107	22.61	70.41	