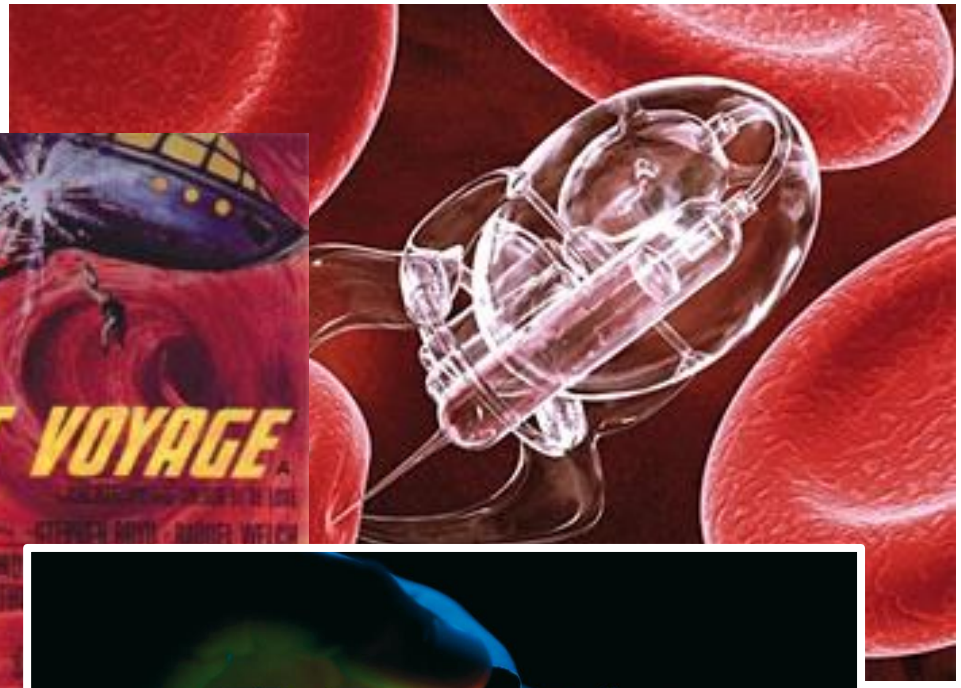
Scientific and Technological Advances in Cardiac and Vascular Surgery. A Translational Approach

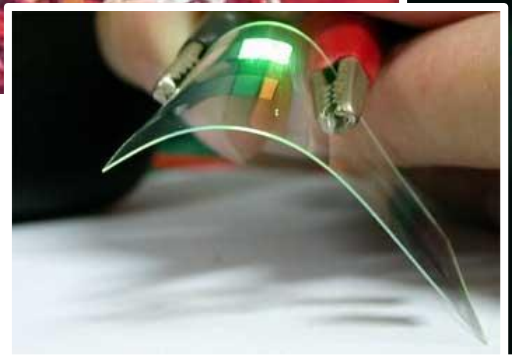
Erice, May, 2015

COLLOIDAL ENGINEERED NANOPARTICLES FOR MULTIMODAL IMAGING, BIO-DIAGNOSTIC AND NANOSENSING

UNIVERSITY OF MILANO BICOCCA
DEPARTMENT OF MATERIALS SCIENCE
PROF. SERGIO BROVELLI

CREDIBILITY DISCLAIMER

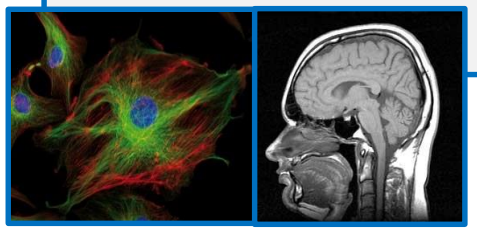




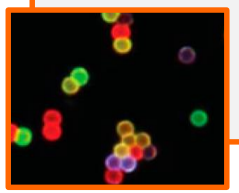
RESEARCH OUTLINE

1.OPTOMAGNETIC IMAGING

Nature Nanotech. *7*, 792, **2012**
PCCP, 16, 2491, **2014**



2. HIGH CONTRAST UC IMAGING PHOTOTRIGGERED THERAPY

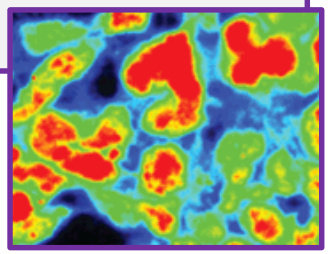


Adv. Funct. Mater. *22*, 139 ,**2012**
PCCP, 17, 4020-4024, **2015**

MULTIFUNCTIONAL NANOMATERIALS

3. INTRACELLULAR SENSING

Nature Comm. 6, 6434, **2015**
Nano Lett., *14*, 3855, **2014**

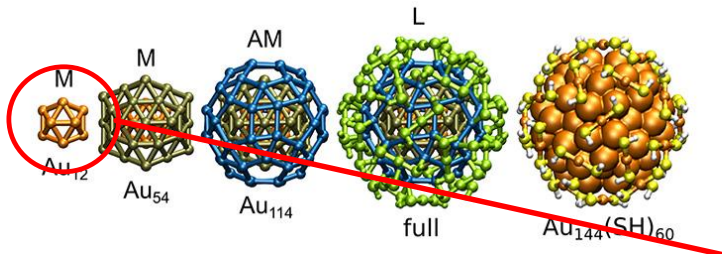


4. NANODEVICES LAB-on-CHIP

Nature Comm. *3*, 690, **2012**

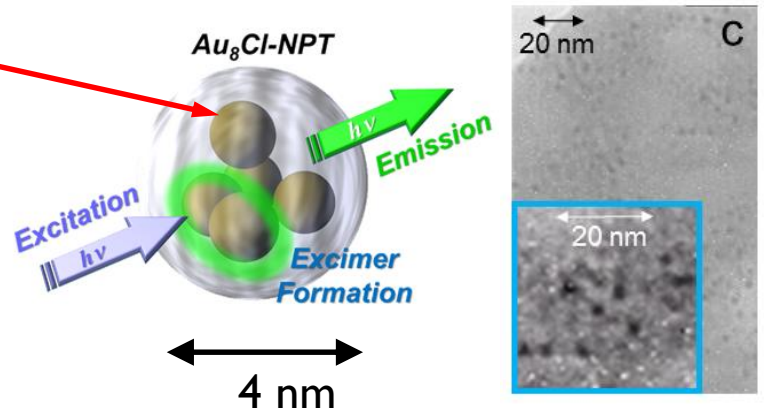
1. OPTOMAGNETIC IMAGING
PHOTO-ACTIVATED GOLD CLUSTER NANOMAGNETS

APPLICATIONS: OPTOMAGNETIC IMAGING, PHOTOTRIGGERED MR and HYPERTHERMIA

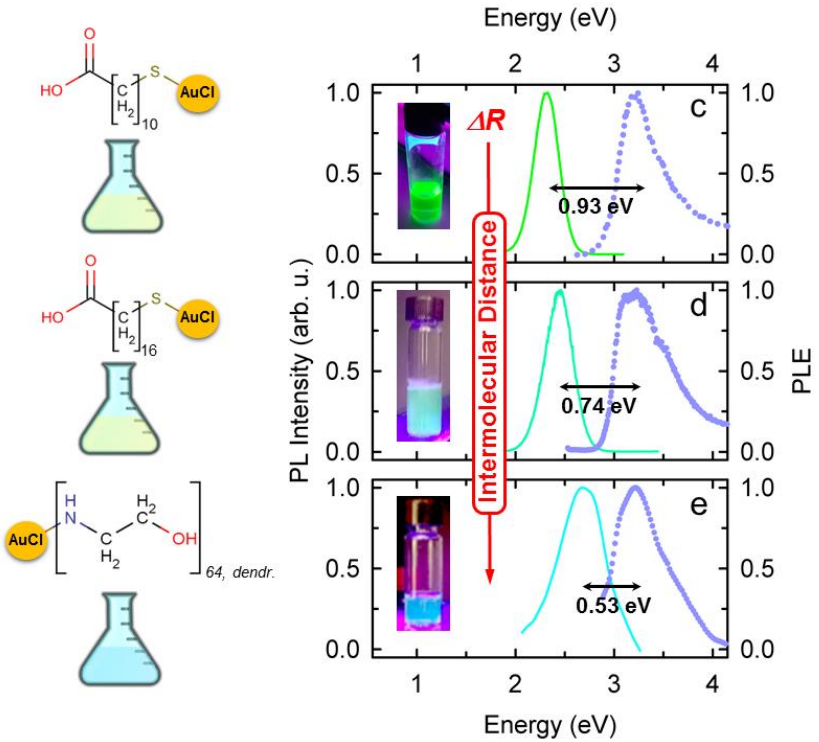


- Fluorescent Nanomaterials
- High Biocompatibility of Au
- Size dependent Photophysical and Photochemical Properties
- Phototriggered Magnetic Properties

CLUSTER LOADED NANOPELLETS

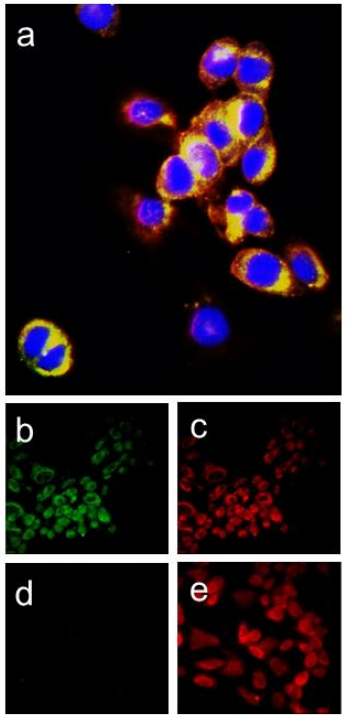


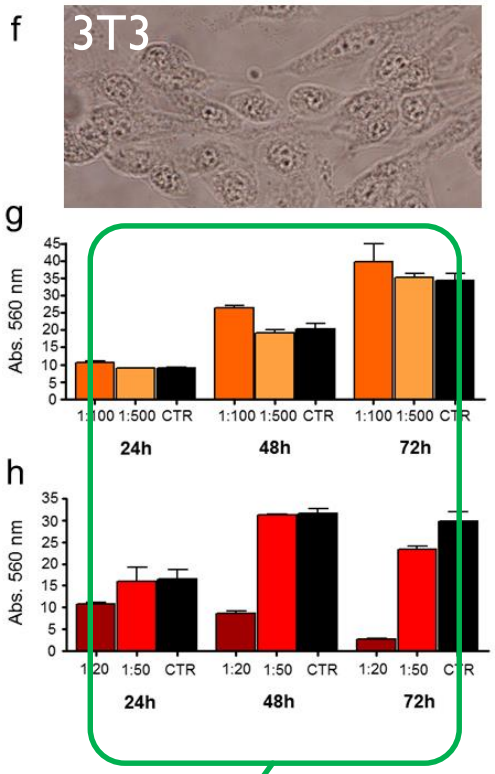
TUNABLE STOKE SHIFT FOR HIGH CONTRAST IMAGING



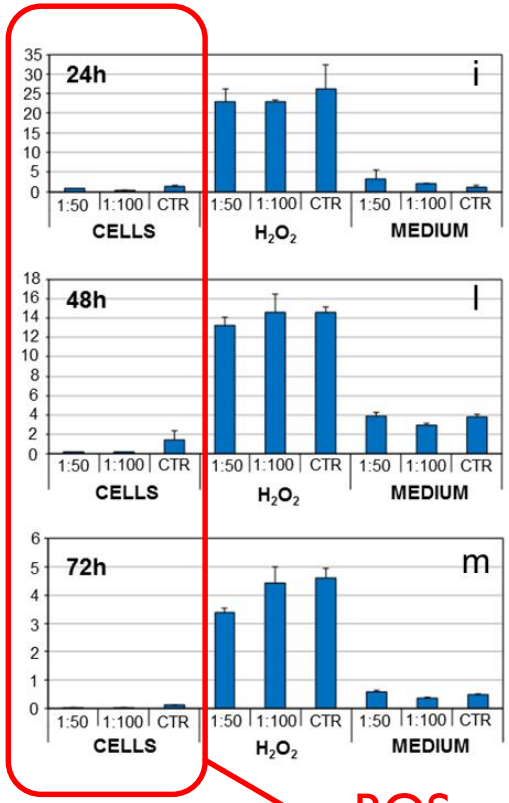
Santiago Gonzalez et al, Nature Materials, under review

1. OPTOMAGNETIC IMAGING
PHOTO-ACTIVATED GOLD CLUSTER NANOMAGNETS





NO EFFECTS ON CELLS VIABILITY

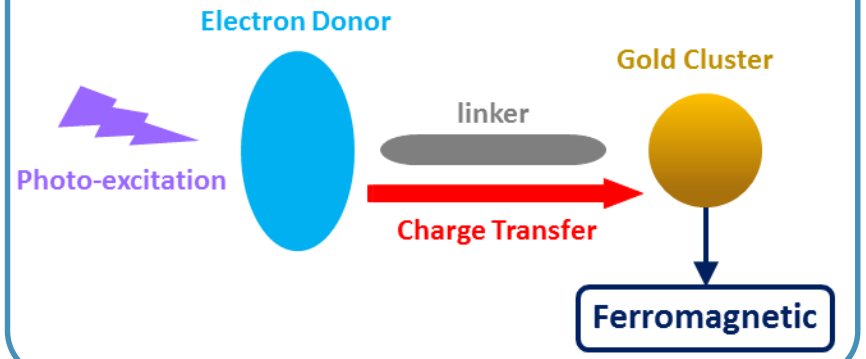


ROS SCAVENGERS

IN COLLABORATION WITH

L'ASSOCIAZIONE AMICI DEL "CENTRO DINO FERRARI" SOSTIENE
CENTRO DINO FERRARI
UNIVERSITÀ DEGLI STUDI DI MILANO
FONDAZIONE IRCCS CA' GRANDA OSPEDALE MAGGIORE POLICLINICO

PHOTOACTIVATED FERROMAGNETISM



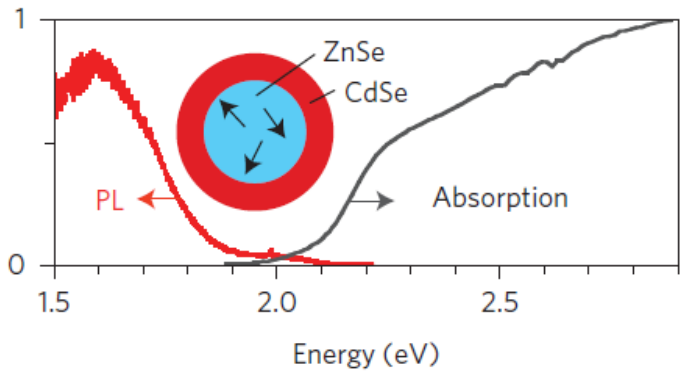
Santiago Gonzalez et al, Nature Materials, under review

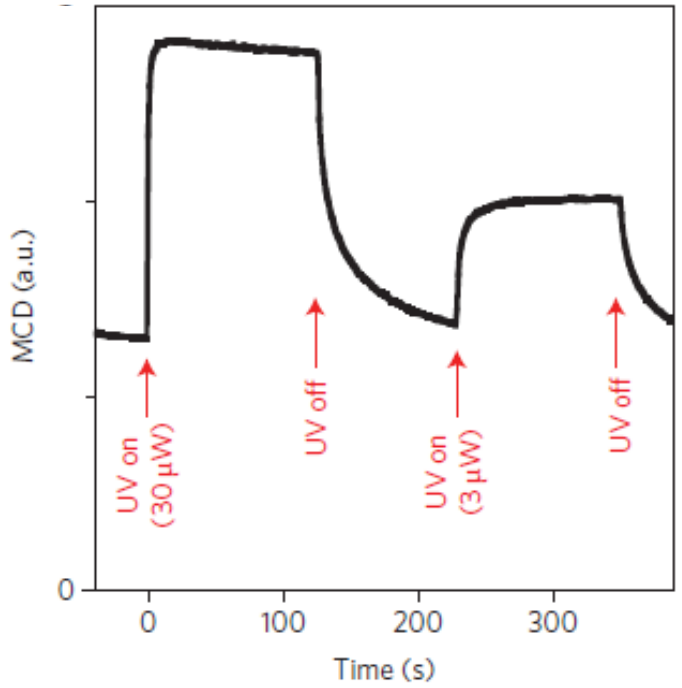
1. OPTOMAGNETIC IMAGING
PHOTO-MAGNETIC COLLOIDAL NANOPARTICLES

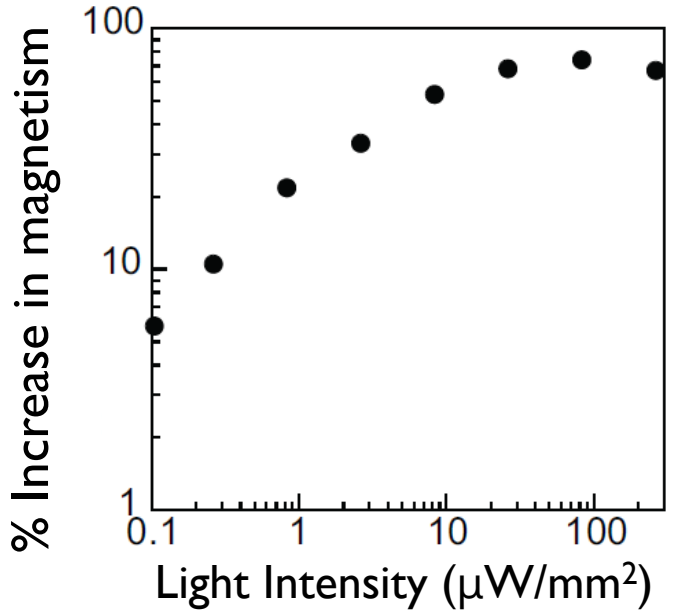
LETTERS
PUBLISHED ONLINE: 2 DECEMBER 2012 | DOI: 10.1038/NNANO.2012.210
nature nanotechnology

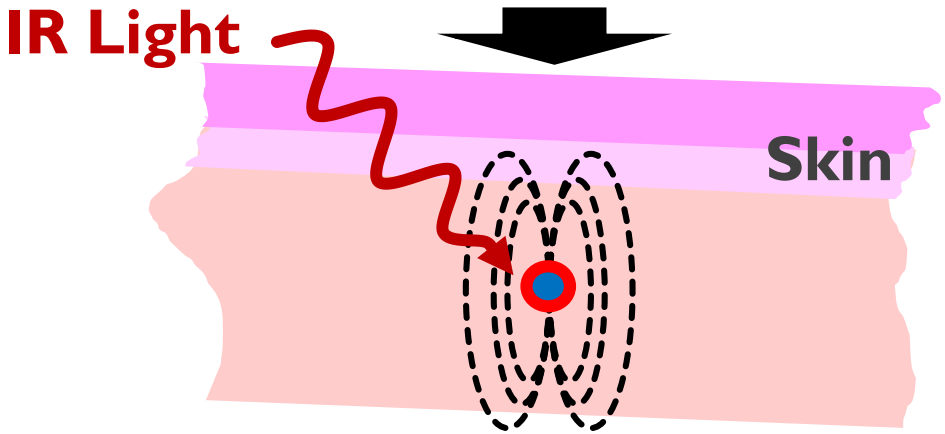
Long-lived photoinduced magnetization in copper-doped ZnSe–CdSe core–shell nanocrystals

A. Pandey[1], S. Brovelli[1,2], R. Viswanatha[1], L. Li[1], J. M. Pietryga[1], V. I. Klimov[1]* and S. A. Crooker[3]*





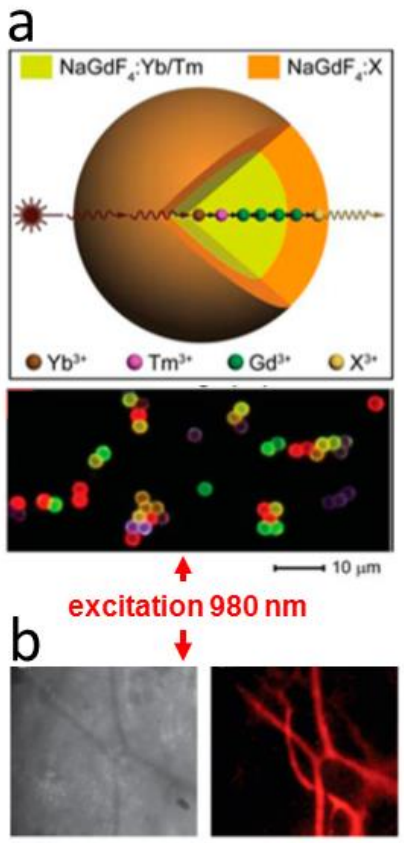




2. HIGH CONTRAST IMAGING - PHOTOTRIGGERED THERAPY

LOW POWER UPCONVERSION IN ORGANIC SYSTEMS

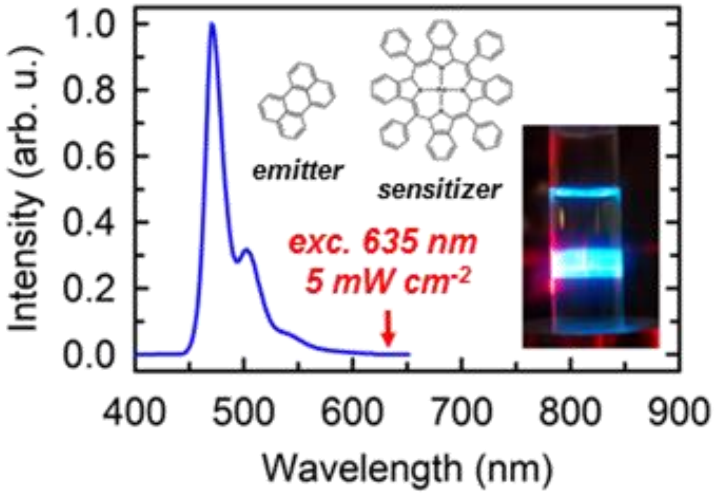
Photon up-conversion is a process which leads to the emission of light at energy higher than the absorbed light (anti-Stokes shift)



UC nanomaterials based on rare-earth ions have been successfully applied for living cells and small animals imaging.

- Eliminates the noise given by auto-fluorescence.
- Improved penetration depth.
- Improved resistance to photobleaching

ULTRA-LOW POWER UC IN ORGANICS



- Higher bio-compatibility
- Higher efficiency at low power, reducing the damage to the biological environment
- Blue photons to trigger the release of drugs and contrast agents and to initiate chemical reactions.

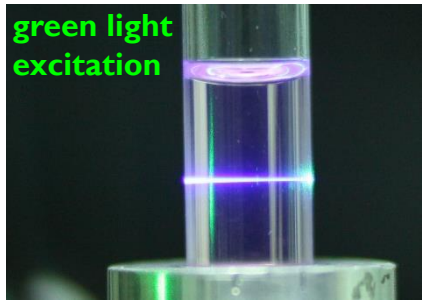
Monguzzi et al., **PCCP**, 17, 4020-4024, **2015**

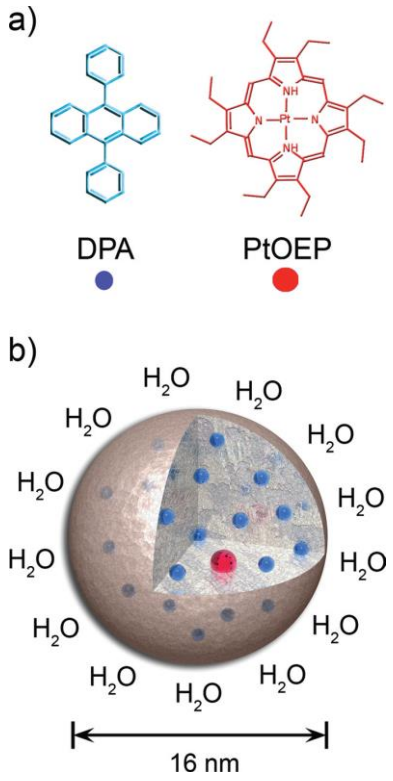
2. HIGH CONTRAST IMAGING - PHOTOTRIGGERED THERAPY

LOW POWER UPCONVERSION IN ORGANIC SYSTEMS

UC IN CROSSLINKED NANOPARTICLES

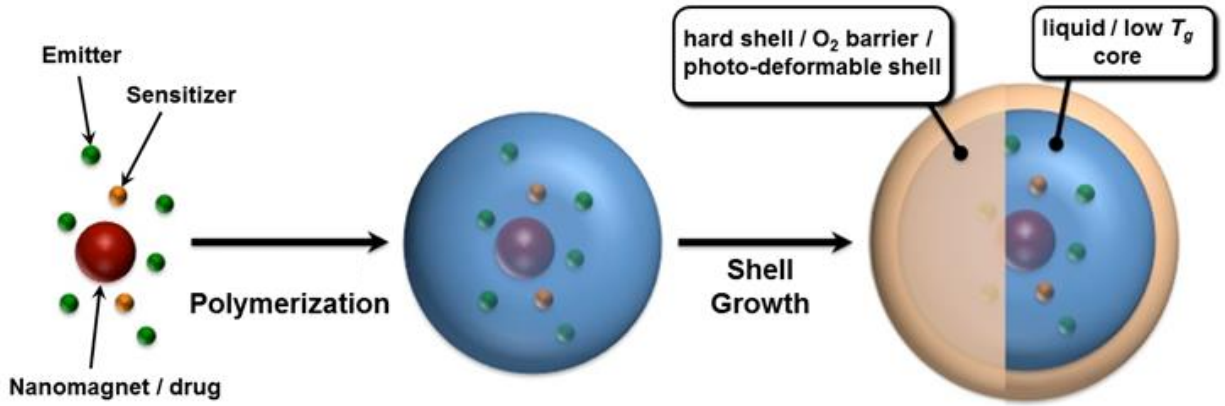
ADVANCED FUNCTIONAL MATERIALS
www.afm-journal.de



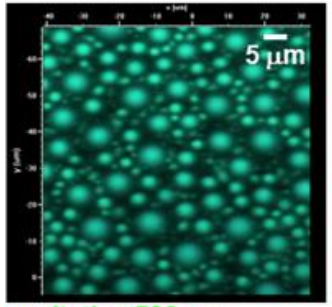


Monguzzi et al., **Adv. Funct. Mater.** *22*, 139 ,**2012**

UC IN CORE-SHELL NANOCAPSULES

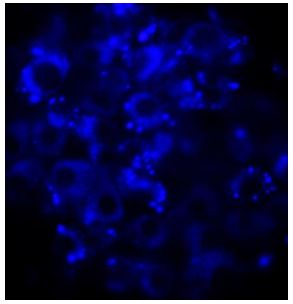


TTA-UC μ–capsule Imaging



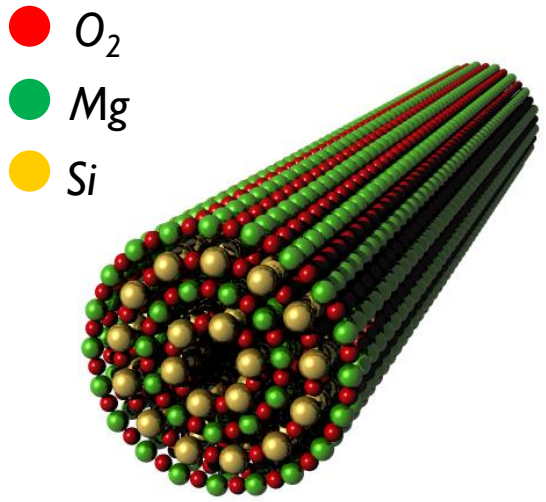
excitation 532 nm
emission 380-480 nm

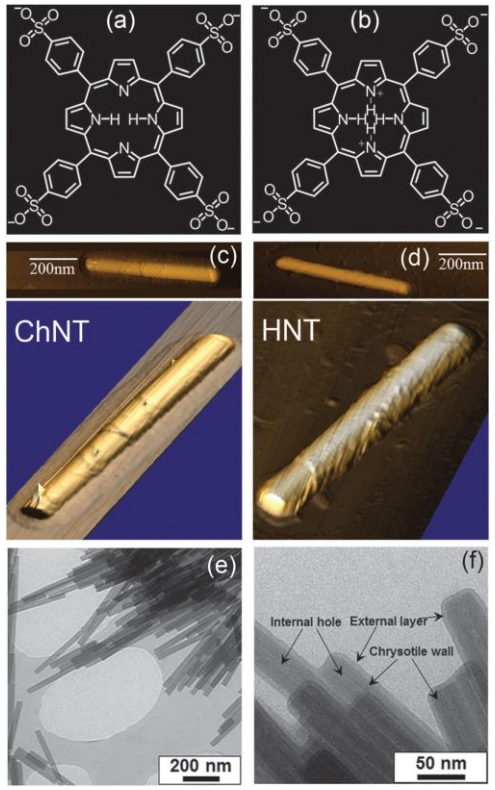
NANOCAPSULE in 3T3 cells



3.INTRACELLULAR SENSING
GEOINSPIRED HYBRID NANOTUBES (HNT)

Nanotubes Functionalized with pH sensitive fluorophores

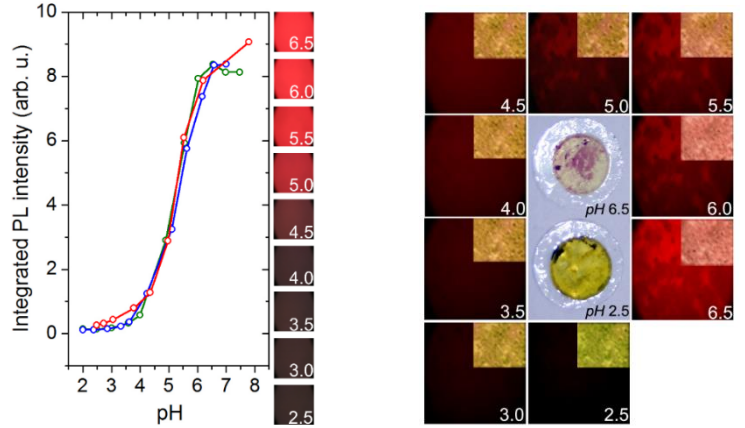


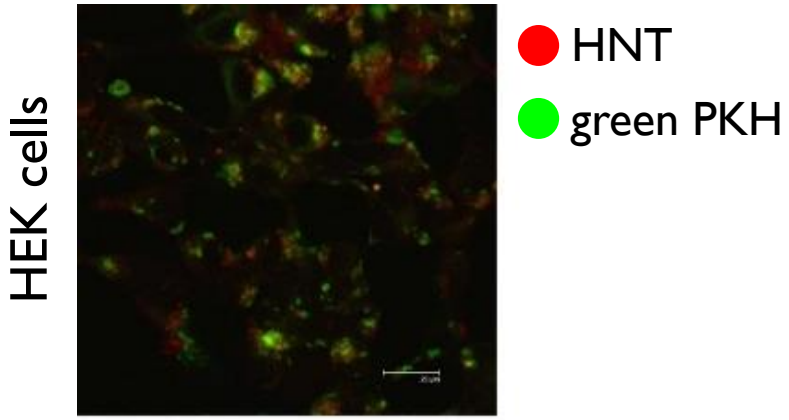


- Modulable length, diameter 50 nm
- Charged surface for ionic functionalization
- Highly durability
- Biocompatible

Monguzzi et al., **PCCP**, 16, 2491, **2014**

pH sensitive fluorescence



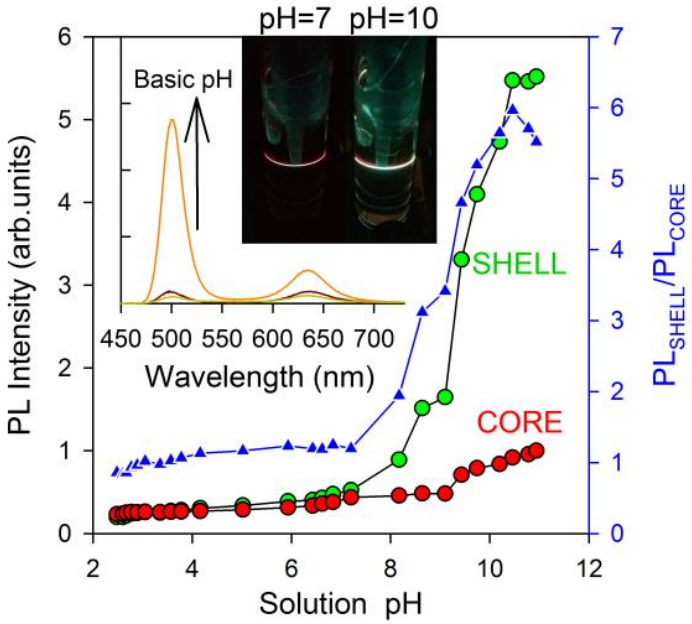


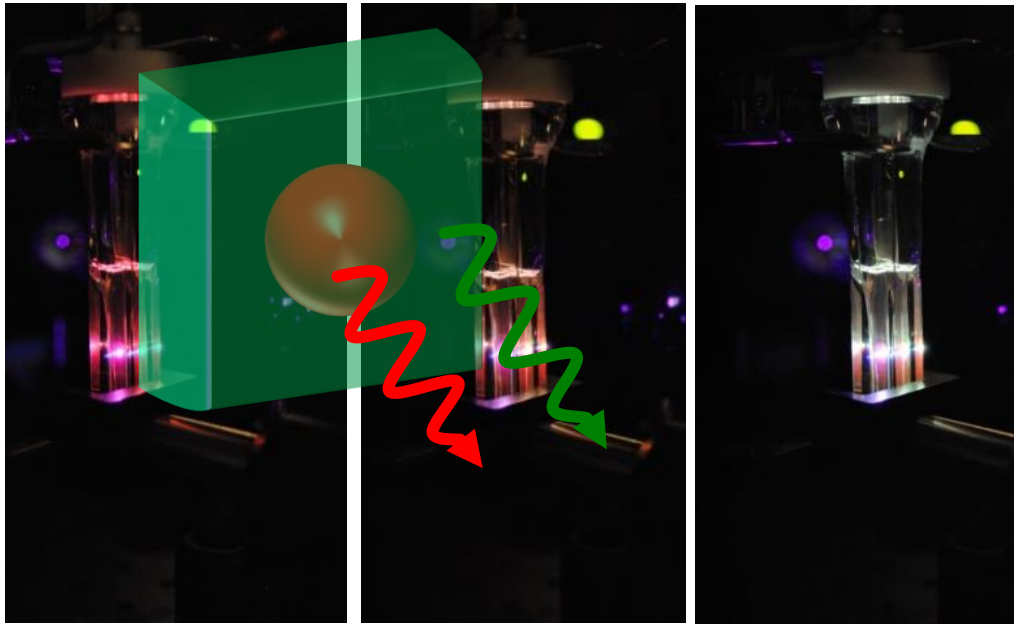
3.INTRACELLULAR SENSING

MULTIFUNCTIONAL COLLOIDAL HETEROSTRUCTURES FOR MULTIMODAL IMAGING

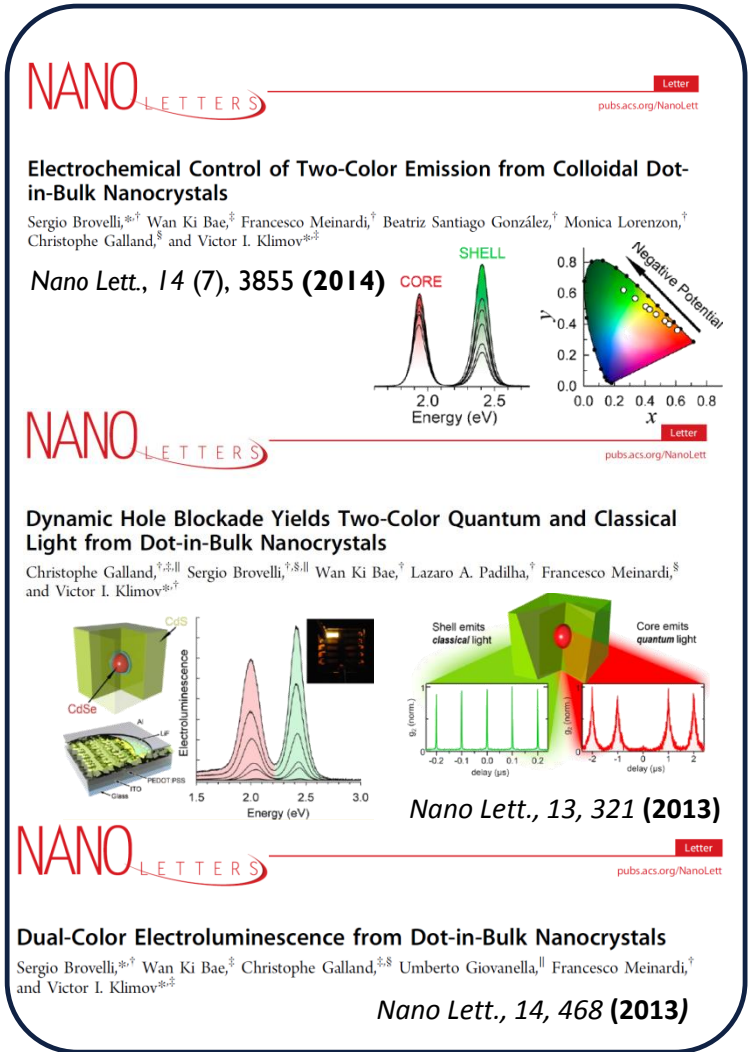
UNIVERSITÀ DEGLI STUDI DI MILANO BICOCCA

Multi-color emitting nanocrystals for intracellular ratiometric sensing





pH=4 pH=7 pH=10 →



NANO LETTERS Letter pubs.acs.org/NanoLett

Electrochemical Control of Two-Color Emission from Colloidal Dot-in-Bulk Nanocrystals

Sergio Brovelli,*,† Wan Ki Bae,‡ Francesco Meinardi,† Beatriz Santiago González,† Monica Lorenzon,† Christophe Galland,§ and Victor I. Klimov*,‡

Nano Lett., *14* (7), 3855 **(2014)**

NANO LETTERS Letter pubs.acs.org/NanoLett

Dynamic Hole Blockade Yields Two-Color Quantum and Classical Light from Dot-in-Bulk Nanocrystals

Christophe Galland,†,‡,∥ Sergio Brovelli,†,§,∥ Wan Ki Bae,† Lazaro A. Padilha,† Francesco Meinardi,§ and Victor I. Klimov*,†

Nano Lett., *13*, *321* **(2013)**

NANO LETTERS Letter pubs.acs.org/NanoLett

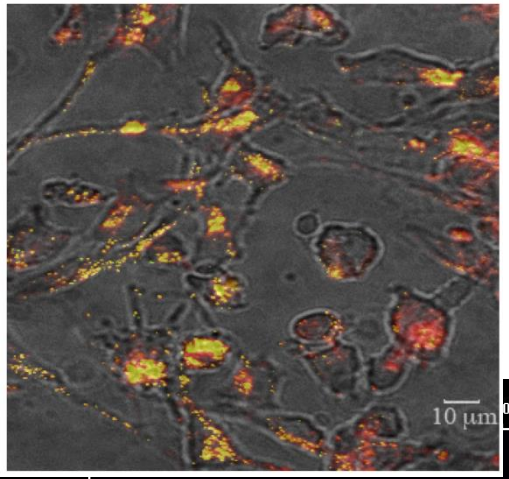
Dual-Color Electroluminescence from Dot-in-Bulk Nanocrystals

Sergio Brovelli,*,† Wan Ki Bae,‡ Christophe Galland,‡,§ Umberto Giovanella,∥ Francesco Meinardi,† and Victor I. Klimov*,‡

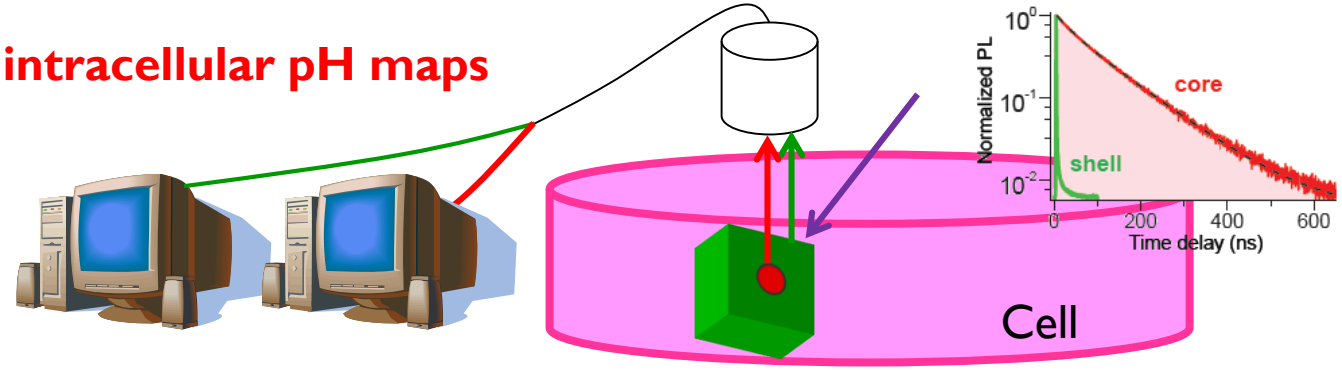
Nano Lett., *14*, *468* **(2013)**

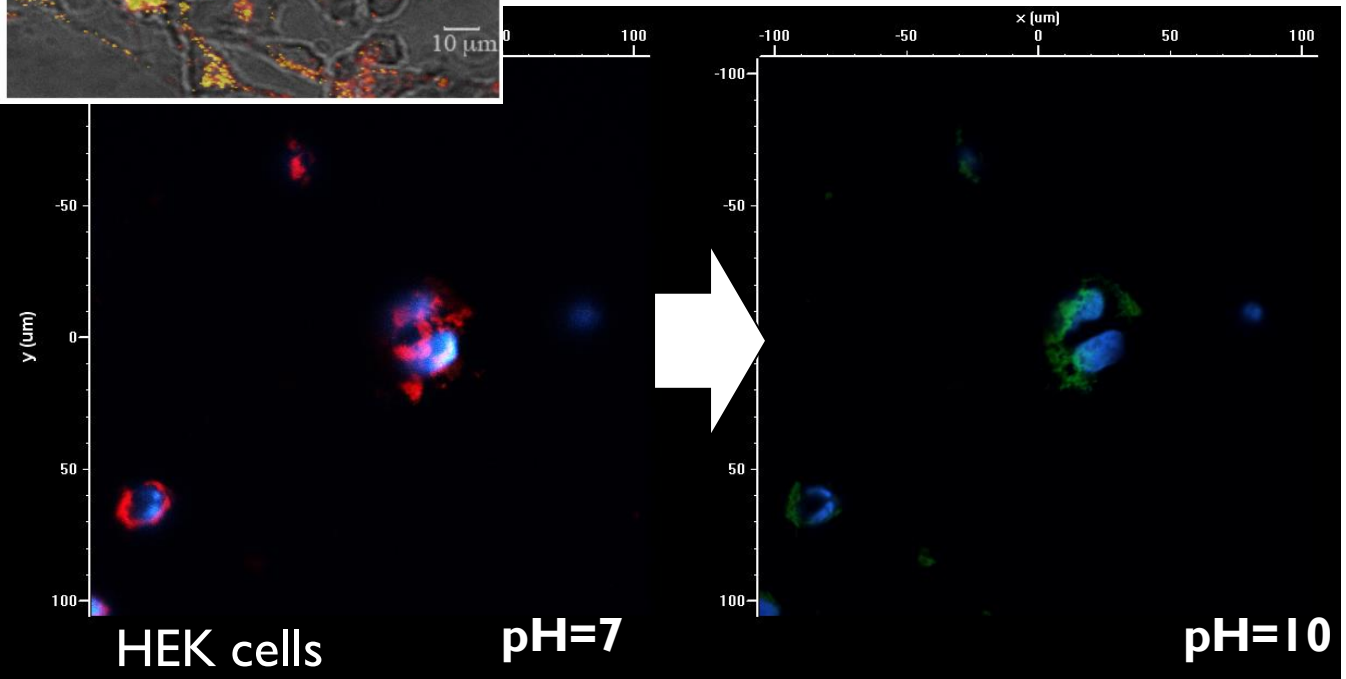
3.INTRACELLULAR SENSING

MULTI-COLOR EMITTING NANOCRYSTALS FOR RATIOMETRIC SENSING



Ratiometric pH sensing → intracellular pH maps



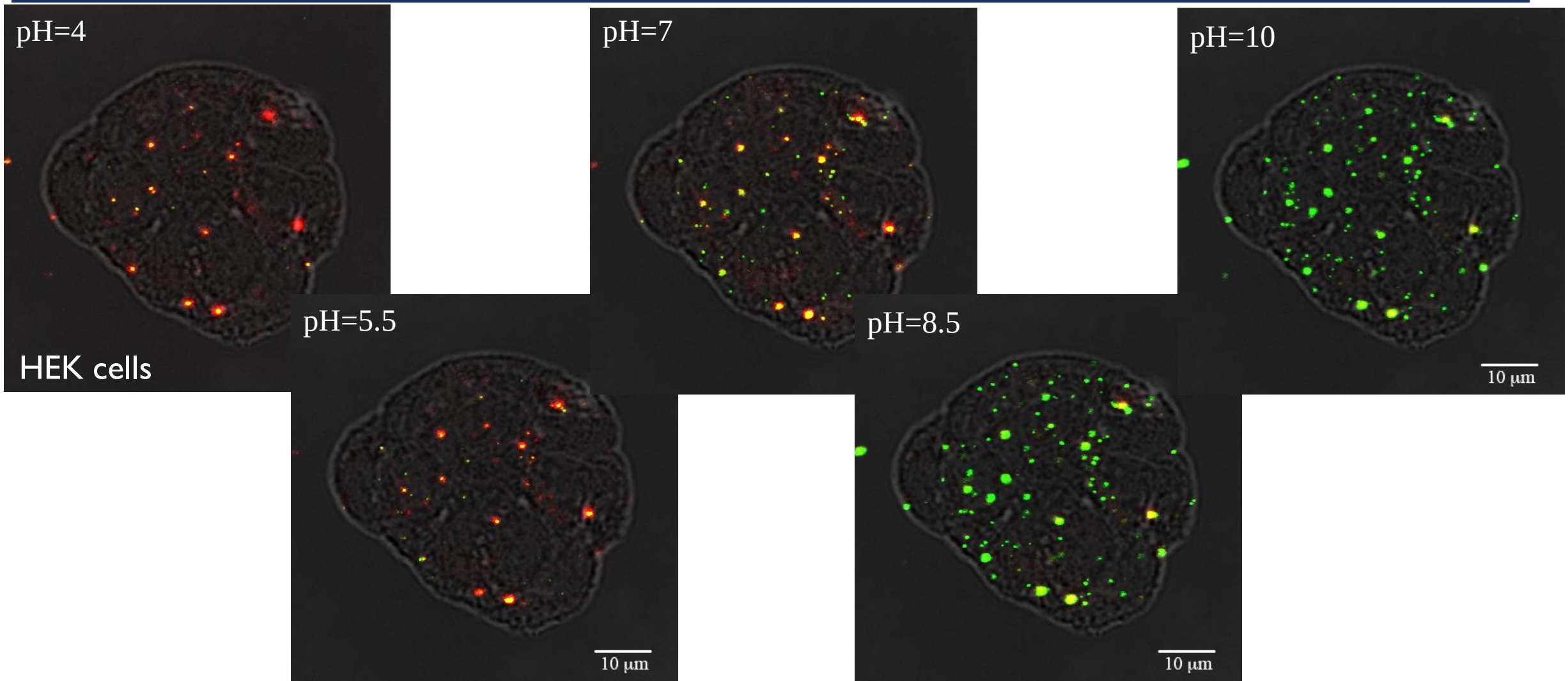


Green shell emission:
- highly sensitive to chemical environment
-Ultrafast decay time (ps)
- quadratic dependence on excitation power

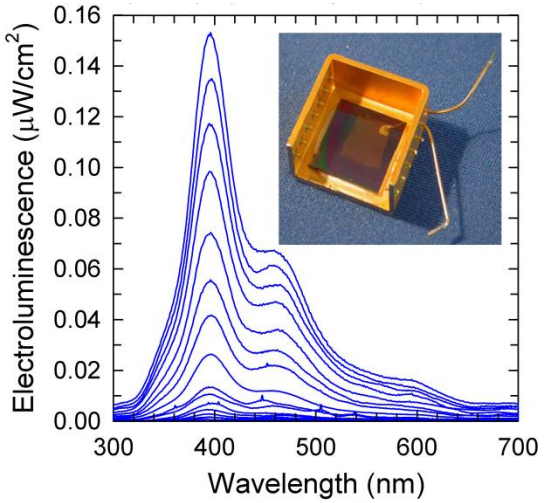
Red core emission:
-insensitive to chemical environment
- slow decay time (200ns)
- linear dependence on excitation

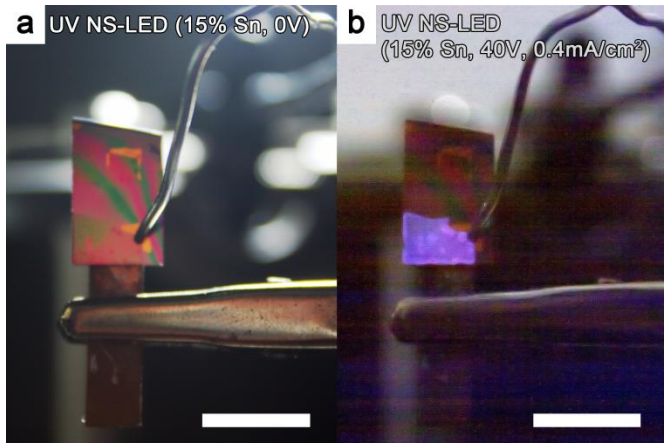
→ RATIOMETRIC INTRACELLULAR SENSING
→Enhanced imaging resolution through shell PL
→multi-timescale Fluorescence Lifetime Imaging (FLIM)

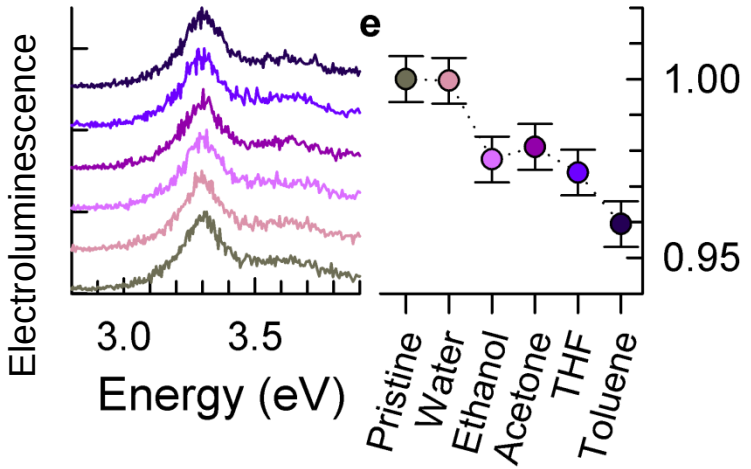
3.INTRACELLULAR RATIOMETRIC PH SENSING



4.CHEMICALLY INERT LEDS FOR IMPLANTABLE UV SOURCES







Brovelli et al **Nature Communications** *3*, 690, **2012**

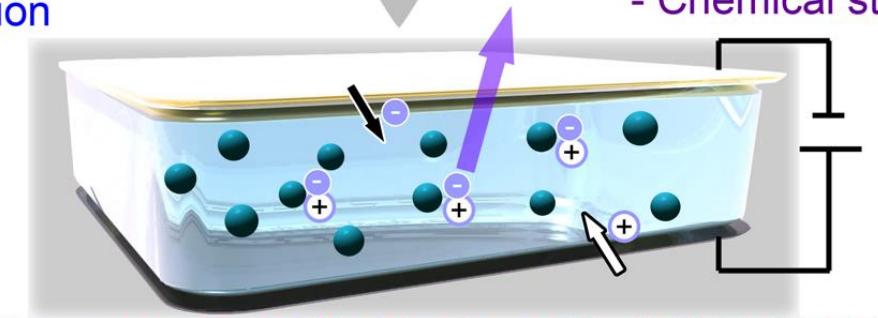
Oxide nanocrystals

- Wide band-gap
- Stoichiometry doping
- Nanocrystallinity
- Chemical stability
- UV emission

- Sol-gel synthesis
- Solution process (e.g. spin-coating)

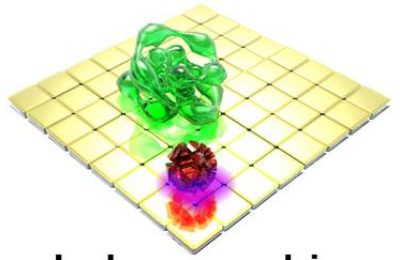
Oxide matrix

- Optical features
- Si compatibility
- Workability
- Chemical stability

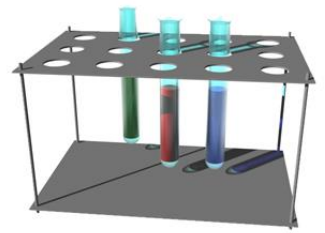


Solution-processed Oxide-in-oxide NS UV-LEDs

Implantable UV sources



Lab-on-a-chip UV-μLEDs arrays



Operation on immersion