Electronic Supplementary Material (ESI) for Nanoscale Advances.

Supplementary material

Experimental measurement of local high temperature at the surface of gold nanorods using doped $ZnGa_2O_4$ as nanothermometers

Estelle Glais[a,b], Agnès Maître[c], Bruno Viana[b], Corinne Chanéac[a] *

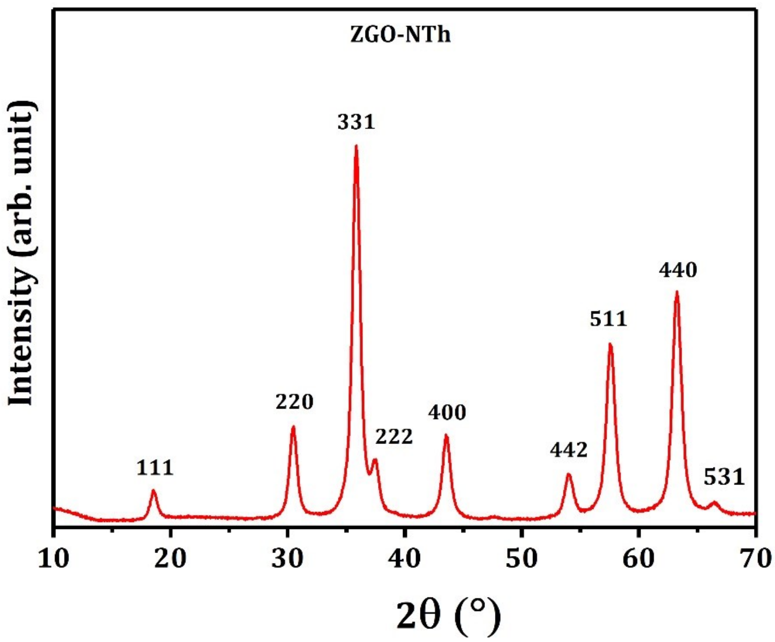
[a] Sorbonne Université, CNRS, Collège de France, UMR 7574, Laboratoire de Chimie de la Matière Condensée de Paris, 4 place Jussieu 75005 Paris, France

[b] PSL Research University, IRCP, Chimie ParisTech, CNRS, 11 rue P. et M. Curie, 75231 Paris cedex 05, France

[c] Sorbonne Université, CNRS, UMR 7588, Institut des Nanosciences de Paris, 4 place Jussieu 75005 Paris, France

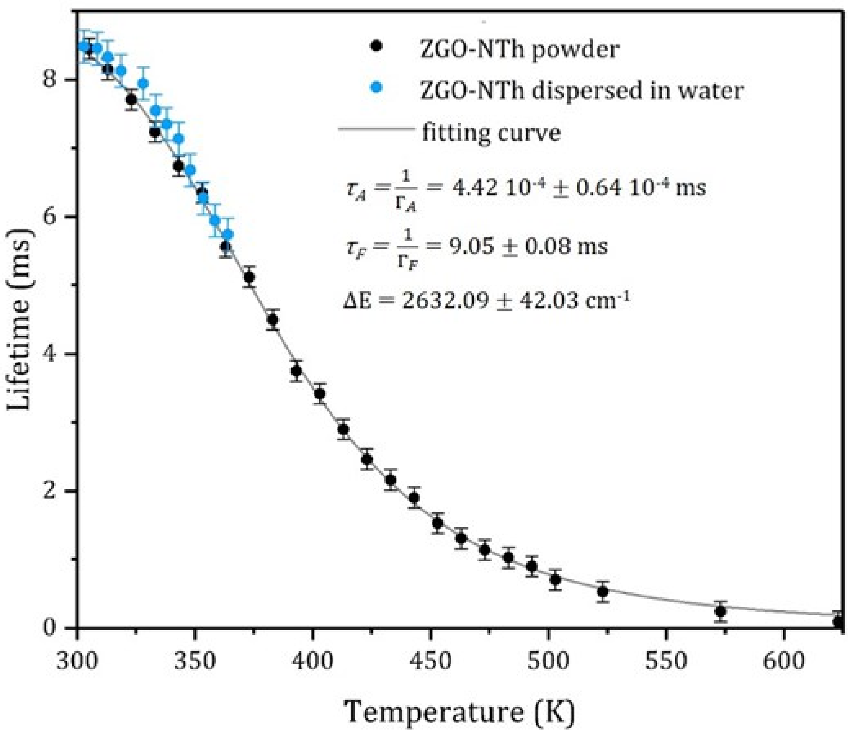
* *Corresponding author: corinne.chaneac@sorbonne-universite.fr*

SI-1: XRD pattern of ZGO-NTh. $ZnGa_2O_4$ nanoparticles crystallize in a cubic spinel structure with a *Fd-3m* (O_h^7) space group. No other pic are identified, which reveal the purity of the sample.

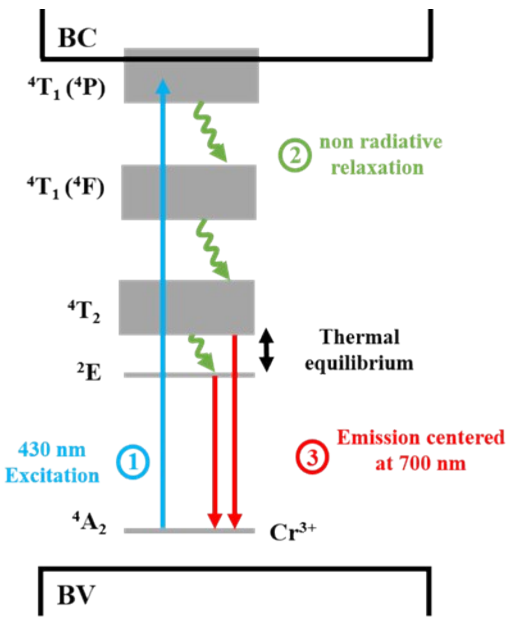


SI-2 Variation of ZGO-NTh experimental lifetimes with the temperature, gray line represents the fitting curve determined from Eq2 - (λ_{exc} = 430 nm). No difference of the ZGO-NTh response according to the temperature has been observed for samples dispersed in water compared to powder samples. The obtained τ_A and τ_F values, corresponding to the lifetime of the $^4T_2 \rightarrow ^4A_2$ and $^2E \rightarrow ^4A_2$ radiative transition, are in good agreement with the expected value for a spin-allowed and a spin-forbidden transition respectively. The maximal relative sensitivity reaches 1.9 % °C^{-1} and is deduced from the following formula of relative sensitivity:

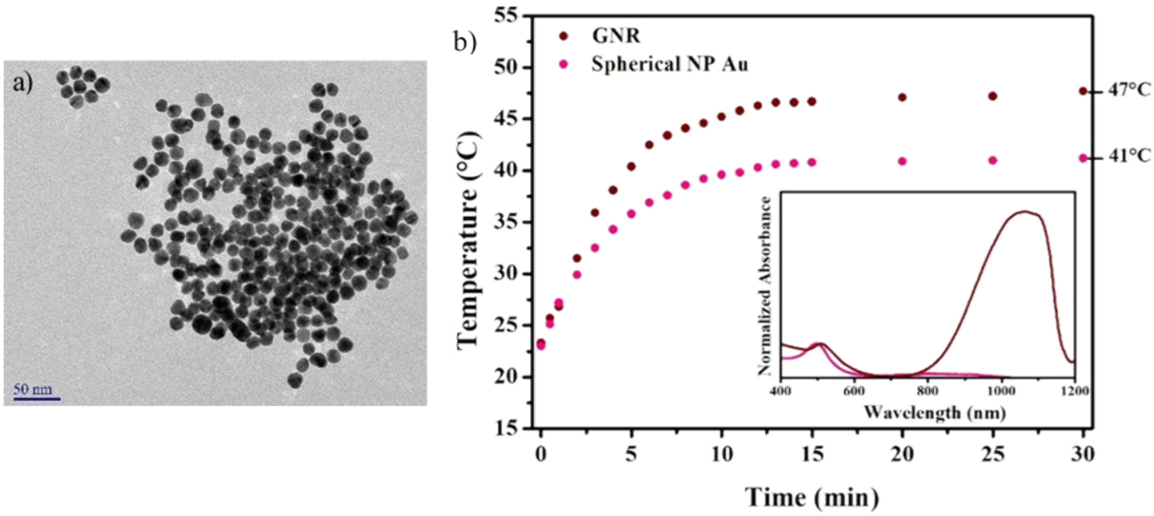
$$S_r = \frac{1}{\tau}\left|\frac{\partial \tau}{\partial T}\right|$$



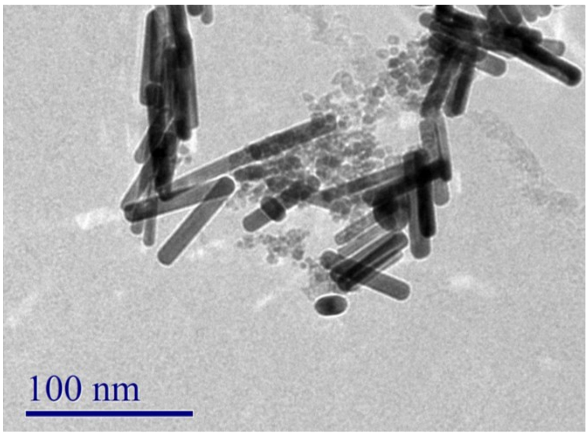
SI-3 : Schematic representation of energetic levels involved in photoluminescence processes of Cr^{3+} ion inserted in ZGO host.

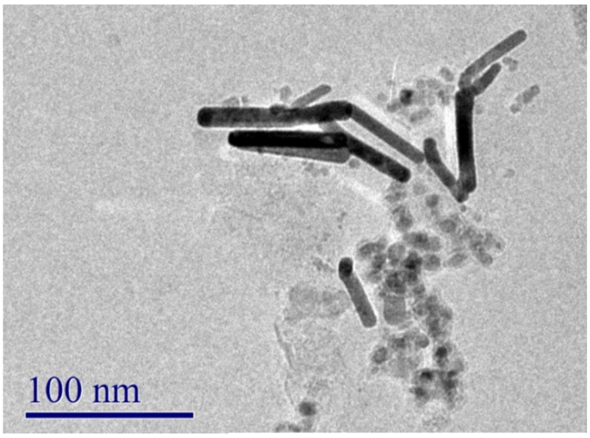


SI-4: a) TEM picture of spherical gold nanoparticles used as control sample. b) Water temperature increase followed by thermal camera picture of gold nanoparticles (spheres and rods) aqueous suspensions after excitation in the same conditions using a 976 nm Laser diode (3 W/cm²). At this wavelength, spherical nanoparticules do not absorb (see inset figure) and the temperature of the water at the 41°C plateau corresponds to the heating due to laser irradiation. Thus for gold nanorods suspension, the water temperature increase is not only due to the laser but also by the nanoparticles themselves. Very good matching of temperature values is obtained using a thermocouple diving into the suspension. The particle concentration of both suspensions is comparable.

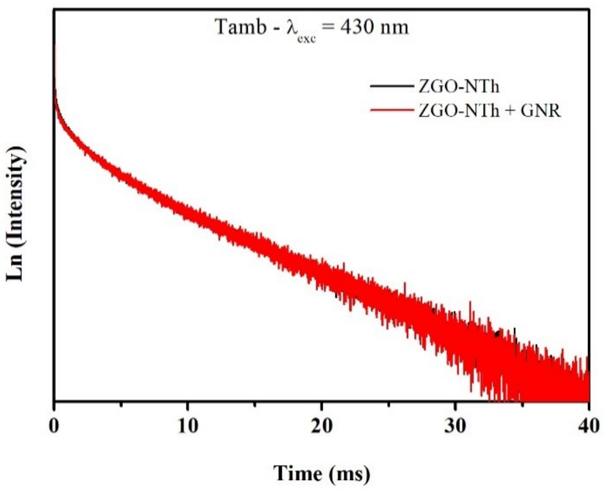


SI-5: The mixing of nanothermometer and nanoheater has also been characterized by Cryo TEM, showing the behavior of ZGO-NTh and GNR in solution. Two pictures of this samples are presented below. They show an in-situ hetero-aggregation of both kinds of nanoparticles.

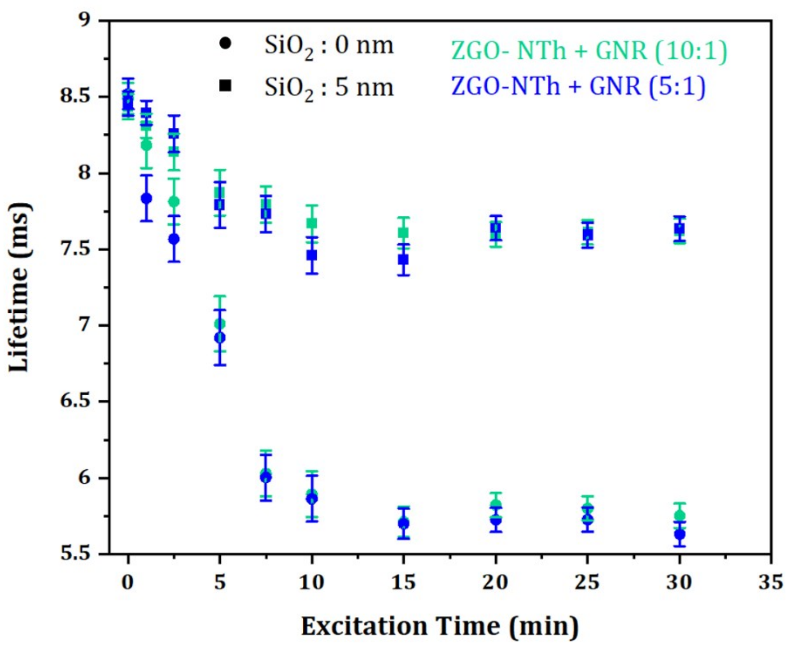




SI-6: No change is observed in the decay profile and so on the experimental lifetime, with the mixing in solution of ZGO-NTh with GNR (10:1) (in red on the following figure) compare to the ZGO-NTh only (in dark). In all the study, the reference measure is the one corresponding to the mixing of nanothermometer with nanoheater under 430 nm excitation (red curve).

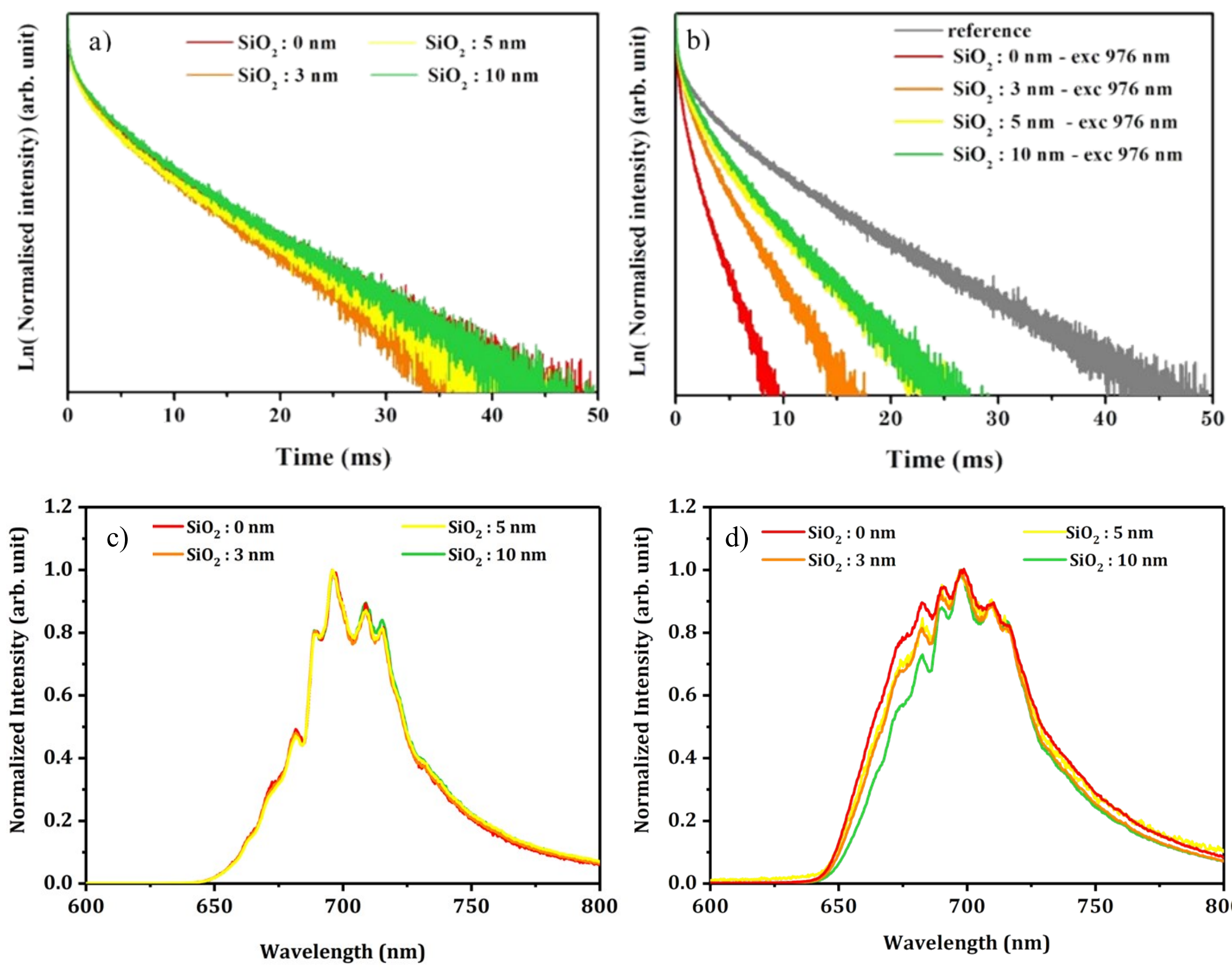


SI-7: Experimentally determined lifetimes according to the laser diode excitation time in aggregated ZGO NTh and GNR system with two different ratios ZGO:GNR of 10:1 and 5:1 .



Measurements have been performed in aqueous media with ZGO-NTh embedded with a 5 nm silica layer and with ZGO-NTh without silica layer.

SI-8: Decay and emission profiles of samples composed by a mixing of gold nanoparticles and ZGO nanothermometers with several silica shell thicknesses (red : 0 nm, orange : 3 nm, yellow : 5 nm and green : 10 nm). a) c) powder nanoparticles mixture under 430 nm excitation and b) d) powder nanoparticles mixture under both 430 nm and 976 nm excitation (for plasmon excitation, a continuous



Laser diode is used, 3 W/cm²).

Table SI-1: Deduced measured temperatures of powder samples and samples dispersed in water for several silica layer thicknesses compared to IR thermal camera measurements. The difference between all samples dispersed in solution and in powder can be explained by the higher nanoheater - thermal sensor distance in solution mostly due to the solvation sphere as detailed in the paper.

Silica shell thickness	**0 nm**	**3 nm**	**5 nm**	**10 nm**
ΔT measured on sample dispersed in water (lifetime)	45 ± 2°C	38 ± 2°C	19 ± 2°C	14 ± 2°C
ΔT measured on sample dispersed in water (thermal camera)	11°C	12°C	10°C	12°C
ΔT measured on powdered sample (lifetime)	128 ± 2°C	98 ± 2°C	71 ± 2°C	56 ± 2°C
ΔT measured on powdered sample (thermal camera)	2°C	2°C	1°C	2°C