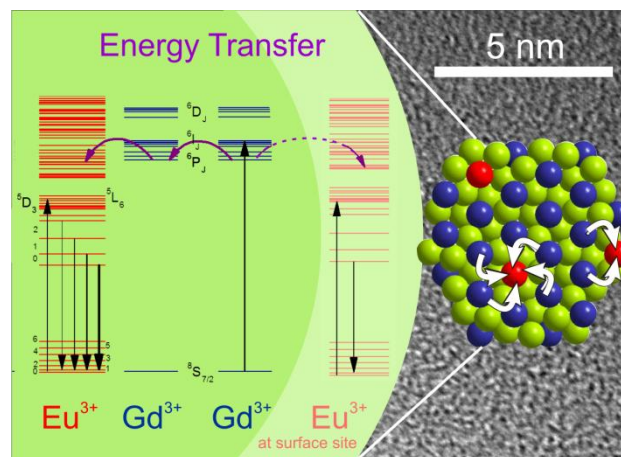




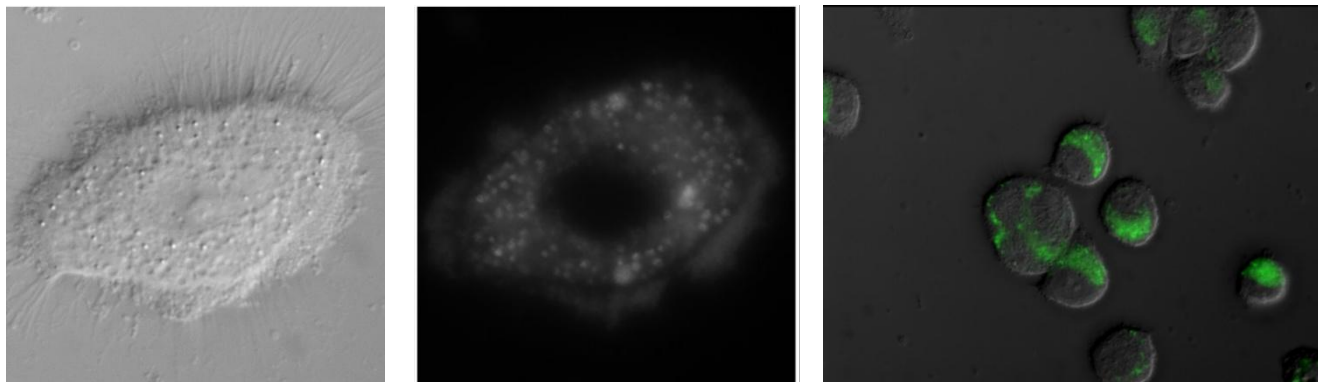
Gadolinium fluoride nanocrystals as a multifunctional probe for biology



Mateusz Banski

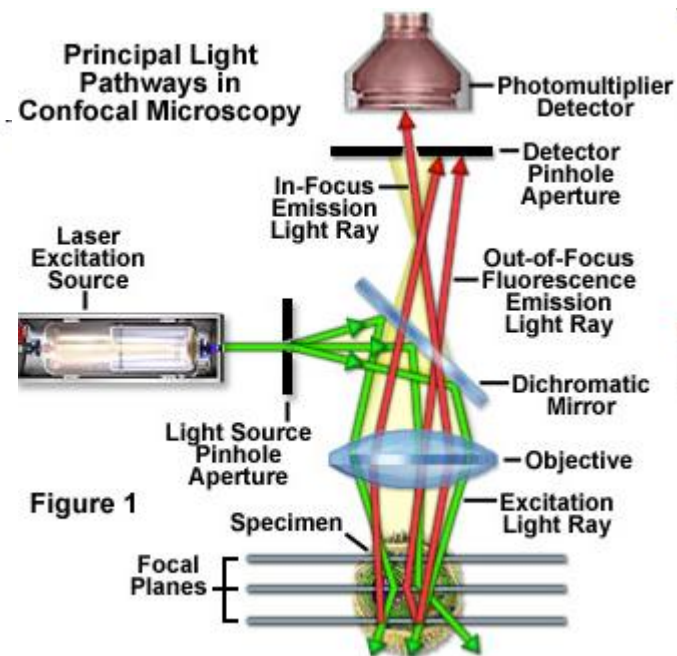
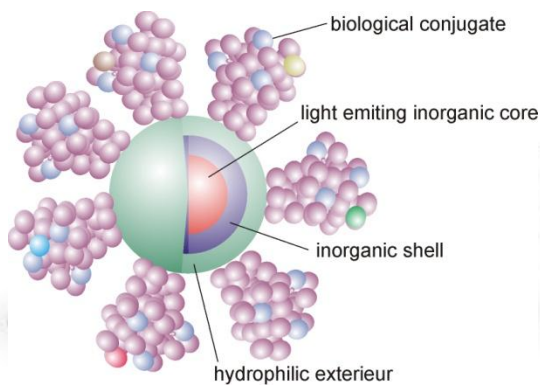
XIX International Summer School Nicolas Cabrera
19.07.2012

MOTIVATION - BIOMARKERS



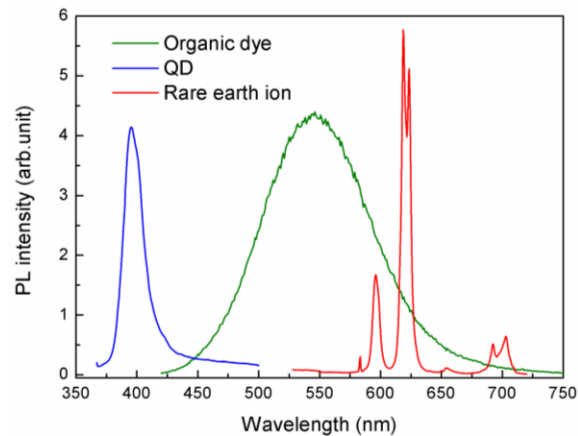
M. Banski, et al. in preparation

- High intensive PL
- Narrow emission line
- Efficient excitation
- Multifunctional

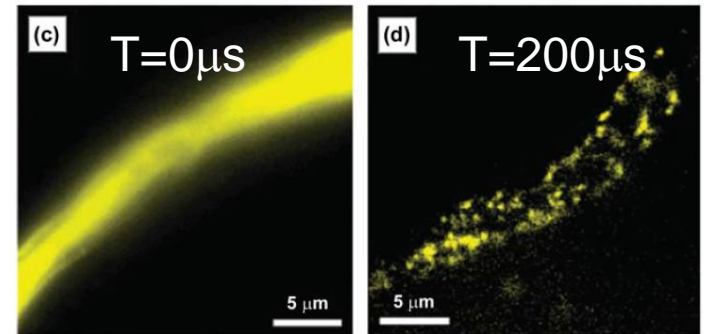


LANTHANIDES (Ln) ADVANTAGES

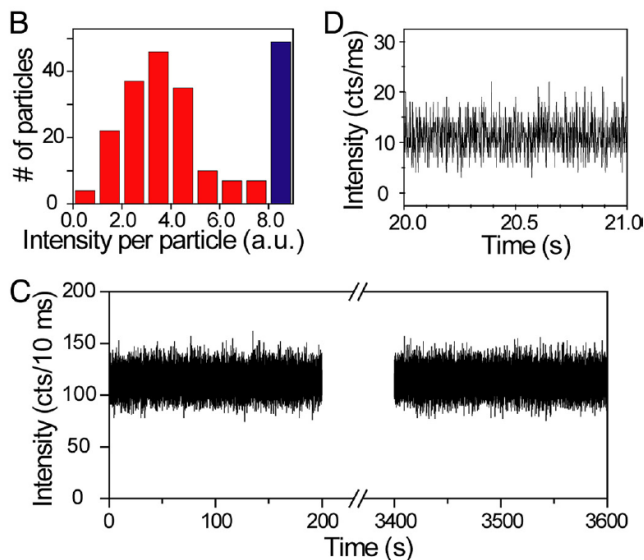
1. Small FWHM of PL



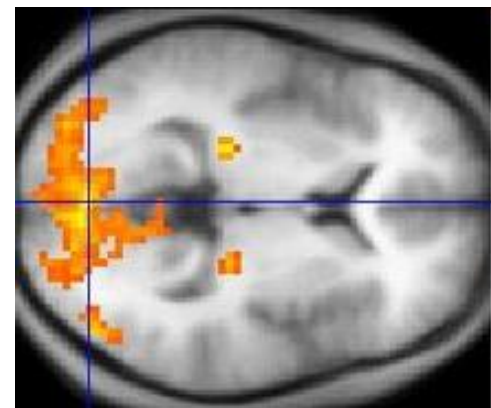
2. Long PL lifetime



3. High time PL stability



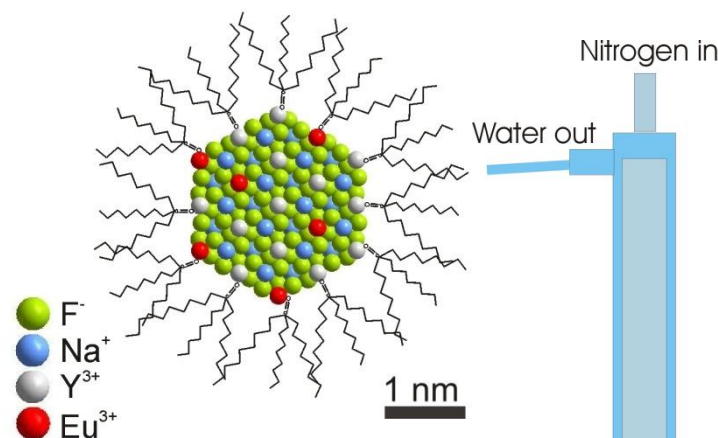
4. Multifunctional



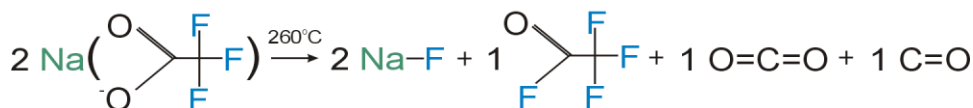
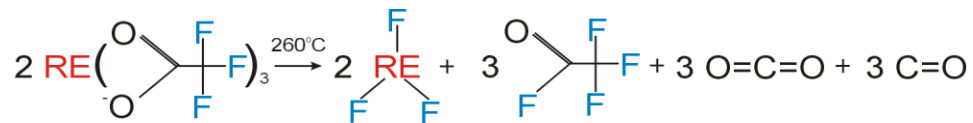
SYNTHESIS



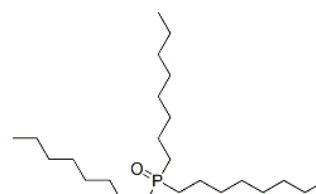
Sun et al. *Chem-Eur J*, 2007, 13, 2320-2332.
 Shan et al. *Nanotechnology*, 2007, 18, 445607.



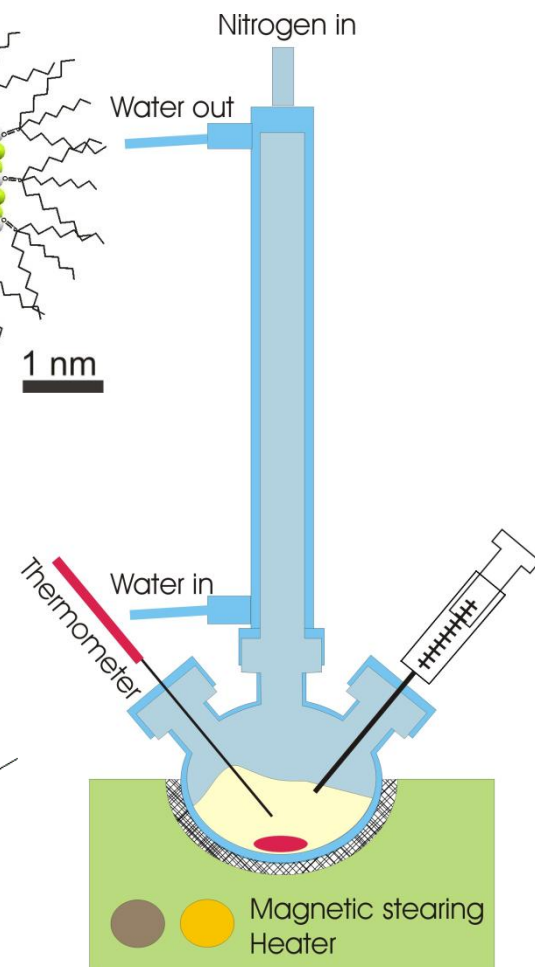
Synthesis reaction



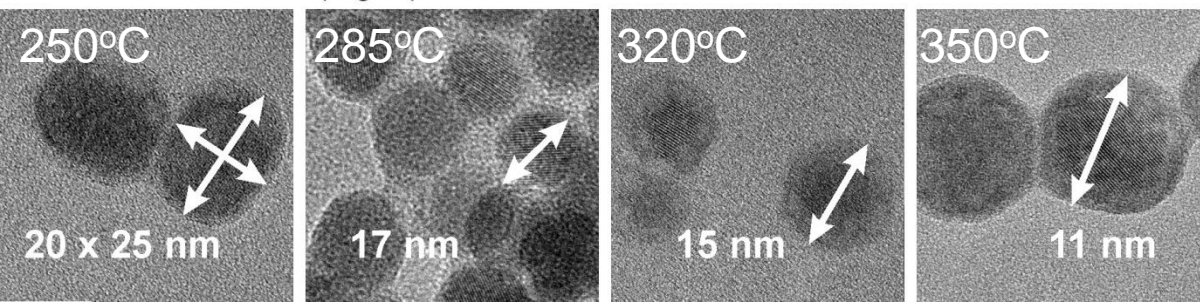
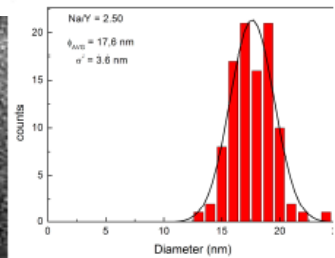
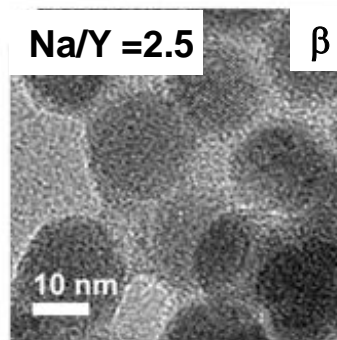
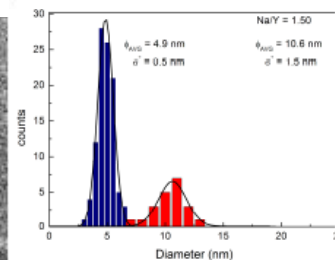
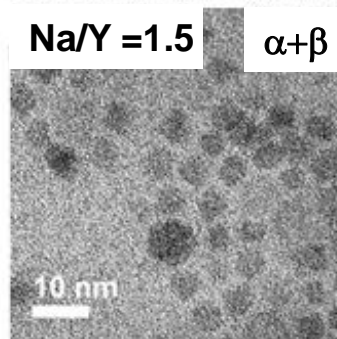
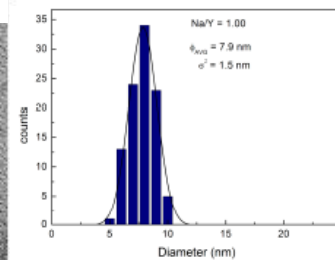
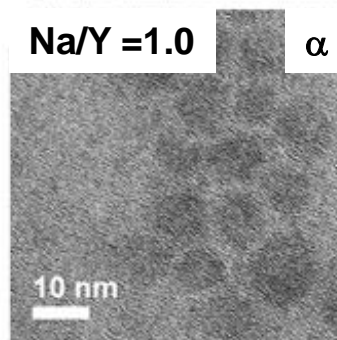
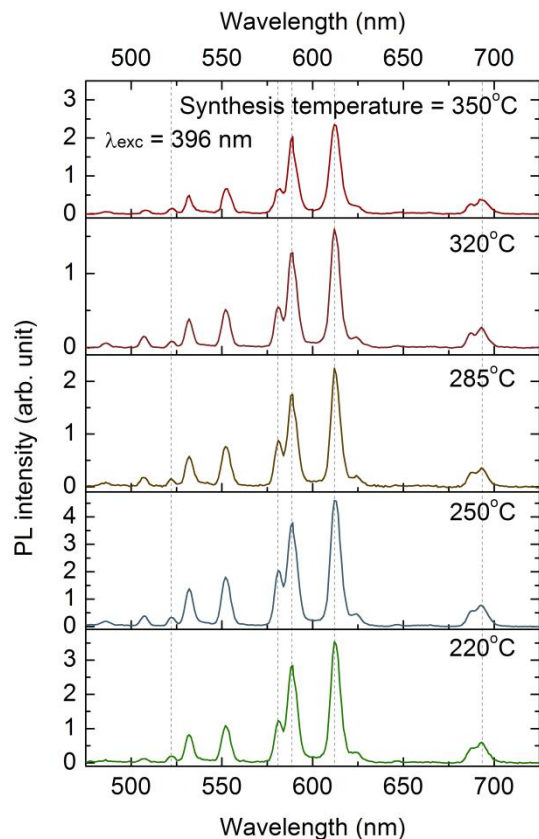
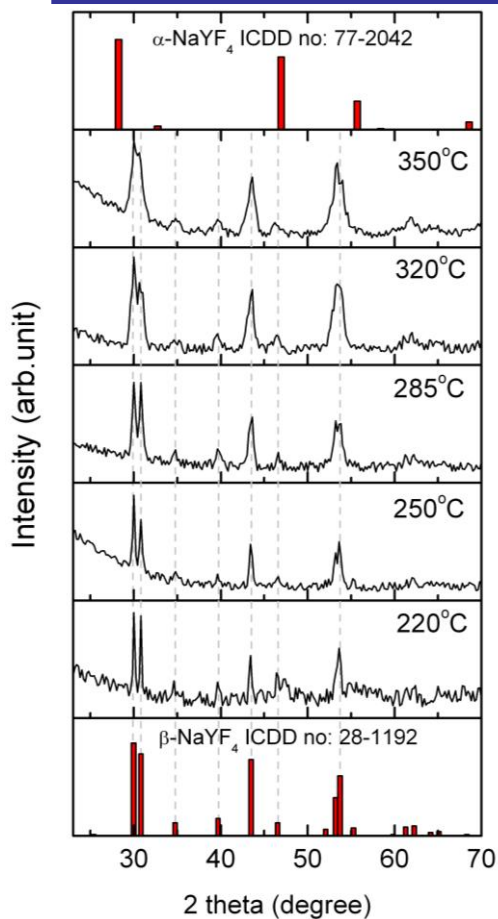
~300°C
 burst nucleation



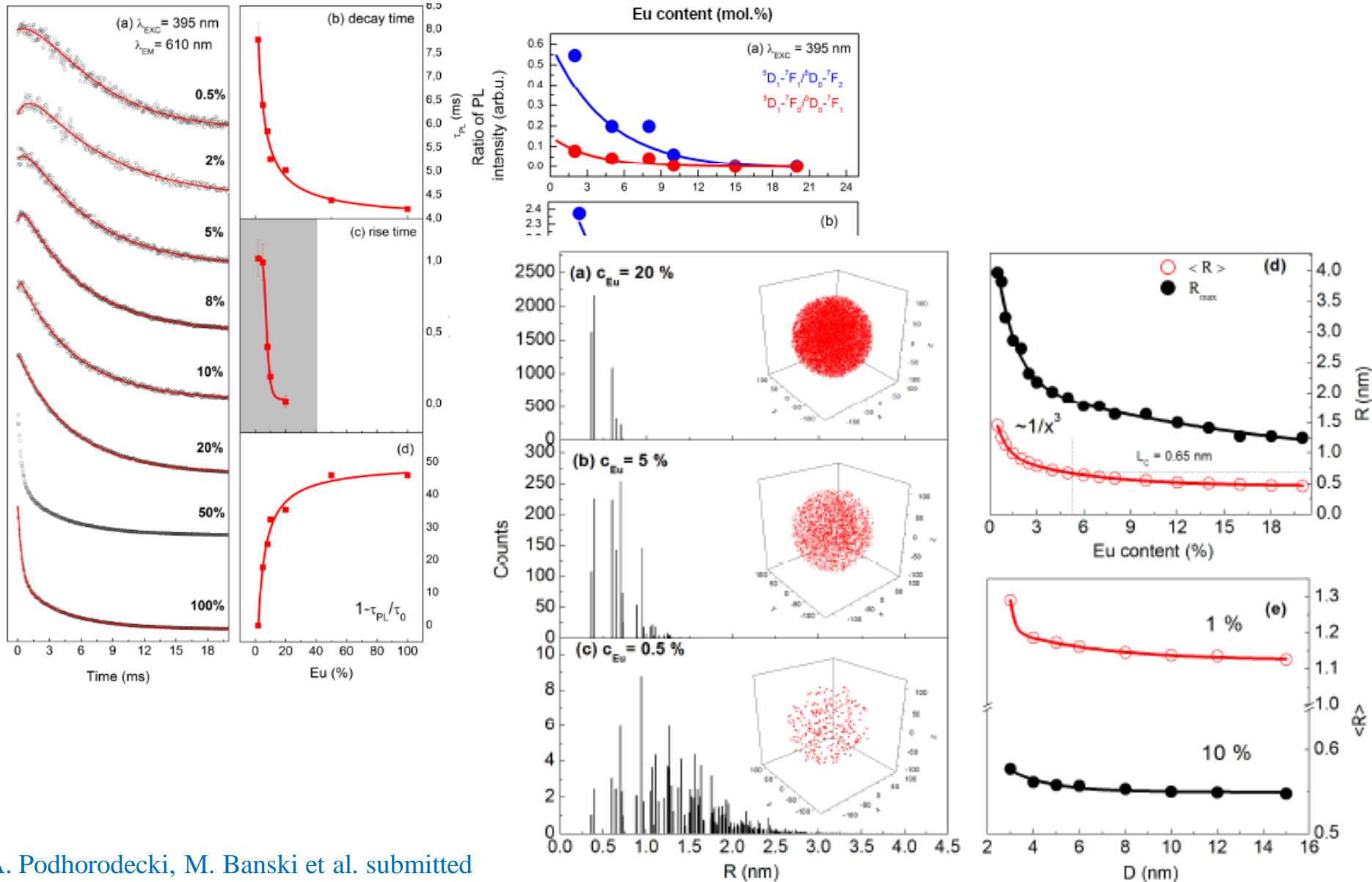
TOPO



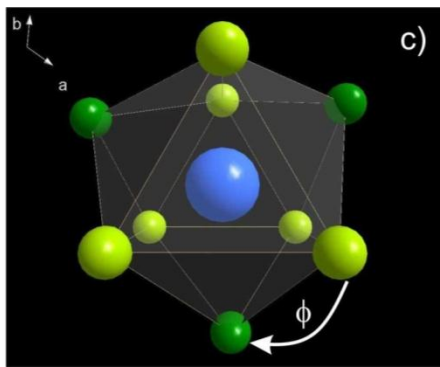
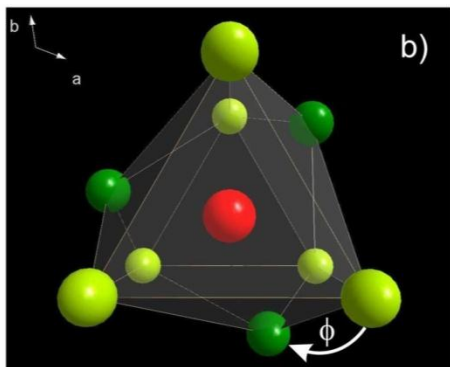
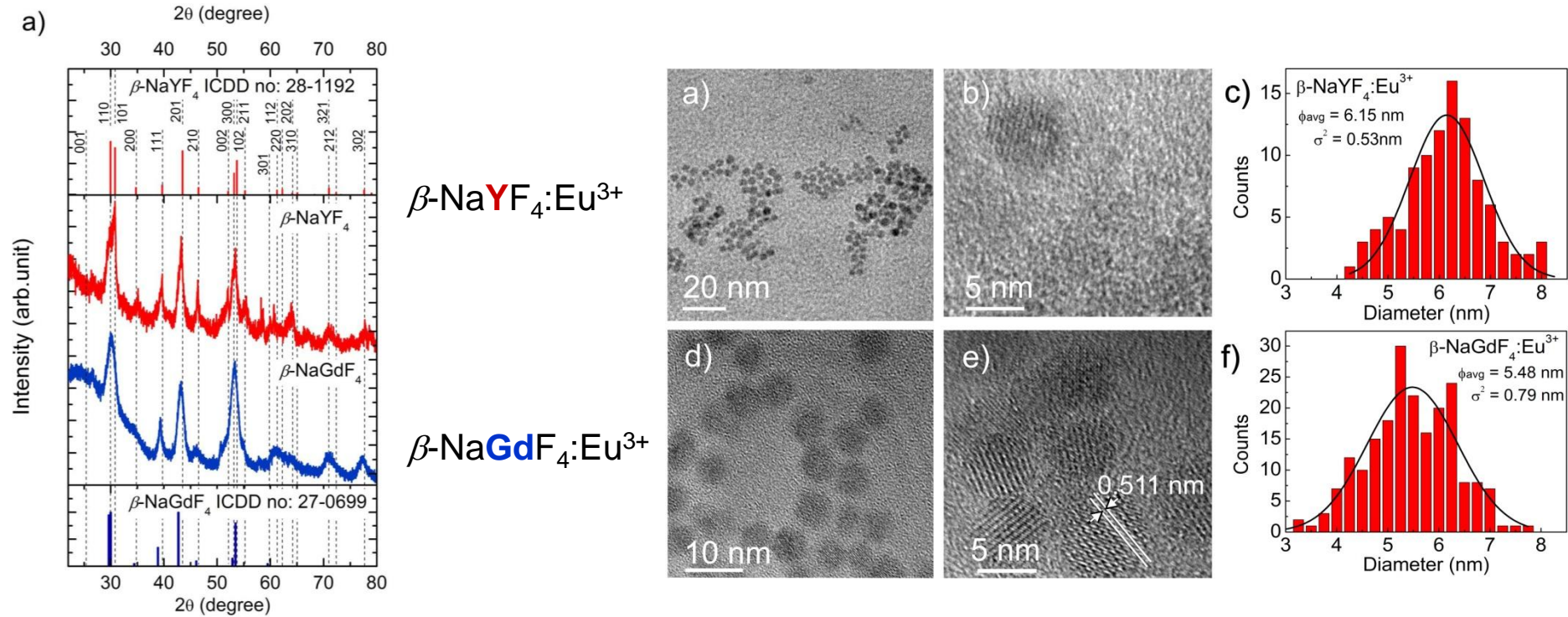
NaYF₄:Eu³⁺ NCs WITH TOPO LIGANDS



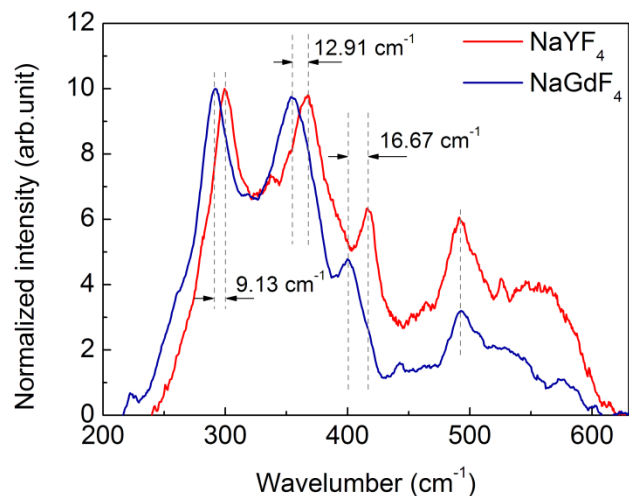
Eu³⁺ CONCENTRATION IN NaYF₄ NCS



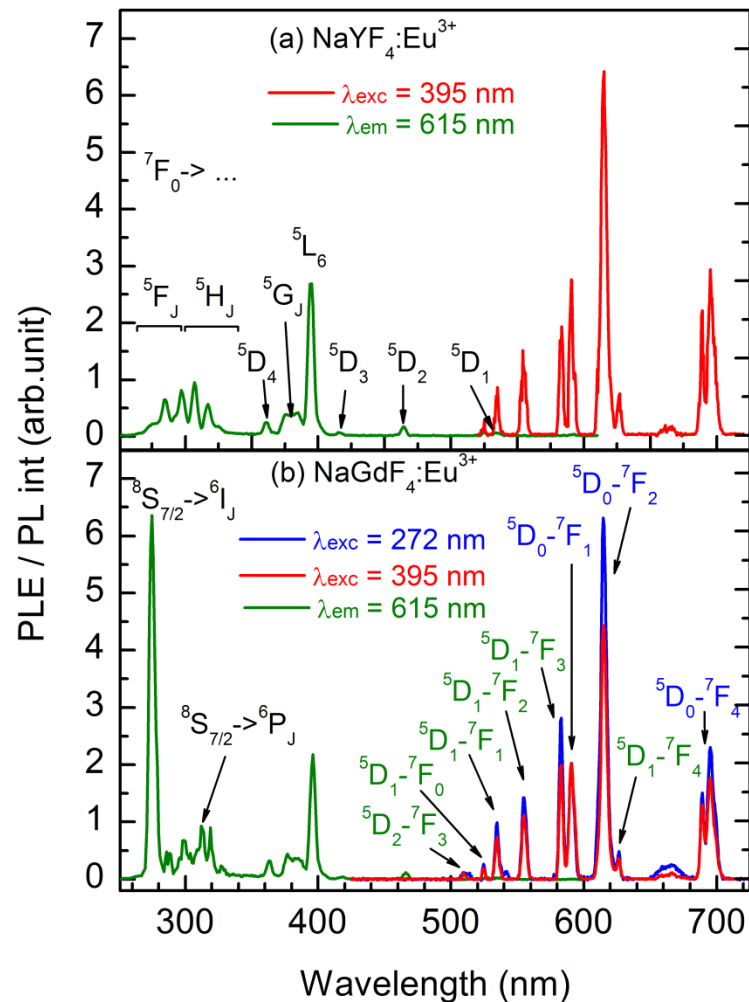
STRUCTURAL PROPERTIES OF β -NaGdF₄:Eu³⁺ and β -NaYF₄:Eu³⁺ NCs



OPTICAL PROPERTIES OF β -NaGdF₄:Eu³⁺ and β -NaYF₄:Eu³⁺ NCs

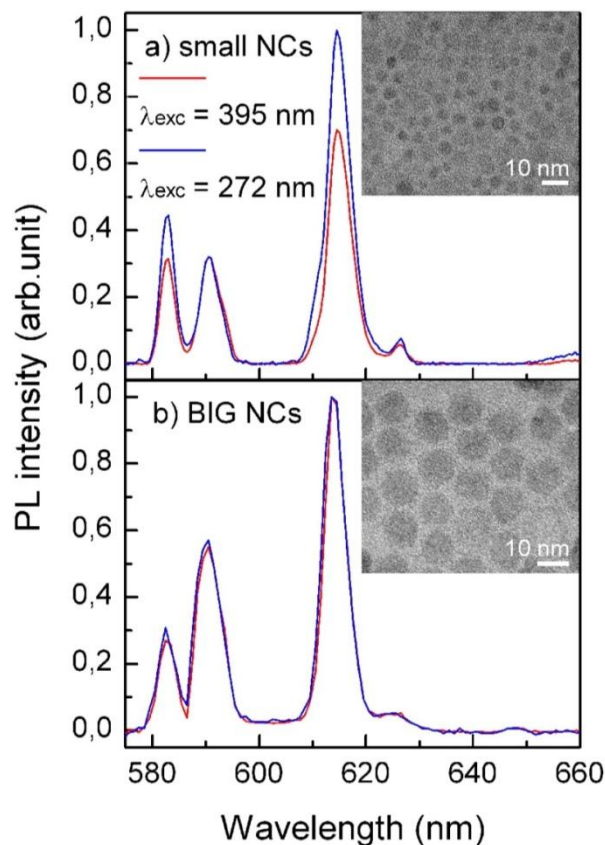


Raman spectra of NaYF₄ and NaGdF₄ hexagonal nanocrystals.

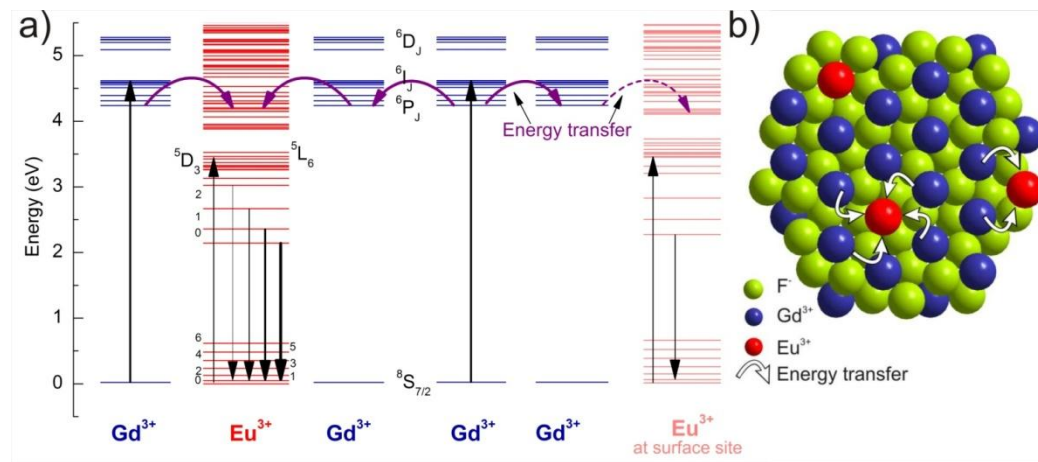


PLE and PL spectra of (a) β -NaYF₄:Eu³⁺ and (b) β -NaGdF₄:Eu³⁺ nanocrystals.

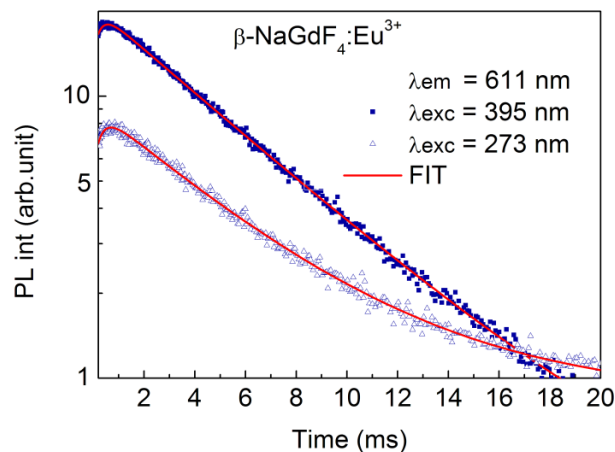
OPTICAL PROPERTIES OF β -NaGdF₄:Eu³⁺ and β -NaYF₄:Eu³⁺ NCs



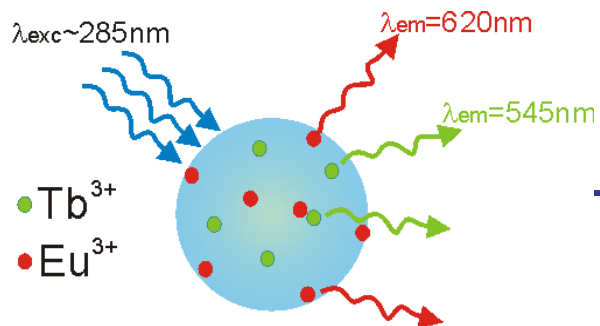
PL spectra of Eu³⁺ ions doped into (a) small (~ 5 nm) and (b) bigger (~10 nm) NaGdF₄:Eu³⁺ NCs excited directly (395 nm) and indirectly (272 nm).



Schematic representation of Eu³⁺ and Gd³⁺ energy levels and the possible energy transfer mechanism.

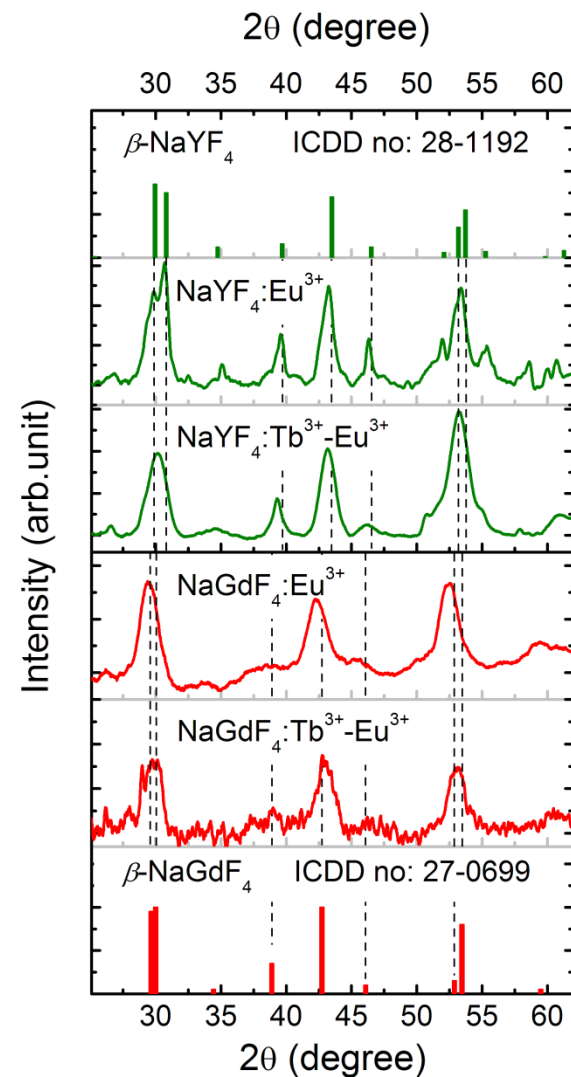
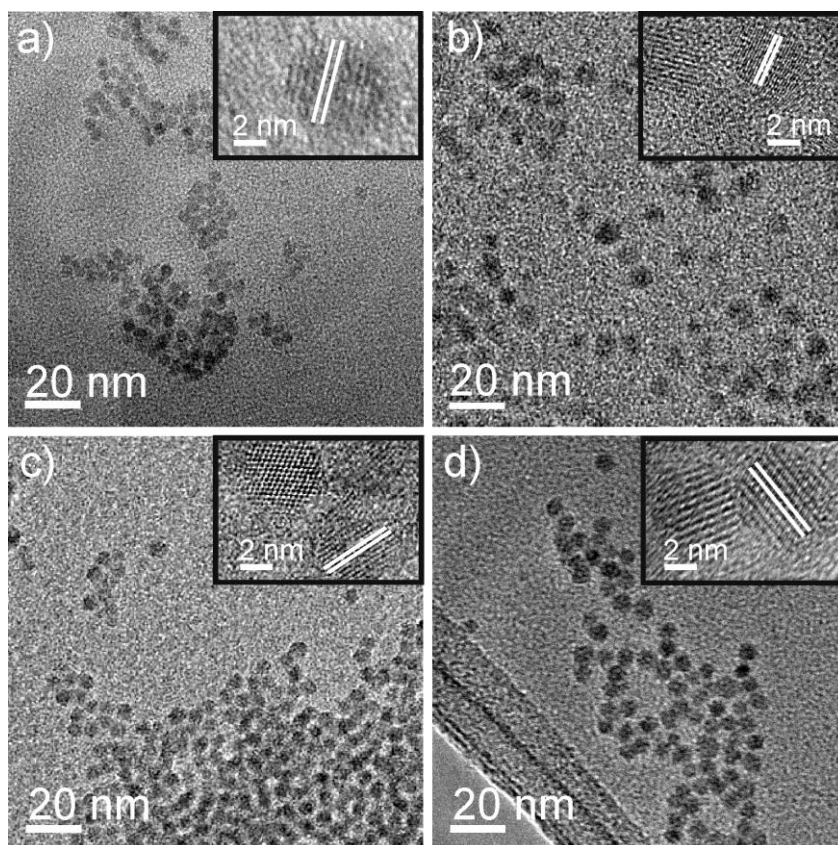


Sample	Excitation	QY _{NORM}
β -NaGdF ₄ :Eu ³⁺	⁵ L ₆ (391 nm)	1.0
	⁶ I ₁ (276 nm)	1.4



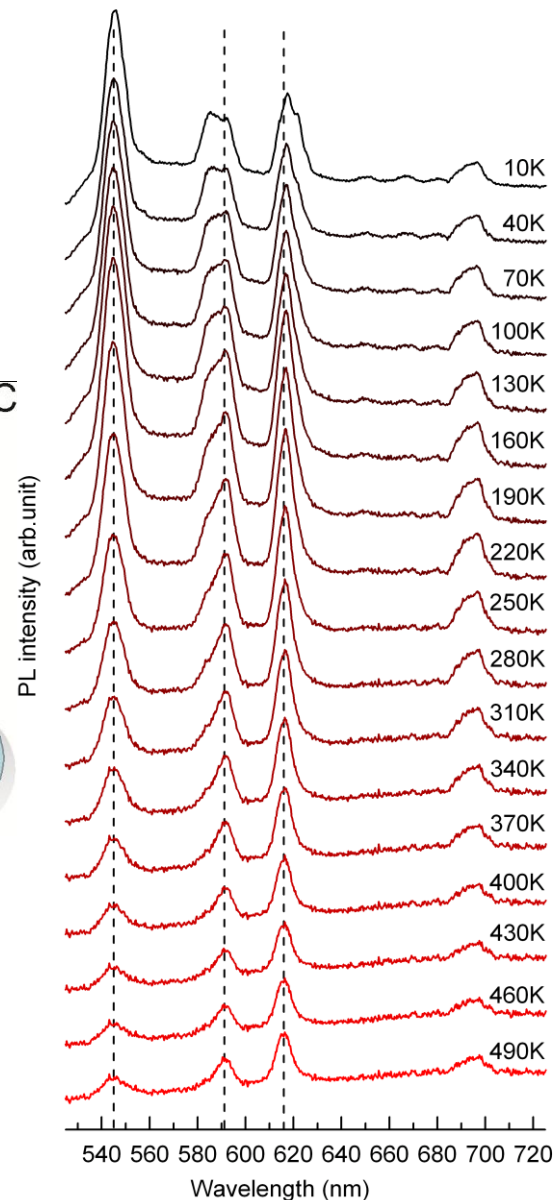
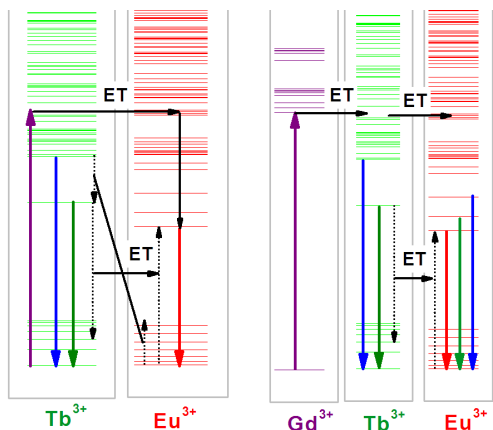
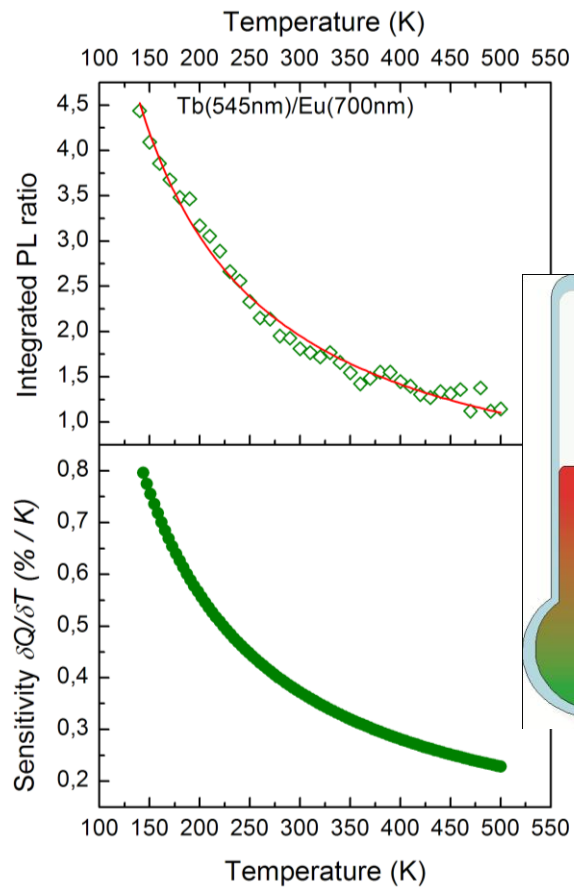
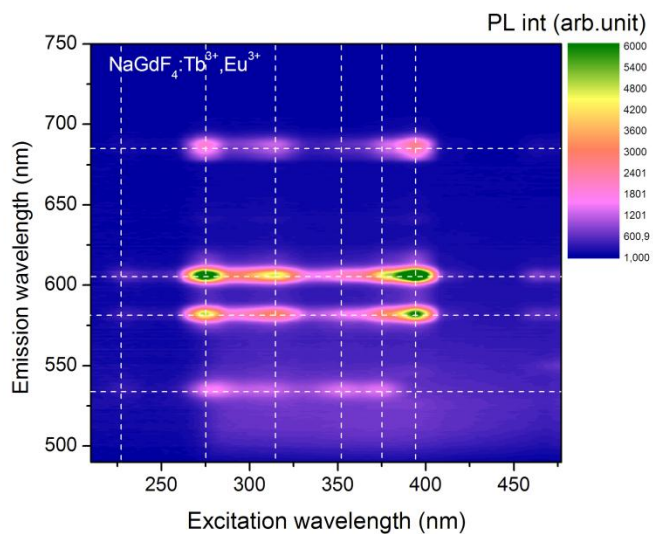
Scheme of dual color NCs emission

Tb^{3+} AND Eu^{3+} CO-DOPING

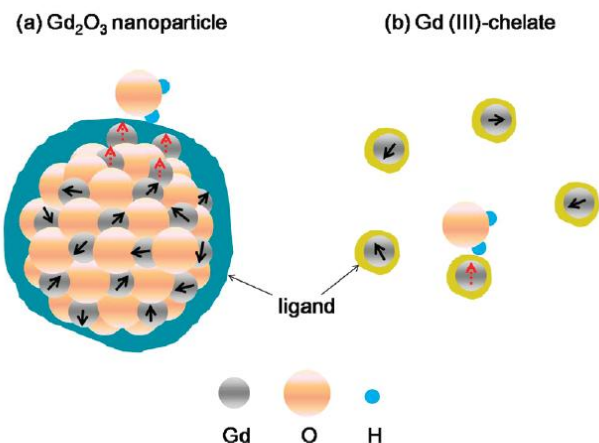


OPTICAL THERMOMETER BASED ON Tb³⁺ TO Eu³⁺ ET

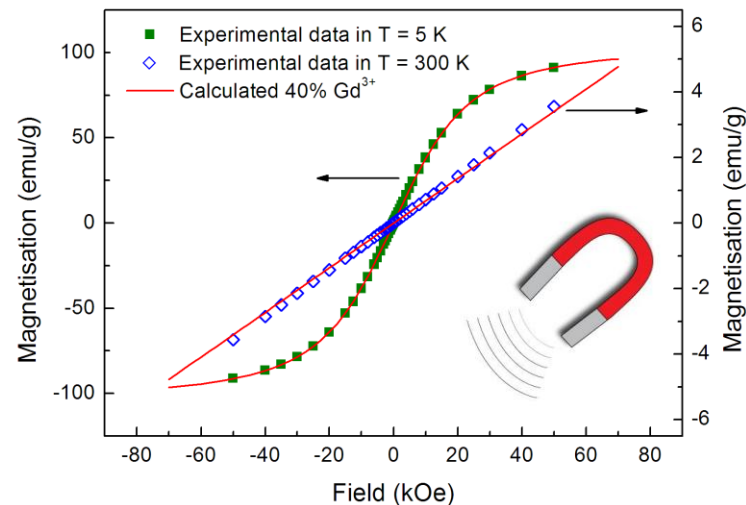
β -NaGdF₄:Tb³⁺, Eu³⁺



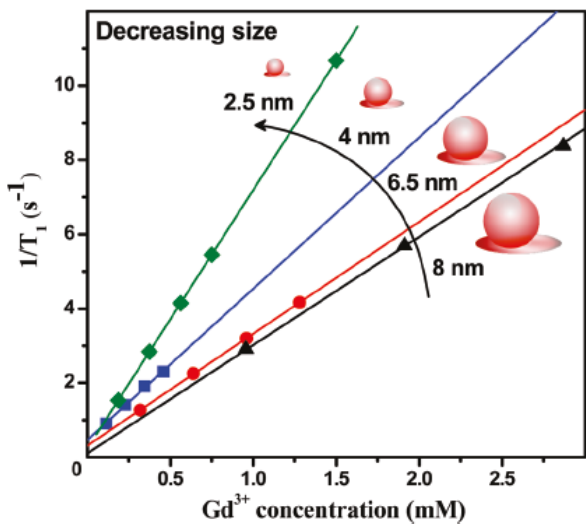
MAGNETIC PROPERTIES OF Gd³⁺ BASED NCs



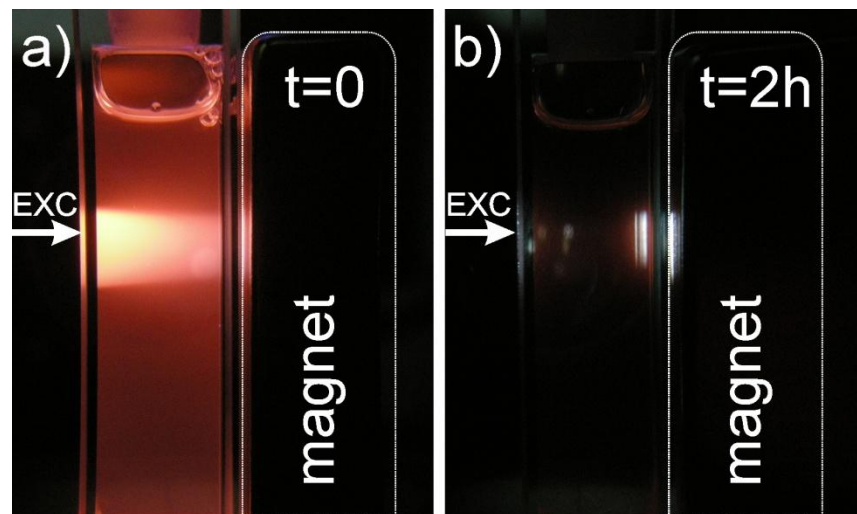
Four surface Gd³⁺ ions as an example cooperatively induce the longitudinal relaxation of the water proton



Hysteresis loop of the NaGdF₄:Tb³⁺, Eu³⁺ nanocrystals



T₁ ionic relaxivity plot for NaGdF₄ NPs of different sizes in water (1.5 T) (where T₁ is the longitudinal relaxation time of water protons).

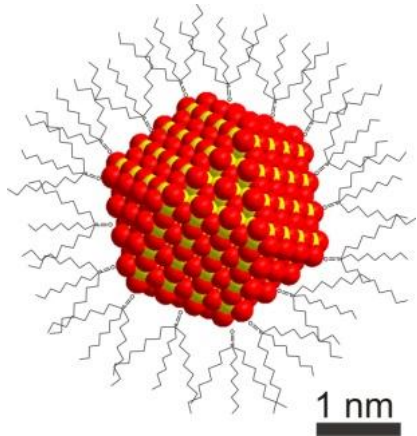


Digital photo of NaGdF₄:Tb³⁺, Eu³⁺ NCs excited by 272 nm wavelength

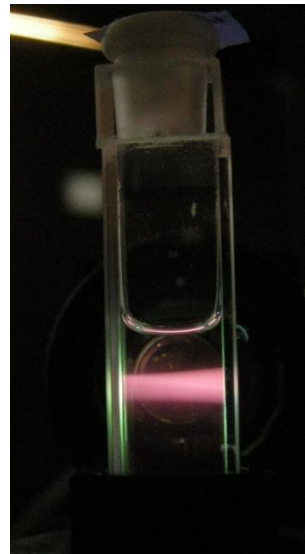
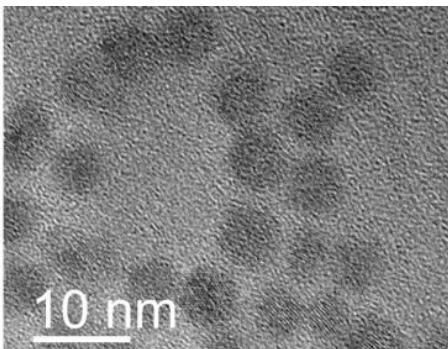
Park, J. Y. *et al.* ACS Nano 3, 3663-3669, (2009).

Johnson *et al.* Chem. Mater. 2011, 23, 3714-3722

CONCLUSIONS



- Synthesis of NaYF_4 and NaGdF_4 nanocrystals with TOPO ligands: hexagonal, ultrasmall, spherical, monodisperse
- High quality emission from Eu^{3+} ions
- Gd^{3+} sensitized emission from Eu^{3+} located in the core of NCs
- Multicolor emission from Tb^{3+} - Eu^{3+} codoped NCs
- Optical nanothermometer based on phonon assisted Tb^{3+} - Eu^{3+} ET
- Magnetic properties of NaGdF_4 ultrasmall NCs



Synthesis of Inorganic Nanocrystals

Doped by Lanthanide Ions for Bio-Medical Applications



<http://www.sindbad.pwr.wroc.pl/>



Artur Podhorodecki
Head of the project



Mateusz Bański
PhD student,



Agnieszka Noculak
PhD student,



Bartłomiej Sojka
PhD student,



Yvonne Yong
MSc student

Marek Ledwon
BSc student

PhD and PostDoc position available



