# Manipulating the thermometric behaviors of $Er^{3+}/Yb^{3+}/Ho^{3+}$-tridoped $La_2Mo_3O_{12}$ polychromatic upconverting microparticles via adjusting spatial mode and sensing strategy

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**Table S1.** Lattice parameters of LMO (ICSD#2107003), $LMO:Er^{3+}/0.18Yb^{3+}$ and $LMO:Er^{3+}/0.18Yb^{3+}/0.02Ho^{3+}$ microparticles

| Parameter | LMO | $LMO:Er^{3+}/0.18Yb^{3+}$ | $LMO:Er^{3+}/0.18Yb^{3+}/0.02Ho^{3+}$ |
|---|---|---|---|
| Phase | monoclinic phase | monoclinic phase | monoclinic phase |
| *a* | 17.0060 Å | 17.0034 Å | 17.0012 Å |
| *b* | 11.9520 Å | 11.9501 Å | 11.9495 Å |
| *c* | 16.0930 Å | 16.0922 Å | 16.0920 Å |
| *V* | 3103.05 Å$^3$ | 3101.93 Å$^3$ | 3100.81 Å$^3$ |
| $R_{wp}$ | - | 0.47 | 0.43 |
| $R_p$ | - | 0.26 | 0.23 |
| $\chi^2$ | - | 3.78% | 4.01% |

**Table S2.** CIE coordinates and CCT values of LMO:$Er^{3+}$/0.18$Yb^{3+}$/2*y*$Ho^{3+}$ microparticles excited at 980 nm

| Compounds | CIE coordinate | | CCT |
|---|---|---|---|
| | *x* | *y* | |
| LMO:$Er^{3+}$/0.18$Yb^{3+}$ | 0.249 | 0.728 | 6650 K |
| LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.01$Ho^{3+}$ | 0.345 | 0.635 | 5319 K |
| LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.02$Ho^{3+}$ | 0.406 | 0.578 | 4345 K |
| LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.03$Ho^{3+}$ | 0.443 | 0.544 | 3721 K |
| LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.04$Ho^{3+}$ | 0.456 | 0.532 | 3499 K |
| LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.05$Ho^{3+}$ | 0.469 | 0.519 | 3272 K |

**Sample characterization**

The X-ray diffraction (XRD) patterns of the microparticles were examined through employing a Bruker D8 Advance diffractometer (Cu K$\alpha$ irradiation). The elemental composition and morphology of the developed products were characterized via a field emission scanning electron microscope (FE-SEM; HITACHI SU3500) , in which an energy dispersive X-ray spectrometer (EDS) was attached. The chemical functional groups and thermal stability of the designed compounds were tested by a Fourier transform infrared (FT-IR) spectrophotometer (Bruker Tensor 27) and differential scanning calorimeter (SDTQ 600), respectively. In addition, the diffuse reflectance spectra of the synthesized compounds were detected by means of an ultraviolet-visible (UV-vis) spectrophotometer (Cary 500). Finally, the UC emission properties of the resultant micron-sized particles were investigated by using a fluorescence spectrometer (Edinburgh FS5), in which a pump power controllable 980 nm laser diode and a heating stage (Linkam HFS600EPB2) were attached.

**Calculation of CCT values of LMO:$Er^{3+}$/0.18$Yb^{3+}$/2*y*$Ho^{3+}$ microparticles**

The correlated color temperature (CCT) values of final products as a function of doping content were investigated through applying the following expressions:[S1]

$$CCT = -437n^3 + 3601n^2 - 6846n + 5514.31 \quad (1)$$

$$n = (x - x_e)/(y - y_e) \quad (2)$$

where $(x_e, y_e)$ = (0.3320,0.1858) and $(x,y)$ refers to the color coordinate of synthesized microparticles. With the aid of these functions as well as the calculated CIE coordinate as listed in Table S2, the CCT values of LMO:$Er^{3+}$/0.18$Yb^{3+}$/2$y$$Ho^{3+}$ microparticles are calculated to be about 6650, 5319, 4345, 3721, 3499 and 3272 K, respectively, when $y$ = 0.00, 0.01, 0.02, 0.03, 0.04 and 0.05.

**References**

S1. P. Du, L. Luo, W. Cheng, *J. Am. Ceram. Soc*. 2020, **103**, 1149-1155.

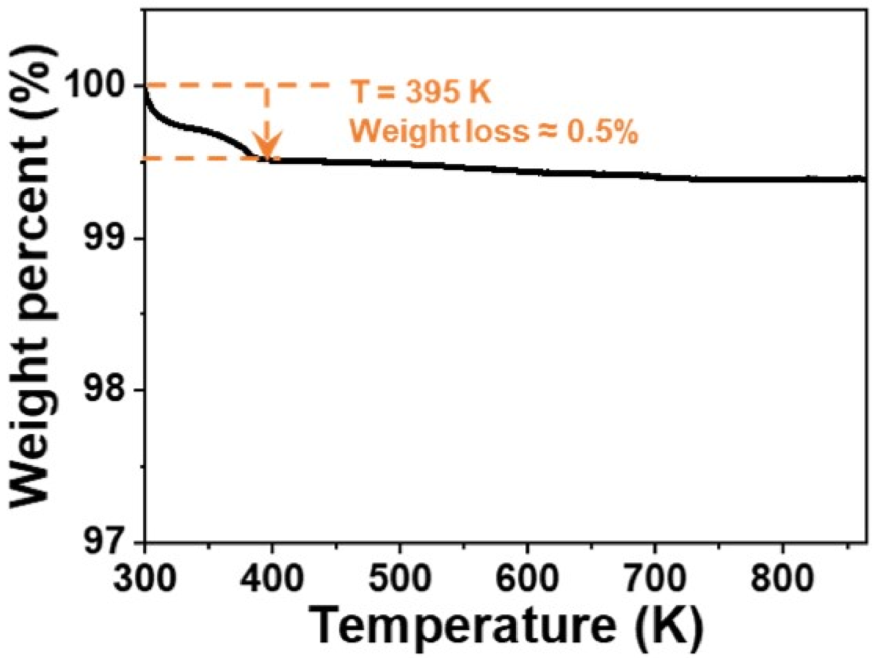


**Figure S1** Thermogravimetric spectrum of the LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.02$Ho^{3+}$ microparticles.

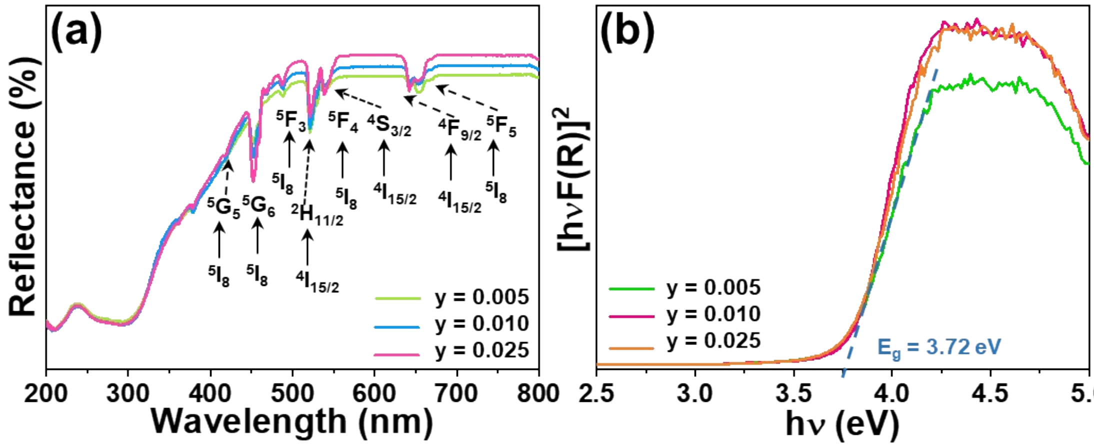


**Figure S2** (a) Diffuse reflection spectra of the LMO:$Er^{3+}$/0.18$Yb^{3+}$/2$y$$Ho^{3+}$ ($y$ = 0.005,0.01,0.025) microparticles. (b) Relationship of $[F(R)(h\nu)]^2$ *vs*. $h\nu$.

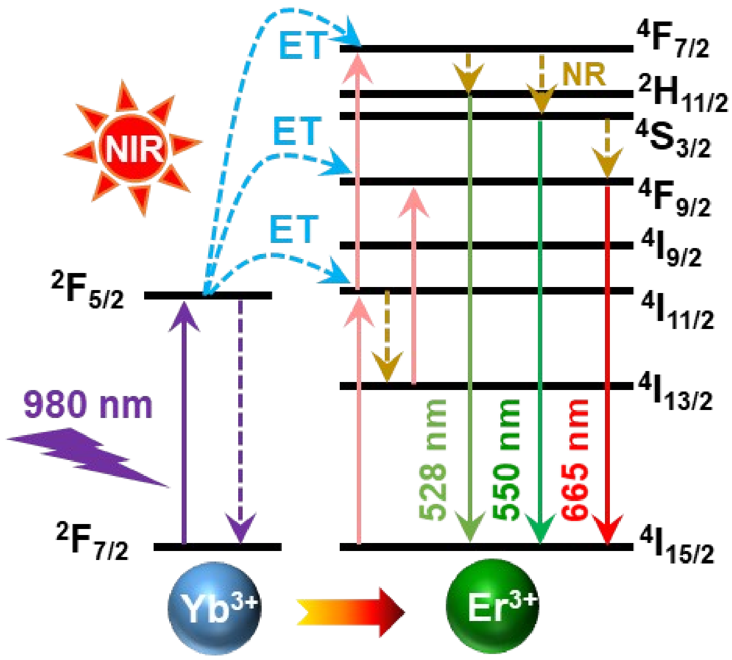


**Figure S3** Energy level diagram of $Er^{3+}$ and $Yb^{3+}$ in the LMO:$Er^{3+}$/2$x$$Yb^{3+}$ microparticles.

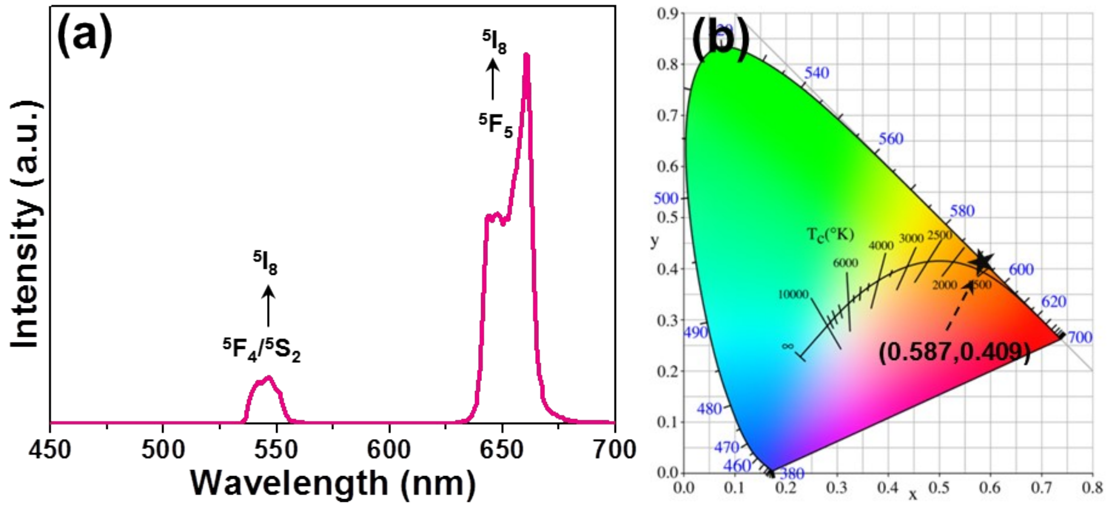


**Figure S4** (a) UC emission spectrum and (b) CIE chromaticity diagram of LMO:0.02$Ho^{3+}$/0.18$Yb^{3+}$ microparticles excited at 980 nm light.

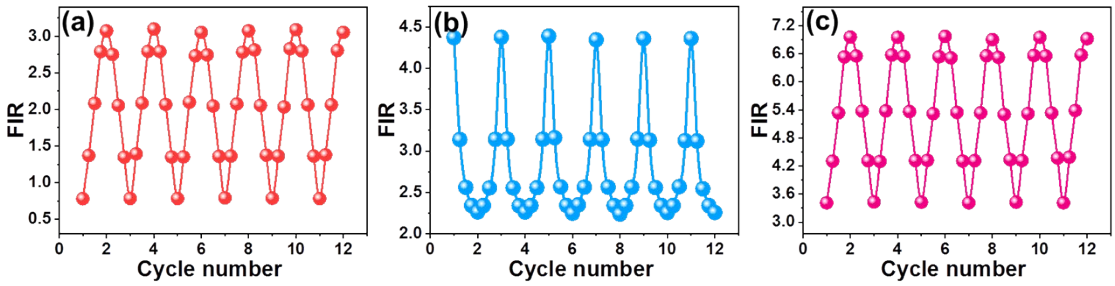


**Figure S5** Temperature-dependent switching of FIR values of the LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.02$Ho^{3+}$ microparticles based on (a) TCLs of $Er^{3+}$, (b) non-TCLs of $I_{660}/I_{530}$ combination and (c) non-TCLs of $I_{660}/I_{553}$ combination.

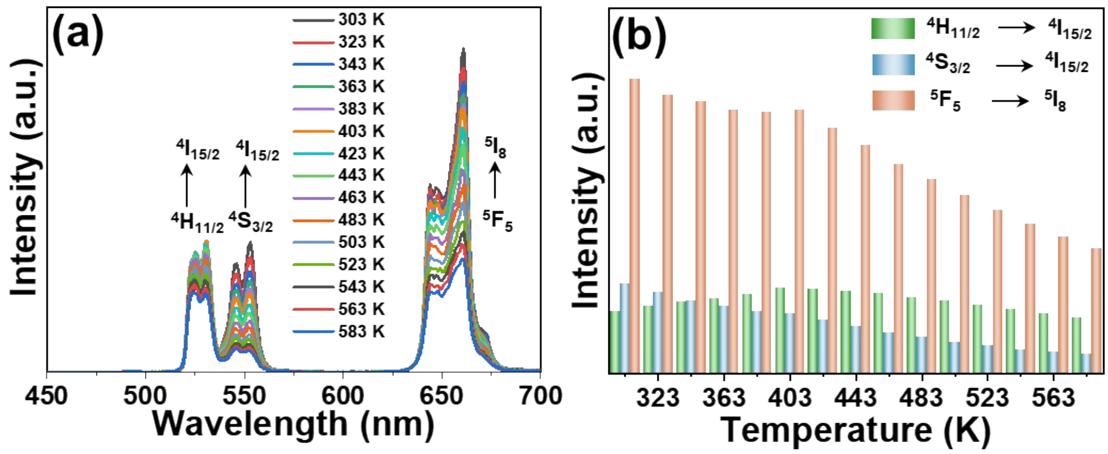


**Figure S6** (a) UC emission spectra and (b) UC fluorescence intensities of LMO:$Er^{3+}$/0.18$Yb^{3+}$/0.03$Ho^{3+}$ microparticles at various temperatures.