Electronic Supplementary Material (ESI) for RSC Advances.

SUPPORTING INFORMATION

$CaGdF_5$ based heterogeneous core@shell upconversion nanoparticles for sensitive temperature measurement

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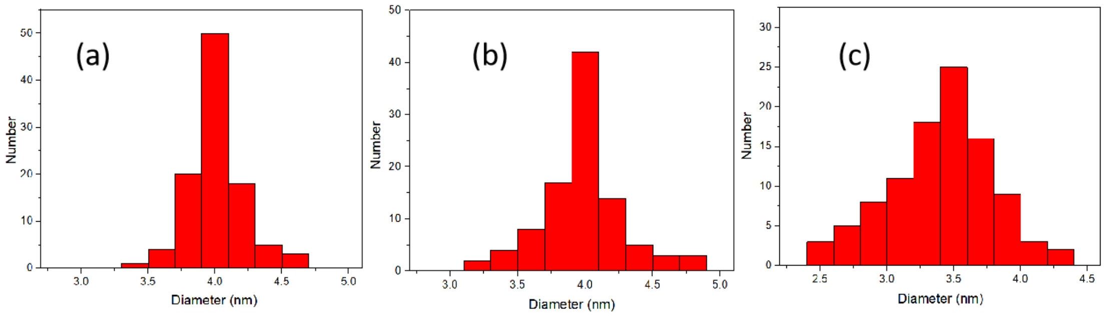
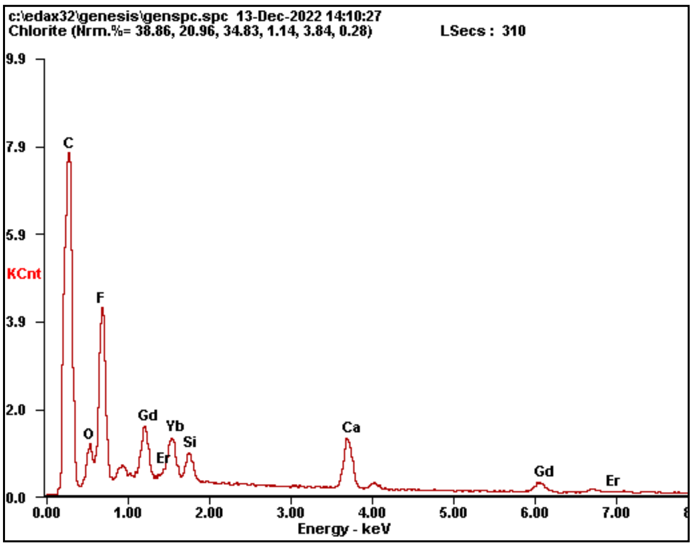


Figure S1. (a-c)Size distribution of the core samples, corresponding to Ca^{2+}/Gd^{3+} molar ratio of 0:1, 1:1, 2:1, respectively.



Element	Wt %	At %
F K	32.03	73.74
YbM	17.42	04.34
CaK	11.27	12.14
GdL	38.59	10.43
ErL	00.69	00.15

Figure S2. Energy dispersive spectra (EDS) of $CaGdF_5$ with Ca^{2+}/Gd^{3+} molar ratio of 1:1.

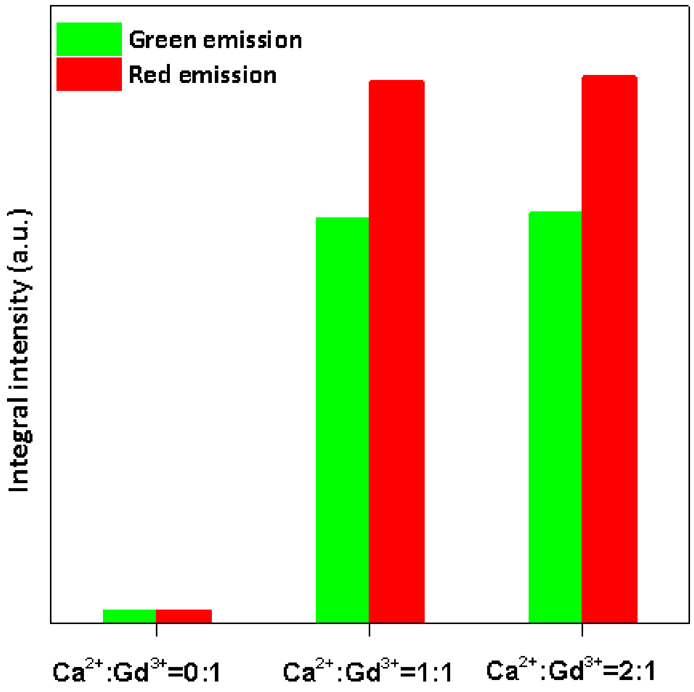


Figure S3. Integral intensities of the core UCNPs with varied Ca^{2+}/Gd^{3+} molar ratio.

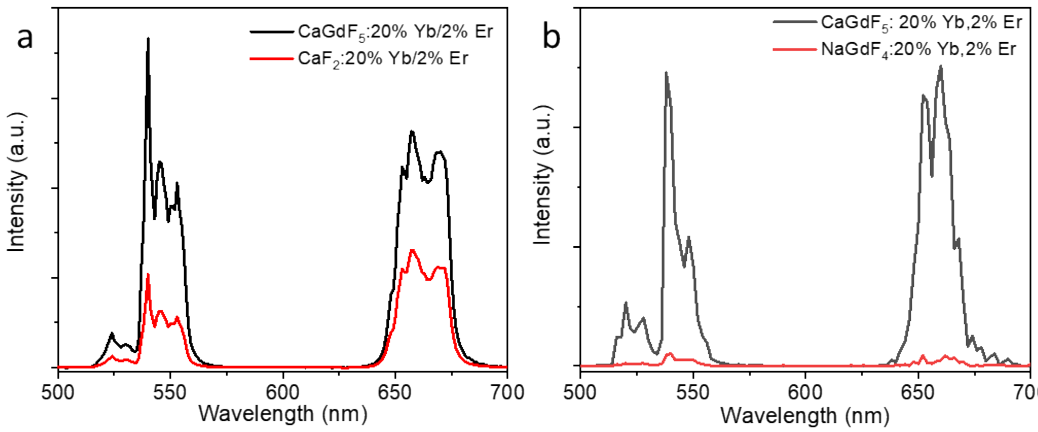


Figure S4. Upconversion emission spectra of (a) CaGdF:20% Yb,2% Er, CaF_2:20% Yb,2% Er and (b) CaGdF:20% Yb,2% Er, $NaGdF_4$:20%Yb,2%Er UCNP samples at 10 W/cm^2.

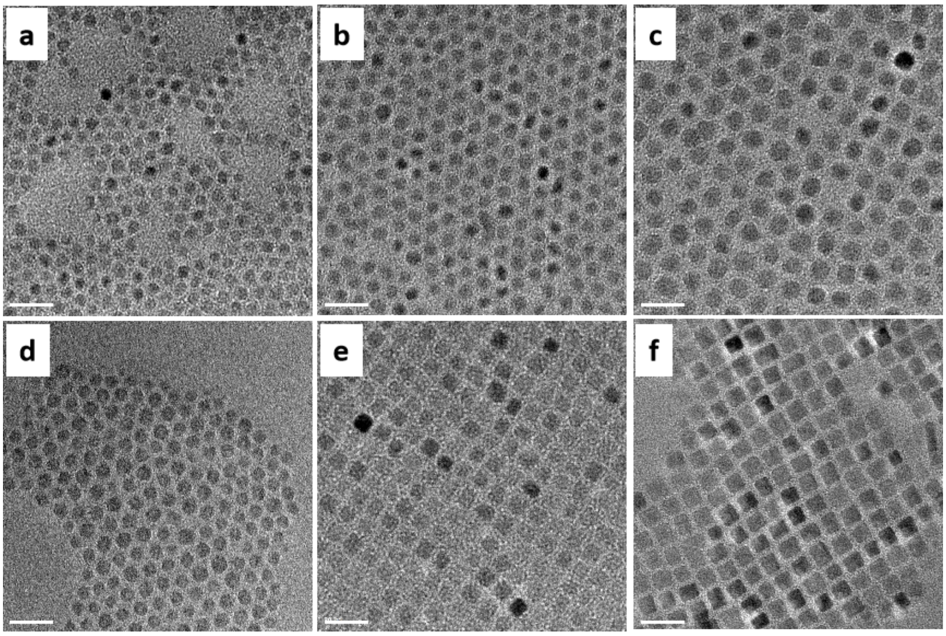


Figure S5. TEM images of (a-c) CGF@CGF and (d-f) CGF@CF UCNPs in 20 min, 40 min, and 60 min, respectively.

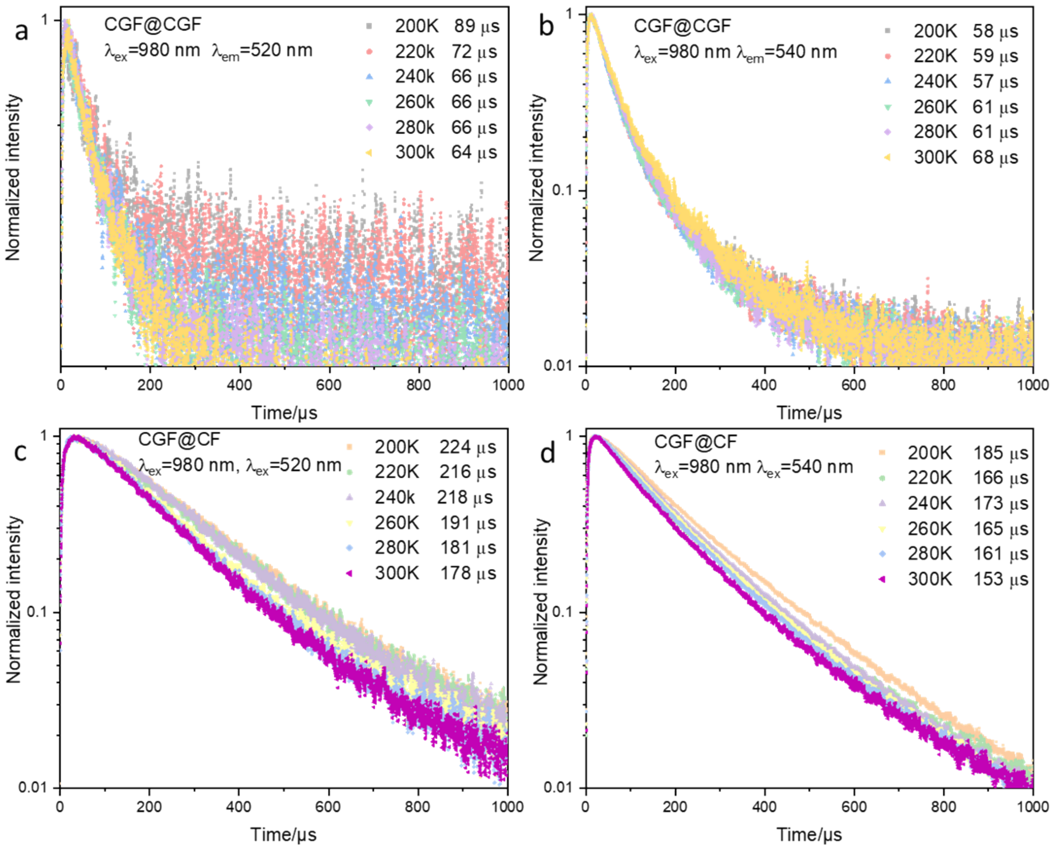


Figure S6. Decay curves of CGF@CGF and CGF@CF under 980 nm excitation at 520 nm, and 540 nm, range from 200 K to 300 K.

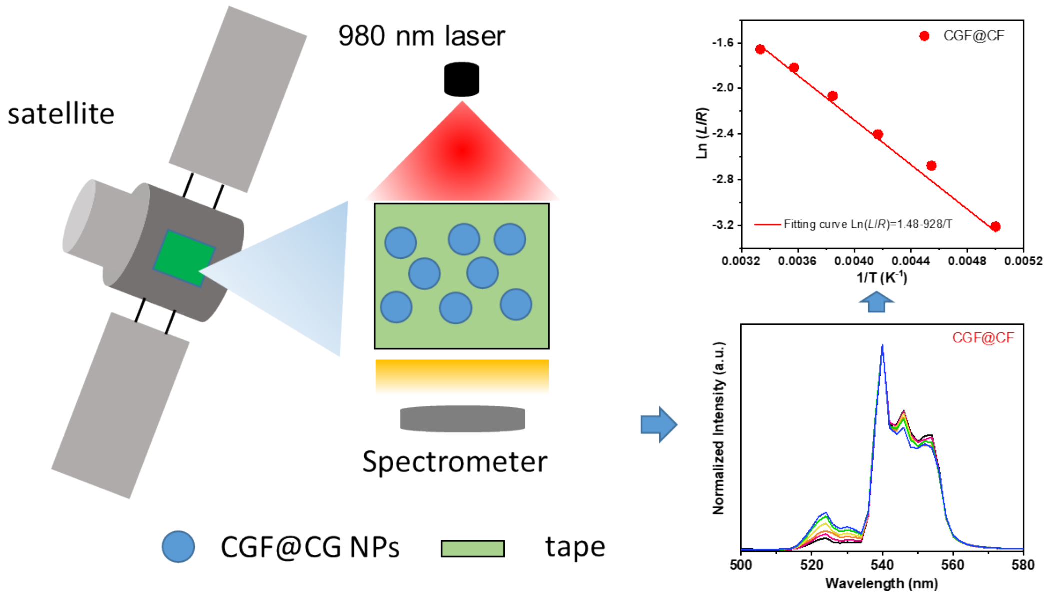


Figure S7. Schematic illustration of in-situ measurement technique in extreme environment.

Table S1. Thermometric performance of RE doped nanoparticles.

Materials	Temperature range(K)	Max-S_r (% K^{-1})	reference
$LaF_3:Yb^{3+}@LaF_3:Nd^{3+}$ NPs	288-323	0.74	1
$NaYF_4:Yb^{3+},Er^{3+}$,25%Ga^{3+} NPs	198-498	0.46	2
$LiLaP_4O_{12}:Yb^{3+},Er^{3+}$ NPs	173-350	1.80	3
$NaErF_4@NaYF_4@NaYbF_4:Tm^{3+}@NaYF_4$ NPs	293-413	0.71	4
$NaYF_4:Yb^{3+},Er^{3+}$ NPs	75-600	0.48	5
$Yb_2W_3O_{12}$: $Er^{3+}@TiO_2$: Yb^{3+}, Er^{3+} NPs	293-573	1.12	6
CGF:$Yb^{3+},Er^{3+}@CF_2$ NPs	200-300	2.48	This work

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