Experimental details

Synthesis

Synthesis of the core-shell nanophosphors (NPs) -gold was done by employing a facile one-pot technique. 0.2 M solution of YCl_3 (78% by Molecular Weight), $YbCl_3$ (20%) and $ErCl_3$ (2%) were mixed with 0.2 M sodium citrate and 1 M NaF (Sigma Aldrich) solution in a 1:2:4 volume ratio and heated to 90 ^{0}C. Then 1.52 μmoles of 0.1% $HAuCl_4$ (Alfa Aesar) were added to the white colored solution, and the heating was continued for two and half hours. The synthesis of core nanophosphor was done with the same above procedure without the addition of the $HAuCl_4$, resulting in white colored nanoparticles. The nanoparticles were centrifuged and dried at 80-100 ^{0}C. The resulting xerogel was crushed and heated to 350 ^{0}C for 12 h in N_2 flow furnace.

Powder X-ray diffraction

The phases of the calcined powders of coated and uncoated NPs were characterized by Sintag XDS 2000 fitted with a copper Kα source, operating at -45KV and 40 mA. Powdered samples were spread on a low background glass slide and scanned in a 2θ-2θ geometry from 10 to 60 degrees.

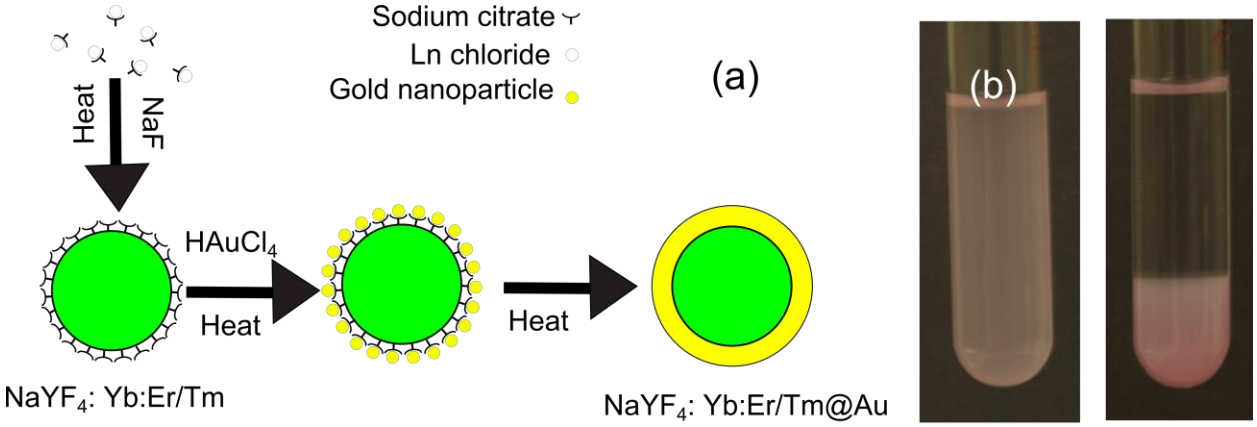
Transmission electron microscopy

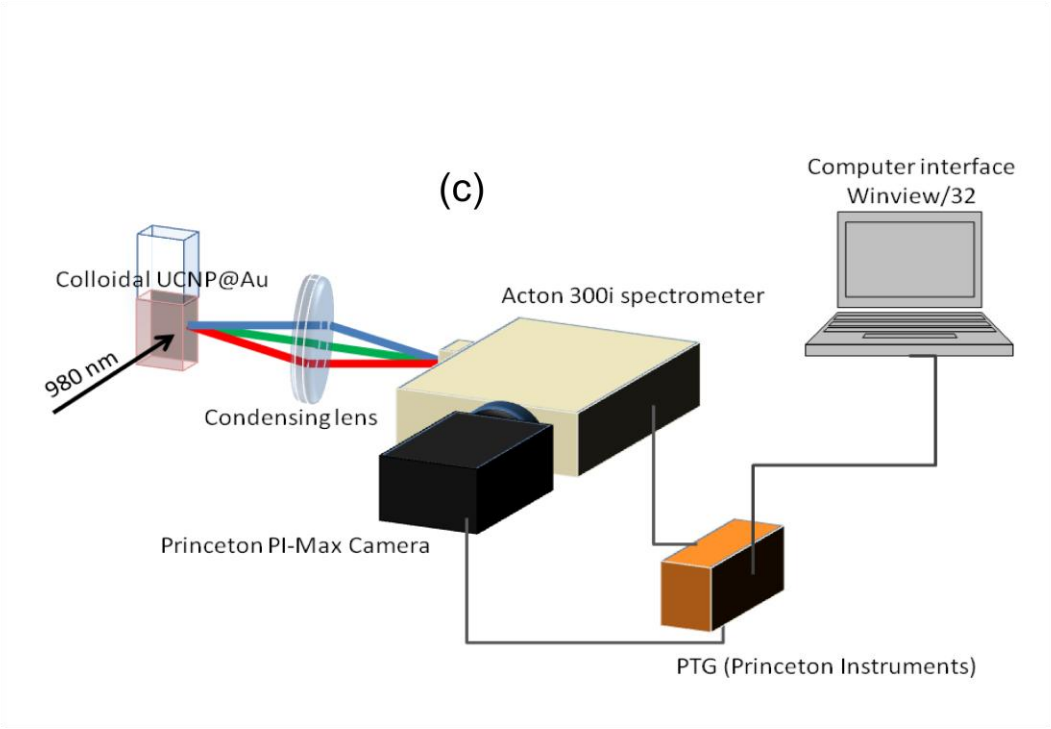
The powder samples were deposited on a formvar/carbon coated copper grids from a water solution, dried before taking the bright field transmission electron micrographs from Phillips CM-12 operating at 120KeV and 15 mA. The HAADF-STEM images were taken using a field emission gun JEOL JEM 2500SE (S)TEM instrument operated at 200kV with a 1nm spot size and 800 mm camera length, corresponding to an inner and outer semi-collection angle of 35 and 90 mrad, respectively.

Dynamic light scattering experiments, Absorbance and emission (Phosphorescence)

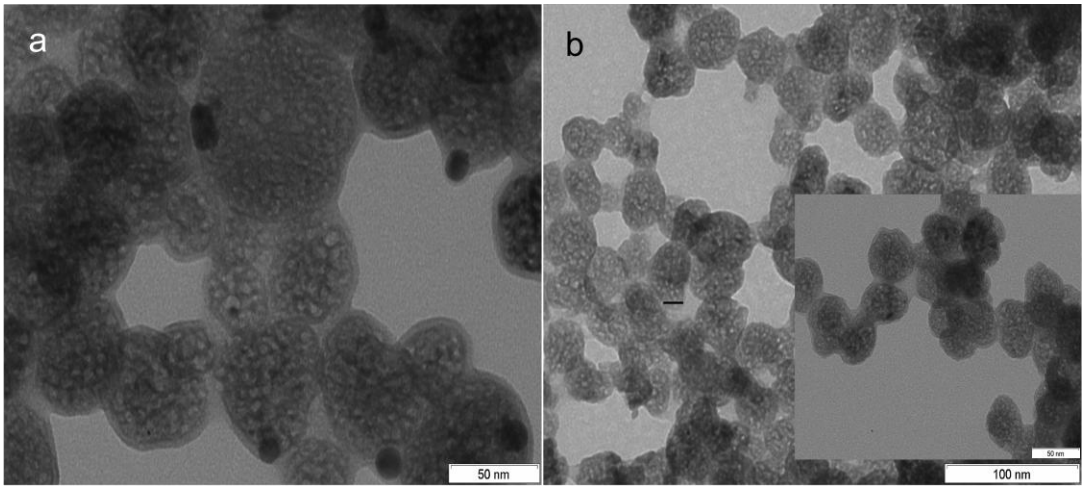
A 0.1% solution of these core-shell nanoparticles was prepared in water. The Dynamic light scattering experiments were performed with the Brookhaven ZetaPlus instrument. The experiments. A single run was of two minutes duration and the data was averaged over five runs for each sample. The absorbance of this solution was measured by spectramax M2 from Molecular Devices in a quartz cuvette.

Upconversion emission experiments were performed by a continuous wave laser (Lasermate) operating at 975 nm. The PTG (Princeton instruments controlled the shutter on the Princeton Instruments PI-MAX camera fitted with a charge-coupled device sensor. The photons emitted by the upconverting NP were focused on to Acton spectrapro 300i series spectrometer by objective and condensing lenses. The controller, the camera and the spectrometer were synchronized by Winview/32 software provided by Princeton Instruments.
Quartz cuvette was used in all experiments and the laser with a power density of 67W/cm^{-2} was focused on the quartz cuvette and the emission collected by a combination of condensing lens that focused the light on the slit of the spectrometer.

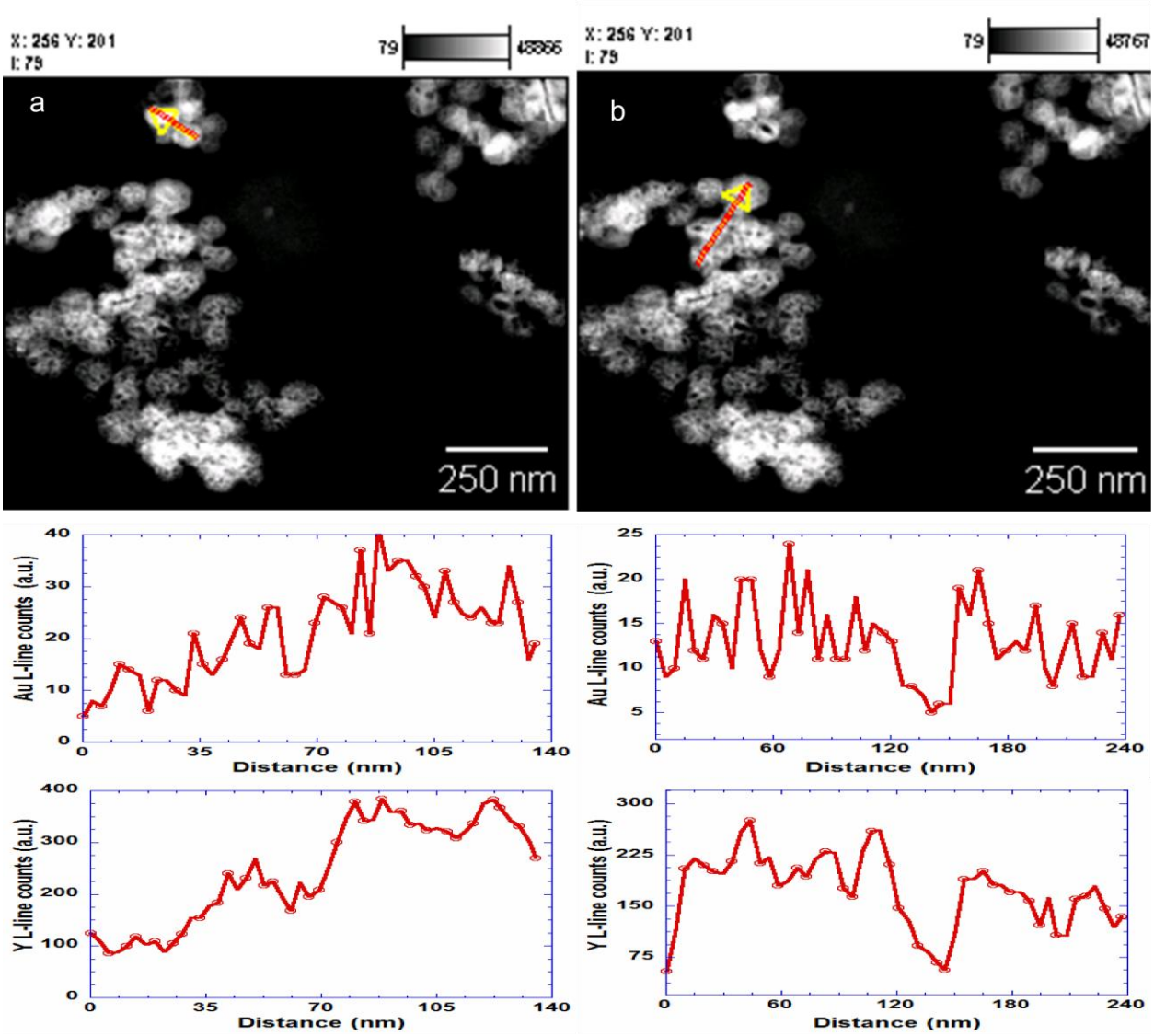




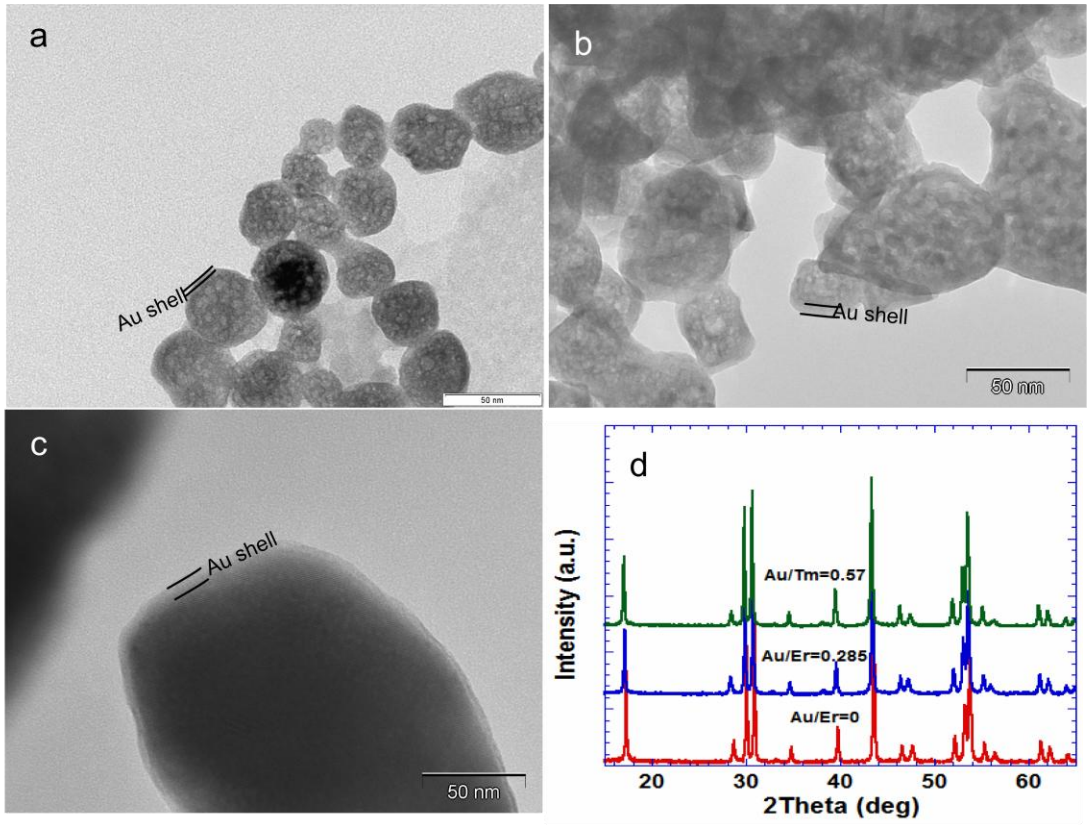
Supplementary figure 1: Schematic depiction of gold coating of $NaYF_4$ up-converting nanophosphors using a citrate method, a). b) Picture of the of the corresponding gold coated UCNP. c) Schematic of the emission data collection system.



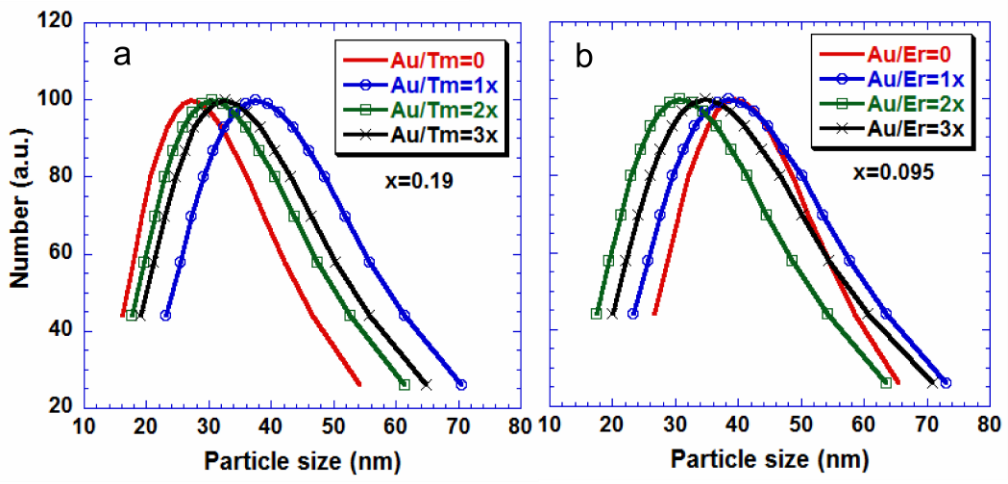
Supplementary figure 2: Effect of concentration of $HAuCl_4$ solution, with the same concentration ratio of Au/Er, on the gold coating of cubic-$NaYF_4$ 20%Yb:2%Er nanophospors, a) 1% and 0.1%) $HAuCl_4$.



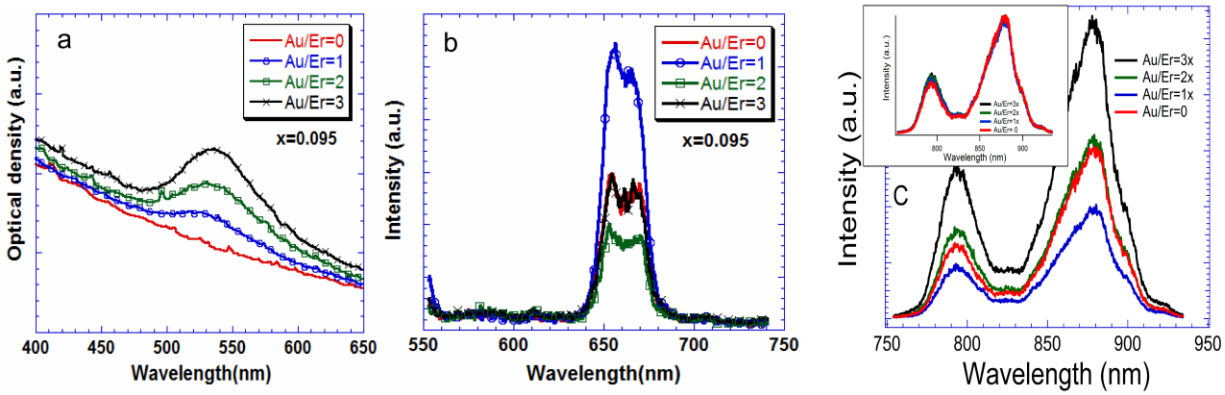
Supplementary figure 3: HAADF-STEM images and the corresponding EDS spectra from gold coated cubic-NaYF4 :20% Yb : 2% Er (a and b) nanoparticles.



Supplementary figure 4: $NaYF_4$:20%Yb:2%Er with with Au/Er ratio of 0.095 a) 90 ^{0}C heated at 12 h and b) heated to 350 ^{0}C for 4 h. C) $NaYF_4$:20%Yb:2%Er with with Au/Er ratio of 0.285 heated to 350 ^{0}Cfor 12 h. d) X-ray diffraction of $NaYF_4$: 20%Yb: 2%Er and 1% Tm nanophosphors with gold coating heated to 350 ^{0}C for 4h. For comparison an uncoated $NaYF_4$: 20%Yb: 2%Er nanophosphor treated at the same condition is shown. The nanophosphors have a mixture of cubic (JCPDS-77-2042) and hexagonal phase (JCPDS-39-0724), with the hexagonal phase being the dominant phase.



Supplementary figure 5: Particle size distribution from dynamic light scattering of 0.1% colloidal solutions of cubic-$NaYF_4$: 20% Yb with a) 1% Tm, b) 2% Er and different gold coatings.



Supplementary figure 6: a) Optical absorbance of 0.1% solutions of cubic-NaYF4: 20%Yb: 2%Er with different gold coatings and up-conversion emission in the red, b) and near infrared, c) from from the same excited at 975 nm. The NIR emission of Er at 795 nm normalized to the 880 nm emission component of the laser, inset in C.