Supporting Information of

Enhanced up-conversion photoluminescence in fluoride-oxyfluoride nanophosphor films by embedding gold nanoparticles

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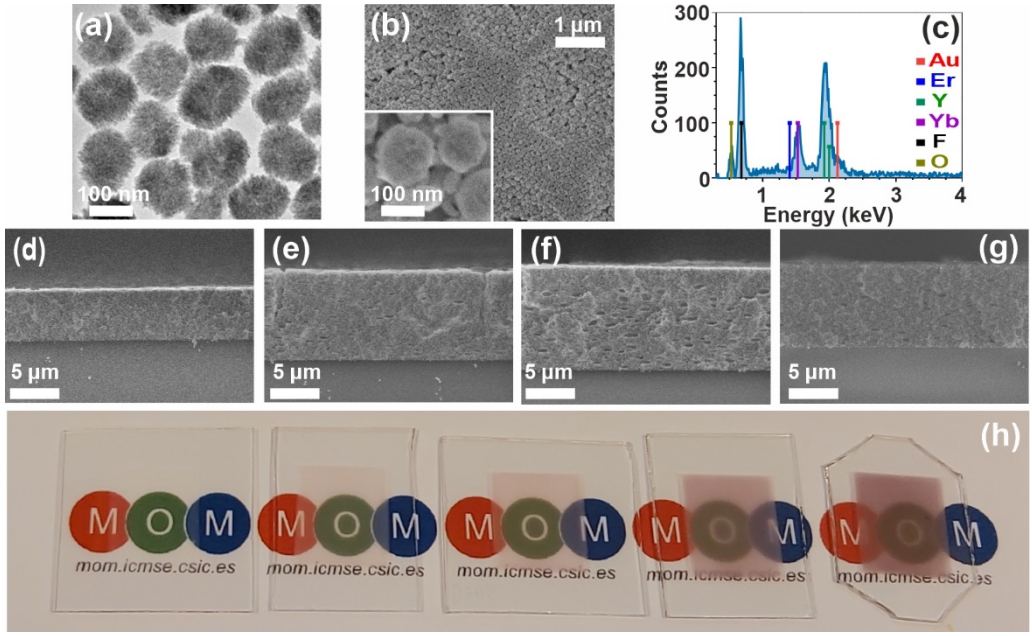

Figure S1. (a) TEM image of YF_3:Yb-Er phosphor NPs. (b) SEM image of a top view of a nanophosphor film without gold NPs embedded. (c) Elemental analysis in a region (shown in Figure 1d) of a nanophosphor film containing 2 wt% of gold NPs. (d-g) SEM images of a cross section of reference nanophosphor films (devoid gold NPs) (d), and with embedded gold NPs with 0.125 wt% (e), 0.5 wt% (f) and 2.0 wt% (g). (h) Pictures of nanophosphor films without (first image from the left) and with embedded gold NPs - concentration increases from left to right: 0.125, 0.25, 0.5 and 1.0 wt%-.

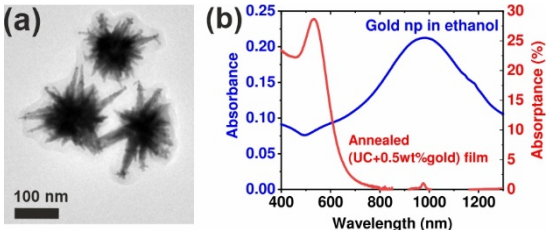

Figure S2. (a) TEM image of commercial gold-SiO_2 core-shell nanoparticles, referred as gold nanoparticles, purchased from Nanoimmunotech, with core diameter of 107 nm ± 4 nm and shell thickness of 11 nm ± 1 nm. (b) Absorbance spectrum of gold nanoparticles dispersed in ethanol (blue line) and absorptance spectrum of a nanophosphor film with 0.5 wt% embedded gold nanoparticles after thermal annealing at 400 °C for 30 minutes (red line).

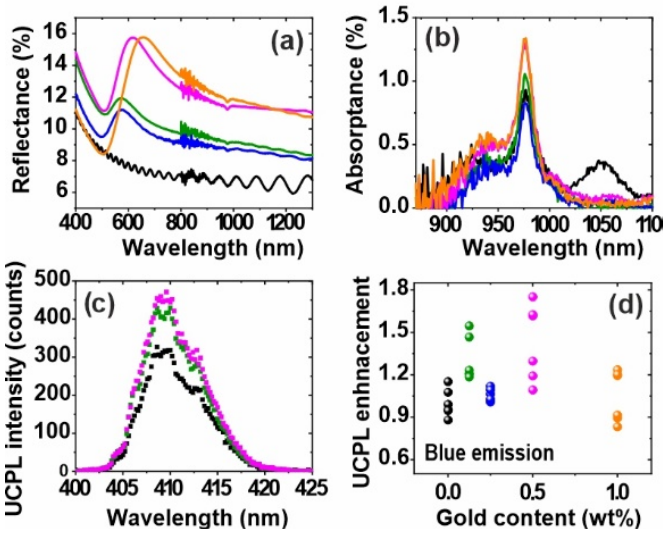

Figure S3. (a) Total reflectance, (b) background-subtracted absorptance and (c) averaged UCPL curves of blue emission bands of nanophosphor films containing different embedded gold content: 0 wt% (black), 0.125 wt% (green), 0.25 wt% (blue), 0.5 wt% (purple) and 1.0 wt% (orange). (d) UCPL enhancement of blue emission bands as function of embedded gold contents. Integrated UCPL (between 400 and 425 nm) is normalized to the average of the integrated UCPL of reference nanophosphor films (devoid embedded gold NPs). PL measurements are performed using a 980 nm continuous wave laser as excitation source.

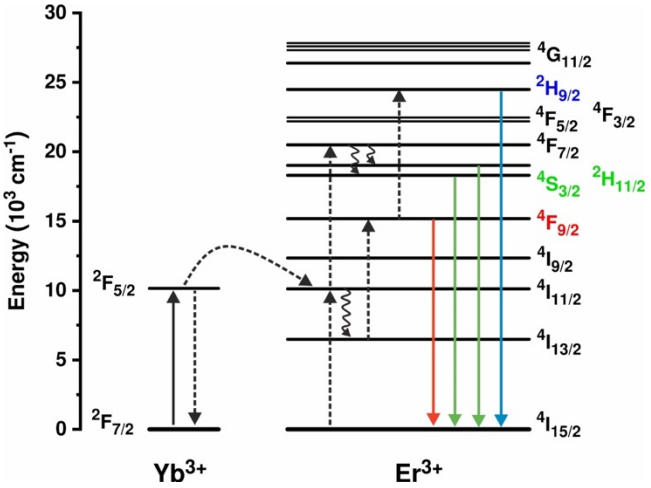

Figure S4. Energy-level diagram of Yb^{3+} and Er^{3+} ions and energy transfer processes. The energy level data are taken from Ref. [1].

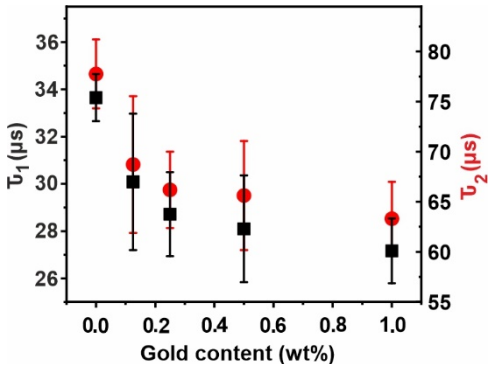

Figure S5. Lifetime components as function of gold content.

Gold content (wt%)	w_1 (%)	τ_1 (µs)	w_2 (%)	τ_2 (µs)	τ (µs)
0	75.5	34.5	24.5	81.8	46.1
	74.4	34.6	25.6	80.1	46.3
	68.1	33.7	31.9	77.4	47.6
	65.3	32.2	34.7	72.8	46.2
	71.7	33.2	28.3	76.8	45.5
Average	71.0	33.6	29.0	77.8	46.3
0.125	52.4	25.7	47.6	59.9	42
	82.1	30.2	17.9	66.2	36.7
	65.4	29.3	34.6	66.2	42
	73.7	32.1	26.3	75.5	43.7
	84	33.1	16	75.8	40
Average	68.9	30.1	31.1	69.4	40.9
0.25	63.3	28.7	36.7	66.4	42.5
	56.7	27.1	43.3	63.4	42.7

	59.3	26.8	40.7	61.5	41
	67.9	30.6	32.1	69.2	43
	67.7	30.4	32.6	70.5	43.6
Average	63	28.7	37.1	66.2	42.6
0.5	76.4	28.7	23.6	67	37.7
	58.6	25.3	41.4	59.4	39.4
	65.6	28.6	34.4	64.8	41.1
	71.3	31.3	28.7	74	43.4
	56.7	26.7	43.3	62.9	42.4
Average	65.7	28.1	34.3	65.6	40.8
1.0	63.2	27.9	36.8	64	41.2
	56.8	26.6	43.2	61.2	41.5
	73.8	29.1	26.2	69.2	39.6
	61.7	26.8	38.3	62.5	40.4
	58	25.5	42	59.7	39.8
Average	62.7	27.2	37.3	63.3	40.5

Table S1. Fitting Parameters of time-dependent UCPL measurements.

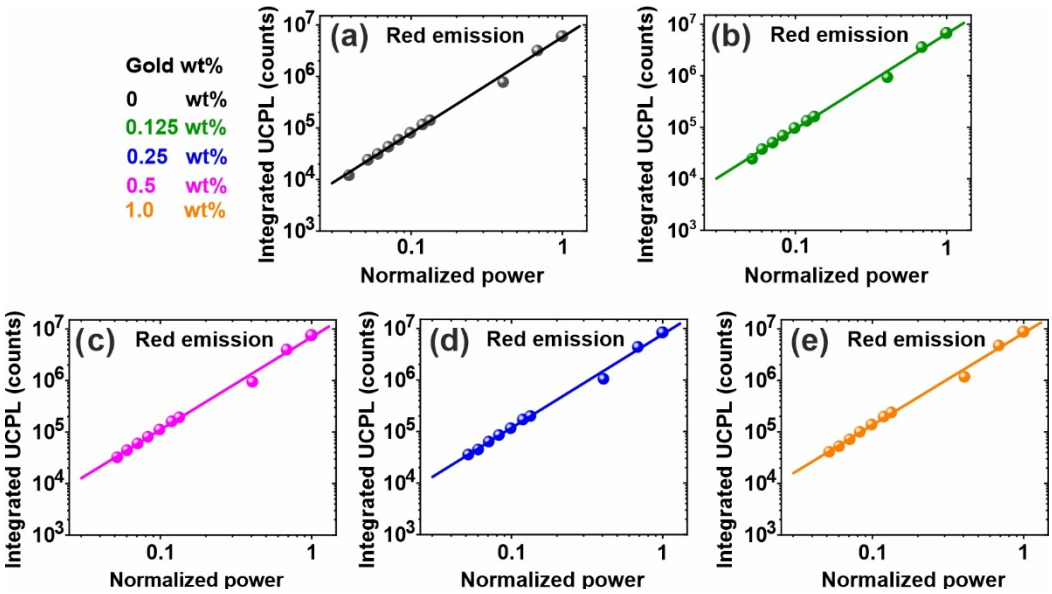

Figure S6. Integrated UCPL intensities (dots) of the red emission (between 620 nm and 720 nm) of nanophosphor films that contain different amounts of gold NPs as a function of the excitation power. Linear fitting is also shown as solid line. Samples are excited with a 980 nm continuous wave laser operating at full power and a computer-controlled neutral density filter wheel is used to attenuate the output of the laser.

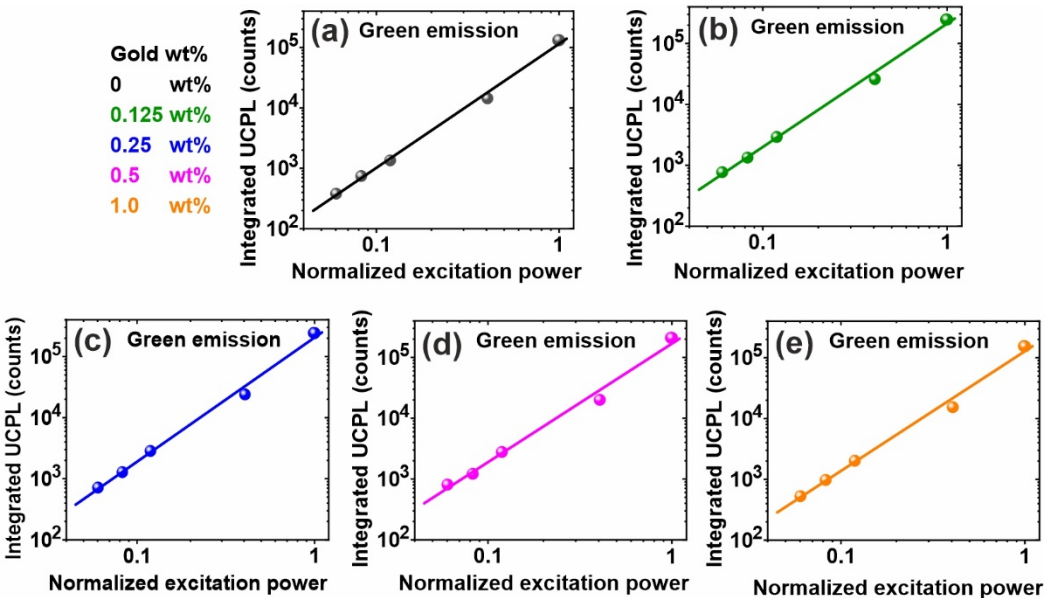

Figure S7. Integrated UCPL intensities (dots) of the green emission (between 510 nm and 570 nm) of nanophosphor films that contain different amounts of gold NPs as a function of the excitation power. Linear fitting is also shown as solid line. Samples are excited with a 980 nm continuous wave laser operating at full power and a computer-controlled neutral density filter wheel is used to attenuate the output of the laser.

References

1 V.S. Sastri, Jean-Claude Buzli, V. Ramachandra Rao, G.V.S. Rayudu and J.R. Perumareddi, *Modern Aspects of Rare Earths and Their Complexes*, Elsevier, 2003.