All-In-One Optical Heater-Thermometer Nanoplatform Operative From 300 to 2000 K Based on Er3+ Emission and Blackbody Radiation

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Light-induced thermal heating of noble metal nanostructures has numerous applications in biological detection, remote release of encapsulated material, sensors, photovoltaic and plasmonic devices. In particular, there is a growing interest in developing plasmonic-induced nanoheaters for applications in nanomedicine. In hyperthermia, for example, a controlled local temperature increase avoids the need for macroscopic heating, reducing the collateral effects arising from over heating healthy tissues. Measuring the temperature at the nanoscale with high spatial (10^{-6} m) and temperature (10^{-1} degree) resolution is very challenging and an exciting field of research.

Suitable nanoplatforms integrating heaters and thermometers, however, have not yet been realized, despite their great potential in nanophotonics and biomedicine. Recently, we have reported a step forward towards assessing the local temperature of laser-excited gold nanostructures using an all-in-one nanoplatform comprising $(Gd,Yb,Er)_2O_3$ nanorods (thermometers) surface-decorated with gold nanoparticles (heaters), Figure 1.[1]

The local temperature is calculated using either Boltzmann's distribution (300 – 1050 K) of the Er^{3+} up-conversion $^2H_{11/2}\rightarrow{}^4I_{15/2}/{}^4S_{3/2}\rightarrow{}^4I_{15/2}$ intensity ratio and the Planck's law (1200 – 2000 K) for a white-light emission ascribed to the blackbody radiation. Increasing the amount of AuNPs increases the surface temperature of the $(Gd,Yb,Er)_2O_3$ nanorods and the operating range of the nanothermometers.

A maximum relative sensitivity up to 1.5 % K (resolution 1K) in the temperature range of physiological interest (301 – 350 K) is demonstrated with NRs-AuNPs-1.25 under low-power (32 – 86 W cm^{-2}) near-infrared light (980 nm) excitation in the therapeutic window. This offers much potential for biological applications in laser-induced controlled hyperthermia and in deep-tissue optical bioimaging, while avoiding thermal damage of the surrounding healthy tissues and background fluorescence.

REFERENCES

[1] M. L. Debasu, D. Ananias, I. Pastoriza-Santos, L. M. Liz-Marzan, J. Rocha, L. D. Carlos, *Adv. Mater.*, 35: 4868 (2013), DOI: 10.1002/adma.201300892 (issue cover).

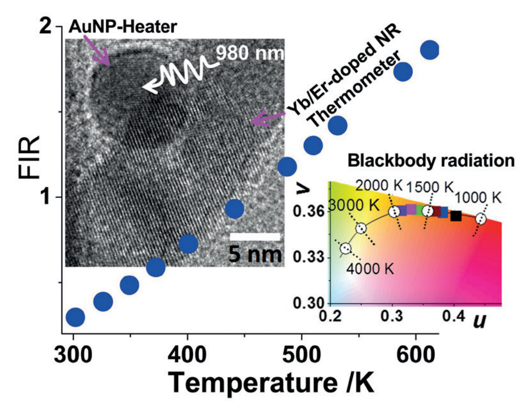

FIGURE 1
TEM image of AuNP heaters and Yb/Er thermometers (top left). The up-conversion emission of this nanoplatform is a function of temperature (main plot), and the CIE chromaticity diagram (bottom right) shows that the variation of the emission color coordinates as a function of the laser pump power follows the Planckian locus.