Supporting Information

Rational composition design of sesquioxide $(Y,Sc,Lu)_2O_3$ single-crystal fibers for robust and high-sensitivity ultrasonic temperature sensor beyond 2100 ℃

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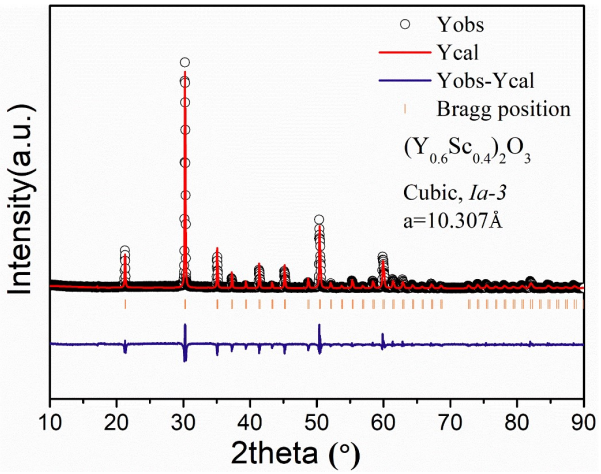

Fig. S1 The refined XRD pattern of the representative $(Y_{0.6}Sc_{0.4})_2O_3$ SCF.

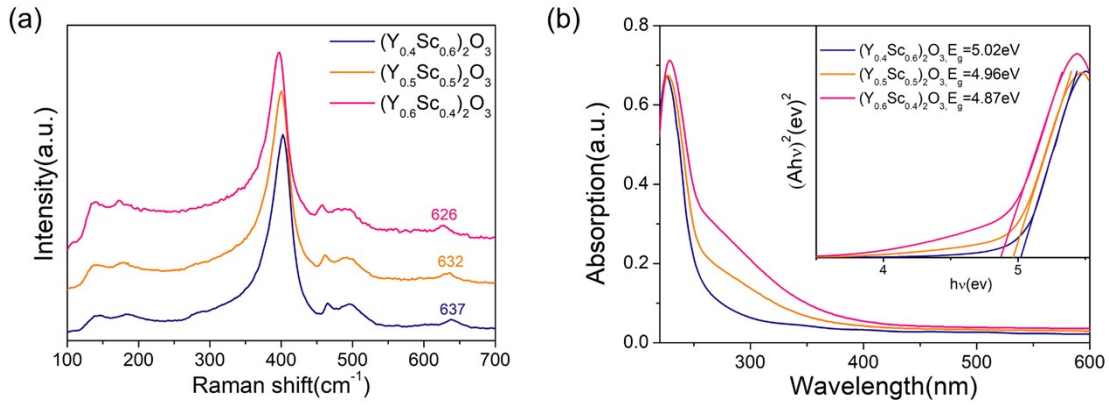

Fig. S2 (a) Raman spectra. (b) Raman spectra and diffuse reflectance spectra.

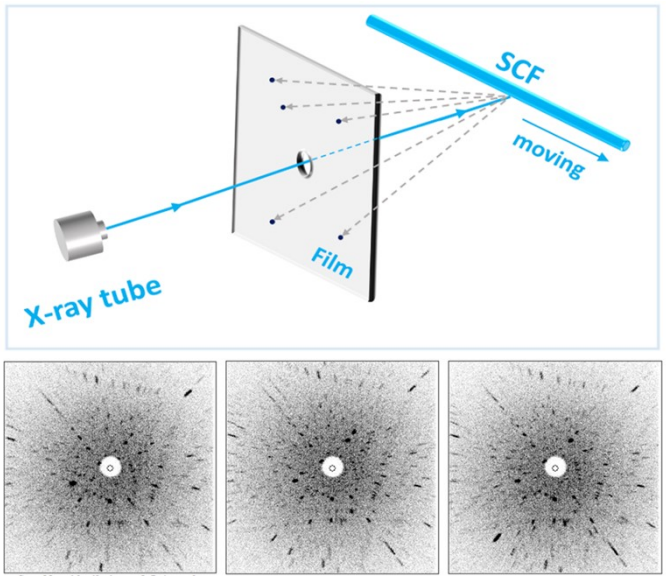

Fig. S3 The Laue diffraction patterns of the $(Y_xSc_{1-x})_2O_3$ SCF. The X-ray is perpendicular to the axis direction of the SCF.

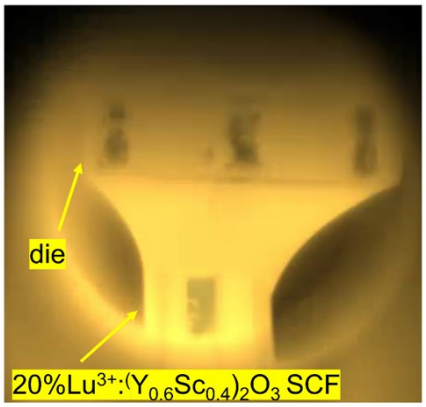

Fig. S4 The real-time crystal growth image of the 20% Lu^{3+}:$(Y_{0.6}Sc_{0.4})_2O_3$ SCF recorded by a CCD camera. The as-grown SCF and melting zone are to be separated.

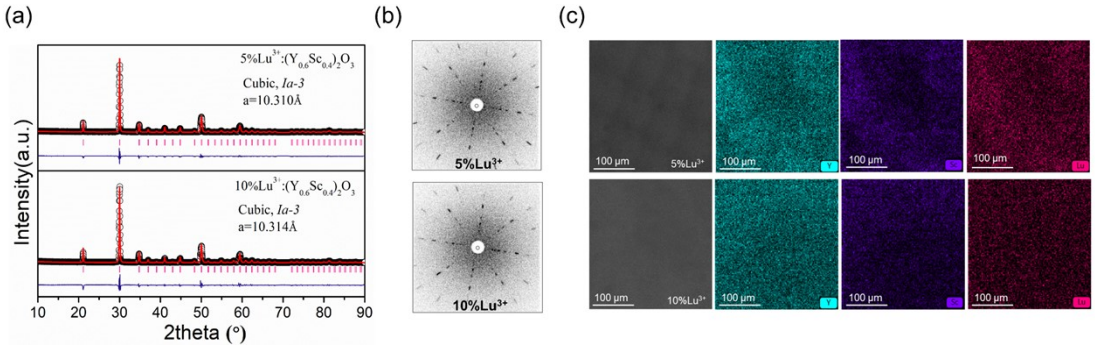

Fig. S5 (a) The refined XRD patterns of the Lu^{3+} doped $(Y_{0.6}Sc_{0.4})_2O_3$ SCF. (b) Laue diffraction patterns. (c) EDS mapping images.

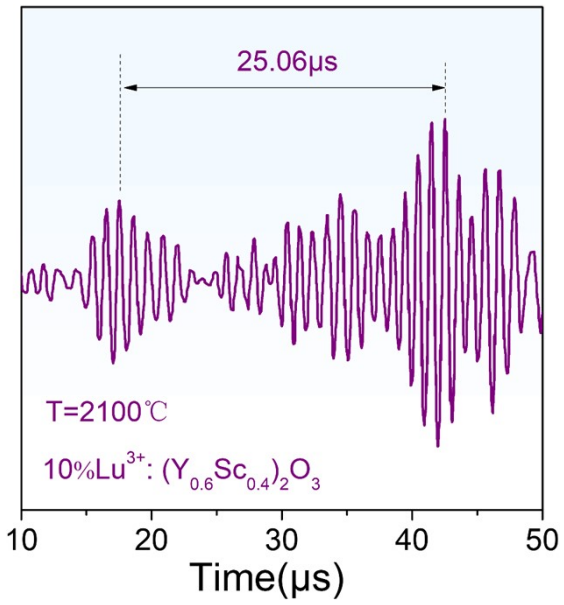

Fig. S6 The reflected signals of the 10% Lu^{3+}:$(Y_{0.6}Sc_{0.4})_2O_3$ SCF at an ultra-high temperature of 2100 ℃.

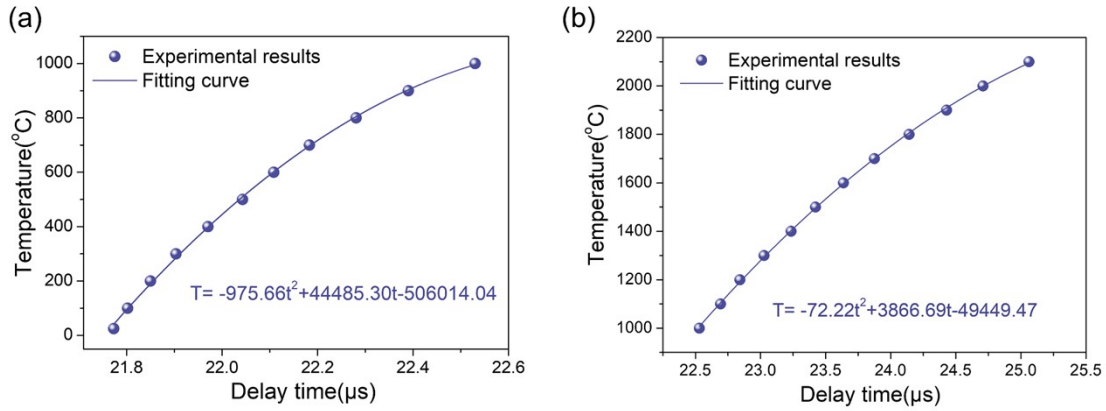

Fig. S7 The thermometry curve of the 10% Lu^{3+}:$(Y_{0.4}Sc_{0.6})_2O_3$ SCF-UTS. (a) 25~1000 ℃. (b) 1000~2100 ℃.

Table S1 The comparison of the acoustic velocity and unit sensitivity of the SCF-UTS with various compositions

SCF-UTS	Acoustic mode	Acoustic velocity (m/s)	Unit sensitivity (ns $°C^{-1}$ m^{-1})
$(Y_{0.4}Sc_{0.6})_2O_3$	P-Wave	6408.4	26.78
$(Y_{0.5}Sc_{0.5})_2O_3$	P-Wave	5772.3	30.73
$(Y_{0.6}Sc_{0.4})_2O_3$	P-Wave	5343.8	40.67
$(Y_{0.4}Sc_{0.6})_2O_3$	S-Wave	4036.3	44.68
$(Y_{0.5}Sc_{0.5})_2O_3$	S-Wave	3601.6	48.25
$(Y_{0.6}Sc_{0.4})_2O_3$	S-Wave	3177.2	52.13
5% Lu^{3+}:$(Y_{0.6}Sc_{0.4})_2O_3$	S-Wave	2984.9	60.30
10% Lu^{3+}:$(Y_{0.6}Sc_{0.4})_2O_3$	S-Wave	2754.7	66.31

Table S2 The thermometry precision of the 10% Lu^{3+}:$(Y_{0.4}Sc_{0.6})_2O_3$ SCF-UTS in the range of 25~1000 ℃.

Delay time（μs）	Fitted temperature（℃）	Actual temperature（℃）	ΔT（℃）
21.77	35.75	25	10.75
21.80	80.38	100	19.62
21.85	178.18	200	21.82
21.90	283.82	300	16.18
21.97	401.24	400	1.24
22.04	508.47	500	8.47
22.11	600.35	600	0.35
22.18	683.19	700	16.81
22.28	808.34	800	8.34
22.39	909.66	900	9.66
22.53	993.91	1000	6.09
$P = \Delta T_{max}/T_r = 21.82/975 = 2.24\%$			

Table S3 The thermometry precision of the 10% Lu^{3+}:$(Y_{0.4}Sc_{0.6})_2O_3$ SCF-UTS in the range of 1000~2100 ℃.

Delay time（μs）	Fitted temperature（℃）	Actual temperature（℃）	ΔT（℃）
22.53	1008.16	1000	8.16
22.69	1105.82	1100	5.82
22.84	1192.00	1200	-8.00
23.03	1294.48	1300	-5.52
23.23	1403.84	1400	3.84
23.42	1497.16	1500	-2.84
23.64	1597.34	1600	-2.66
23.87	1700.96	1700	0.96
24.14	1807.48	1800	7.48
24.43	1910.85	1900	10.85
24.71	1999.67	2000	-0.33
25.06	2095.93	2100	-4.07
$P = \Delta T_{max}/T_r = 10.85/1100 = 0.99\%$			