

Supporting Information

New generation of highly sensitive luminescent thermometers operating in optical window of biological tissues

Lukasz Marciniak^{†*}, Artur Bednarkiewicz[†], Diana Kowalska[†], Wieslaw Strek[†]

[†] Institute of Low Temperature and Structure Research, Polish Academy of Sciences, Okólna 2, 50-422 Wrocław, Poland

Corresponding Author

*Lukasz Marciniak

l.marciniak@int.pan.wroc.pl

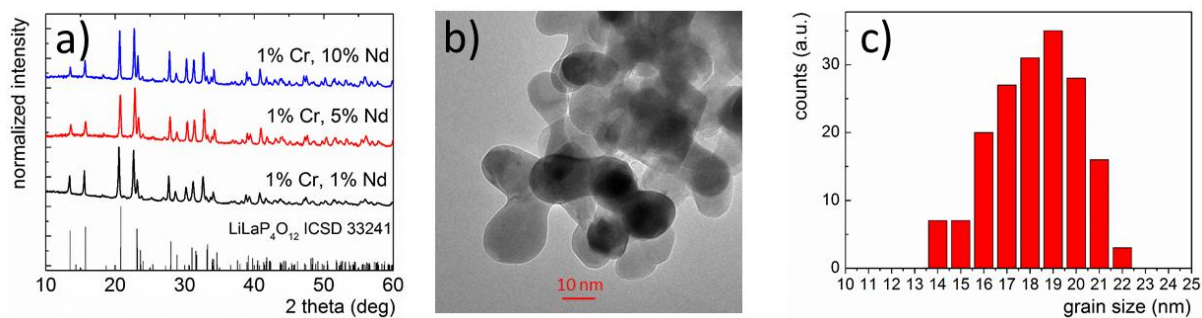


Fig. S1. X-ray diffraction patterns of LiLaP₄O₁₂:Cr,Nd nanocrystals-a; and representative TEM image –b with grain size distribution-c.

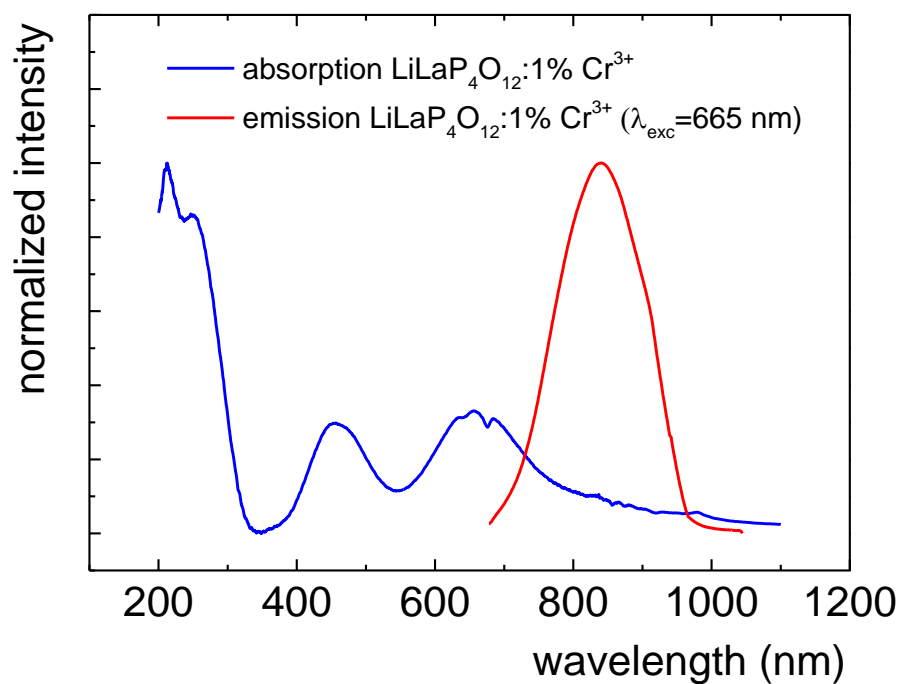


Fig. S2. Comparison of absorption and emission spectra of $\text{LiLaP}_4\text{O}_{12}:1\% \text{Cr}$ nanocrystals

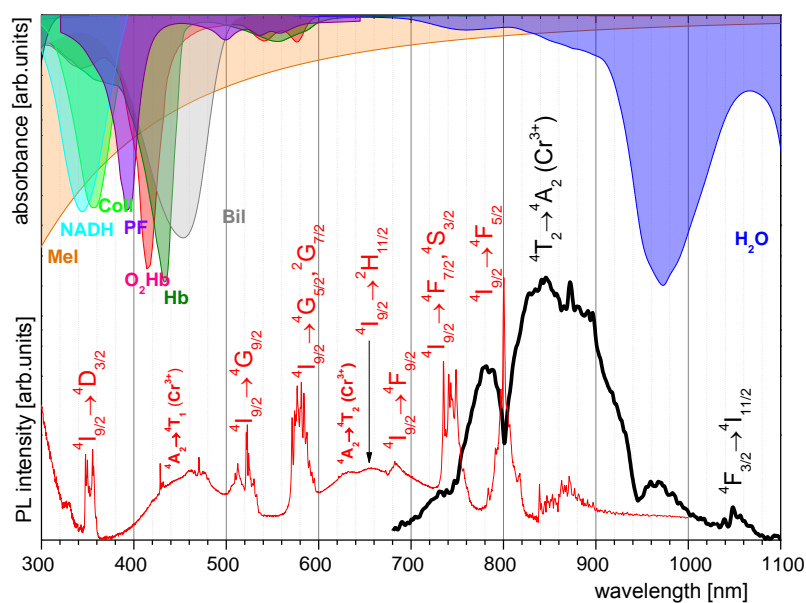


Fig. S 3. Comparison of absorption and emission spectra of $\text{LiLaP}_4\text{O}_{12}:\text{Cr},\text{Nd}$ nanocrystals with absorption of biological molecules Mel-melanine, NADH – Nicotinamide adenine dinucleotide, coll – collagen, PF – protophorphirin, O₂Hb – oxygenated hemoglobin, Hb- deoxygenated hemoglobin, Bil-Bilirubine, H₂O - water

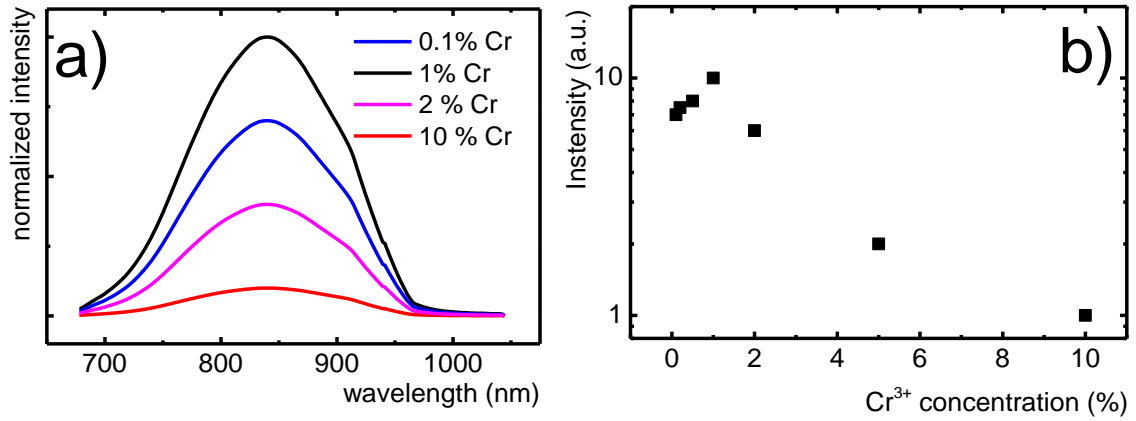


Fig. S4. Emission spectra of LiLaP₄O₁₂:Cr nanocrystals with different concentration of Cr³⁺ ions –a and integral emission intensity as a function of Cr³⁺ concentration-b

The crossing point between ground state parabola and ⁴T₂ parabola of Cr³⁺ ion in LiLaP₄O₁₂ nanocrystals (activation energy) was determined basing on temperature dependence of emission intensity of LiLaP₄O₁₂:Cr nanocrystals for different concentration of Cr³⁺ ions (Fig. S4) using following equation:

$$I_{em} = \frac{I_0}{1 + \exp\left(\frac{\Delta E}{kT}\right)} \quad (\text{S.1})$$

where

I_{em} - emission intensity

I_0 - emission intensity at the lowest temperature

ΔE - activation energy

T-temperature

k- Boltzmann constant

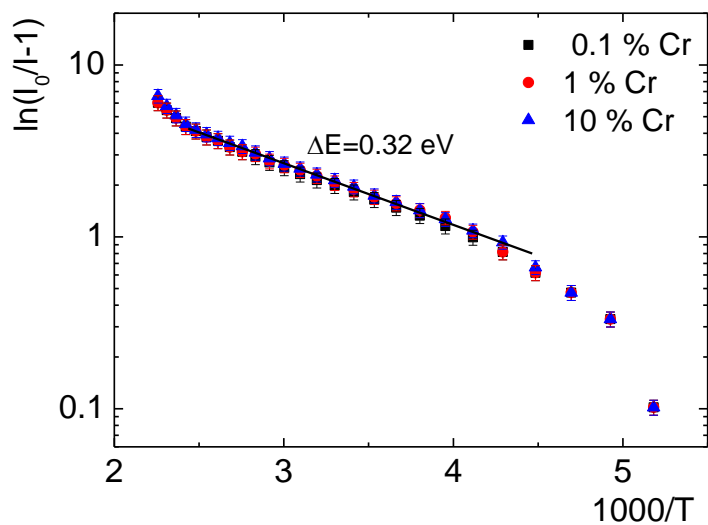


Fig. S5. Temperature dependence of emission intensity of $\text{LiLaP}_4\text{O}_{12}:\text{Cr}$ nanocrystals

Reproducibility of temperature measurement using $\text{LiLaP}_4\text{O}_{12}:1\% \text{Cr}^{3+}, 10\% \text{Nd}^{3+}$ nanocrystals as a luminescent thermometer was confirmed via 6 cooling-heating cycles measurements at two temperatures 0°C and 50°C . At each temperature emission spectra was recorded after 3 minutes.

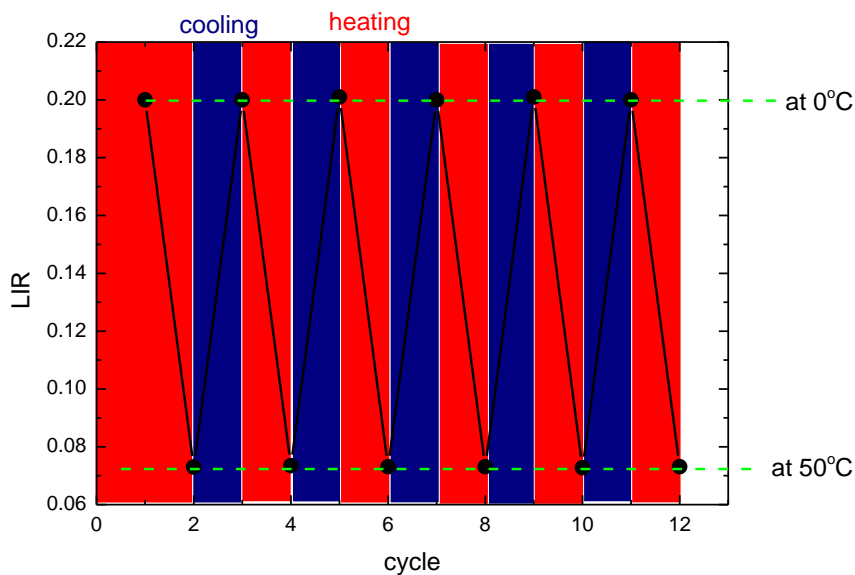


Fig. S6 Reproducibility of LIR measurements for $\text{LiLaP}_4\text{O}_{12}:1\% \text{Cr}^{3+}, 10\% \text{Nd}^{3+}$ nanocrystals in cooling-heating cycles.