



Fig. S1 (a) Liquid nitrogen tank. (b) Temperature controller equipment and sample chamber. (c) Vacuum pump.

(d) 980 nm laser.

Liquid nitrogen tank is used for storing liquid nitrogen, which would be injected into the sample chamber for cooling down the testing sample and offer the cryogenic experiment condition. The temperature controller equipment has dual-functions of temperature indicator displaying and heating. The temperature of sample could be regulated by liquid nitrogen and heater and changed from 85 K-240 K. The measurement resolution is 0.01 K, and the temperature measurement error is less than 0.05% F.S. Vacuum pump is mainly used for offering the vacuum environment for sample chamber. 980 nm laser used in this experiment is semiconductor laser. Above accessories could cooperate with the Fluorolog-3 fluorescence spectrometer to realize temperature-dependent spectral testing.

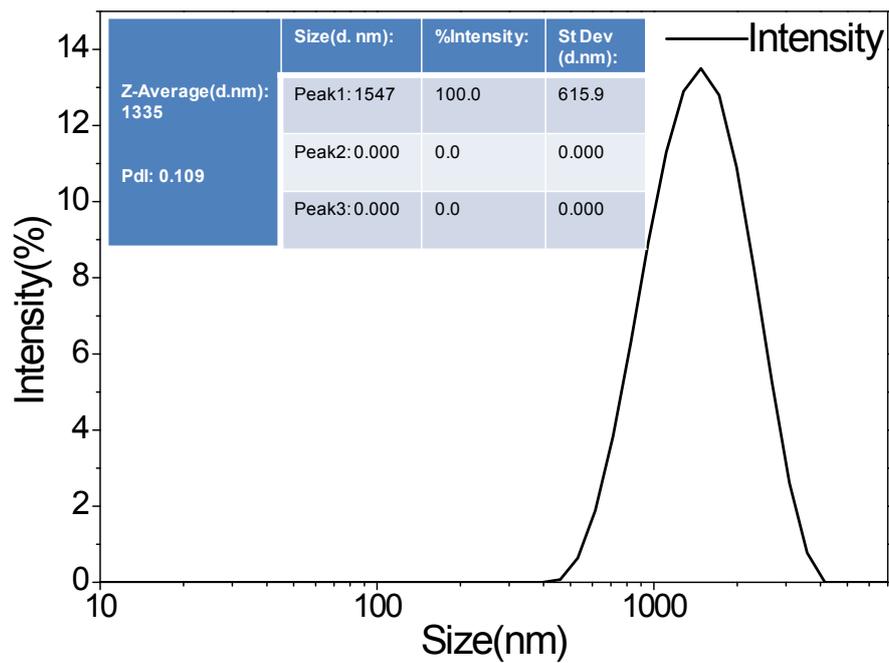


Fig. S2 Diagram of size distribution of $\text{KLa}(\text{MoO}_4)_2: \text{Yb}^{3+}/\text{Ho}^{3+}$ phosphor.

The mean particles size of $\text{KLa}(\text{MoO}_4)_2: \text{Yb}^{3+}/\text{Ho}^{3+}$ phosphor measured by DLS is about $1.335 \mu\text{m}$.

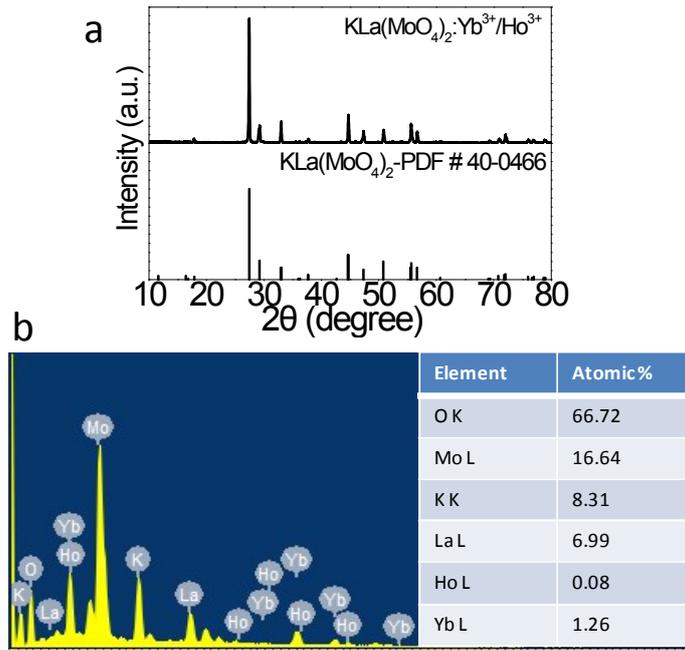


Fig. S3 (a) XRD pattern of $\text{KLa}(\text{MoO}_4)_2:\text{Yb}^{3+}/\text{Ho}^{3+}$ sample. (b) Energy-Dispersive X-Ray Spectroscopy (EDS) of $\text{KLa}(\text{MoO}_4)_2:\text{Yb}^{3+}/\text{Ho}^{3+}$ sample.

The powder X-ray diffraction study reveals that all the diffraction peak positions of $\text{KLa}(\text{MoO}_4)_2:\text{Yb}^{3+}/\text{Ho}^{3+}$ sample are well matched with that of scheelite structure of $\text{KLa}(\text{MoO}_4)_2$ (JCPDS No. 40-0466). And the content of the doped rare earth element can be confirmed by compositional analysis. In the $\text{KLa}(\text{MoO}_4)_2:\text{Yb}^{3+}/\text{Ho}^{3+}$ sample, the content percentage of the rare earth element La:Yb:Ho is 83.91%: 15.13%:0.96%.

Table S1 Chromaticity coordinates CIE (X, Y) of $\text{KLa}(\text{MoO}_4)_2:15\% \text{Yb}^{3+}/1\% \text{Ho}^{3+}$

CIE(X,Y)	Temperature
(0.3558, 0.6368)	85 K
(0.3966, 0.5963)	100 K
(0.4153, 0.578)	120 K
(0.4343, 0.5592)	140 K
(0.4444, 0.5493)	160 K
(0.4686, 0.5255)	180 K
(0.5184, 0.4765)	200 K
(0.5065, 0.4882)	220 K
(0.5184, 0.4765)	240 K

Color coordinates of the $\text{KLa}(\text{MoO}_4)_2:\text{Yb}^{3+}/\text{Ho}^{3+}$ sample at different temperature shows the color change from green area to orange area, which reveals the thermochromic luminescence of sample.

Table S2 Lifetime of $\text{KLa}(\text{MoO}_4)_2\cdot\text{Yb}^{3+}/\text{Ho}^{3+}$ excited at 980 nm and monitored at 544 nm and 664 nm at different temperature

T (K)	544 nm					664 nm				
	τ_1 (ms)	τ_2 (ms)	A_1	A_2	τ	τ_1 (ms)	τ_2 (ms)	A_1	A_2	τ
85	0.251	0.251	0.692	0.692	0.251	0.2005	0.2005	0.7233	0.7233	0.200
160	0.1796	0.1797	0.746	0.746	0.180	0.309	0.3093	0.6757	0.6757	0.309
240	0.153	0.153	0.782	0.782	0.153	0.33814	0.33813	0.6761	0.6761	0.338

The decay curves could be fitted via a double exponential equation:

$$I(t) = I_0 + A_1 \exp(-t/\tau_1) + A_2 \exp(-t/\tau_2) \quad (1)$$

Where I_0 is the initial emission intensity, $I(t)$ is the emission intensity at time t , τ_1 and τ_2 are the fast and slow components of the luminescent lifetimes, A_1 and A_2 are the fitting parameters, respectively.

The average decay lifetime can be calculated by:

$$\tau = (A_1 \tau_1^2 + A_2 \tau_2^2) / (A_1 \tau_1 + A_2 \tau_2) \quad (2)$$

So according to the equations 1 and 2, 0.251, 0.180 and 0.153 ms were obtained for green emission of 544 nm at 85 K, 160 K, 240 K, respectively. And 0.200, 0.309, and 0.338 ms were obtained for red emission of 664 nm at 85K, 160 K, 240 K, respectively.

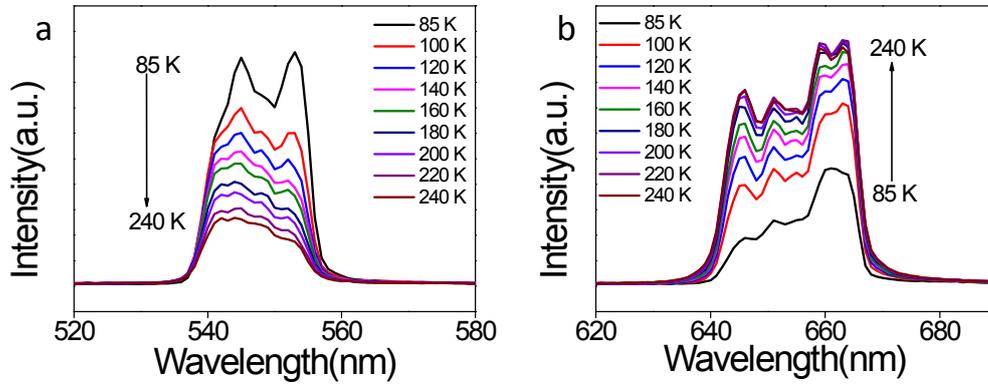


Fig. S4 Temperature dependent UC emission spectra for (a) 544 nm (${}^5F_4/{}^5S_2 \rightarrow {}^5I_8$) and (b) 664 nm (${}^5F_5 \rightarrow {}^5I_8$) of

$KLa(MoO_4)_2:Yb^{3+}/Ho^{3+}$ sample excited by 980 nm laser.

The green and red emissions corresponding to the ${}^5F_4/{}^5S_2 \rightarrow {}^5I_8$ and ${}^5F_5 \rightarrow {}^5I_8$ transitions can be clearly observed

from the UC emission spectra in the wavelength range of 520-580 nm, 620-690 nm, respectively.

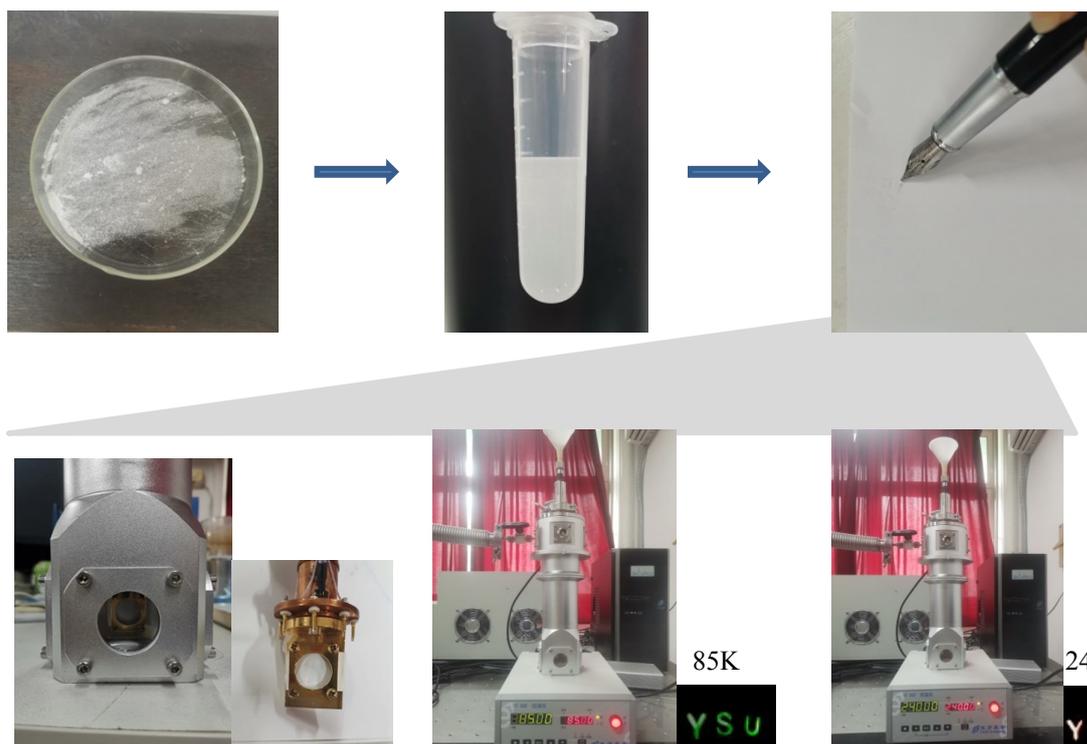


Fig.S5 The preparation of anti-counterfeiting ink and detection process of anti-counterfeiting label

The preparation of anti-counterfeiting ink as following:

First we weighed the appropriate amount of $\text{KLa}(\text{MoO}_4)_2\text{:Yb}^{3+}/\text{Ho}^{3+}$ phosphor and poured it into the ethanol solution, then used the ultrasonic vibration for 3-6 minutes. Then the prefabricated ethanol solution with dispersed $\text{KLa}(\text{MoO}_4)_2\text{:Yb}^{3+}/\text{Ho}^{3+}$ phosphor was added into the glycerol solution. Finally we used the ultrasonic vibration for 3 minutes to obtain the anti-counterfeiting ink of the phosphor stable dispersing in ethanol and glycerol.

The use of anti-counterfeiting ink and detection process of anti-counterfeiting label as following:

We used pen dipped with the synthesized fluorescence security inks to handwrite the acronym of Yanshan University (YSU) on the paper, which could be work as anti-counterfeiting label. We can observe that this label almost invisible under normal sunshine light. However, when fixing this lable in the platform of sample chamber,

we can observe “YSU” with bright green light on the label at 85 K when label was irradiated with 980 nm laser,

and the fluorescence of “YSU” could turn to deep orange as the temperature rises to 240 K.

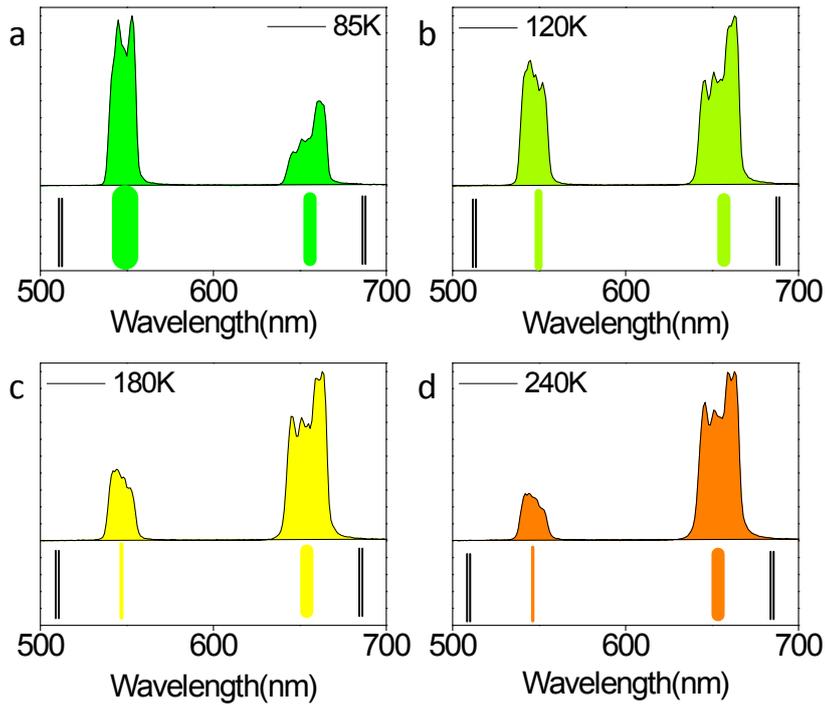


Fig. S6 Photonic barcodes on different temperature (a) 85 K, (b) 120 K, (c) 180 K, (d) 240 K.

The UC photonic barcodes are established according to the UC emission spectrum at different temperatures. It is formed by some solid bars located at the wavelength positions. The width of each bar is determined by the related UC emission intensity at that specific location. Firstly, the emission intensity data at a specific temperature should be processed by normalization. The red emission intensity peaking at 664 nm is defined as the "base value" and its corresponding barcode width is treated as "1", and the barcode width peaking at 544 nm position is determined by the ratio of the corresponding emission peak intensity at 544 nm to the emission peak intensity at 664 nm.