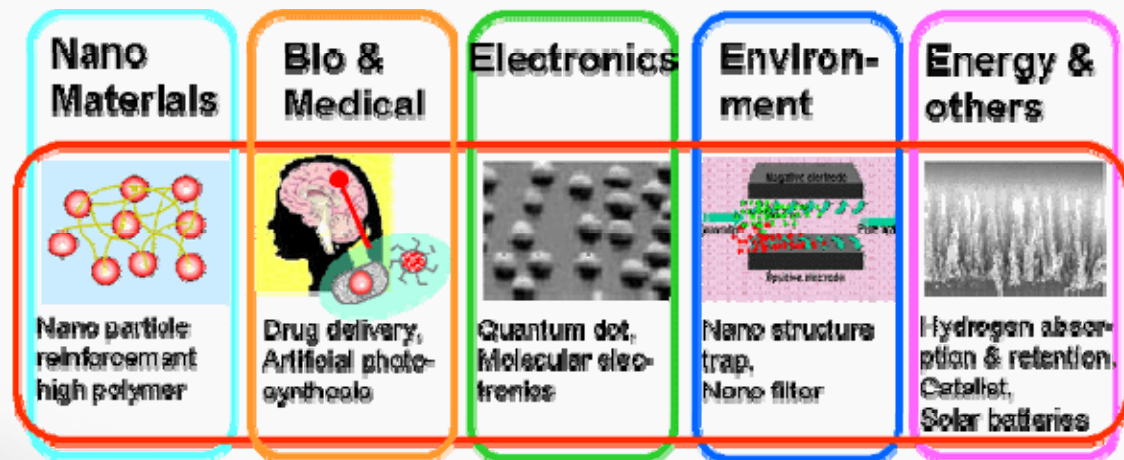


High resolution X-ray nano-spectroscopy techniques applied to nanoscience

Gema Martínez Criado

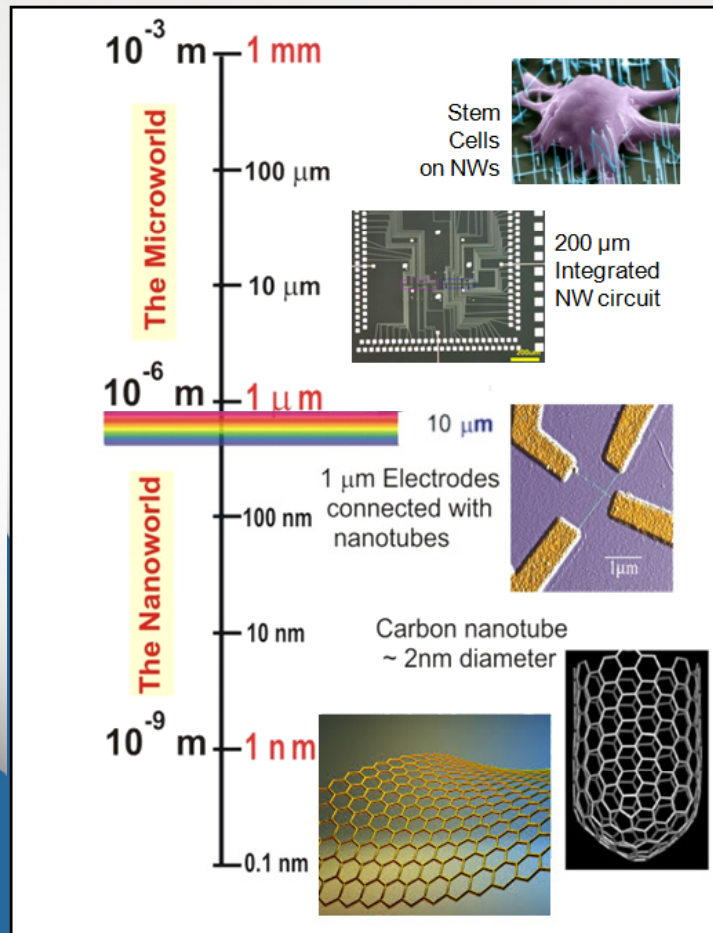


Talk outline

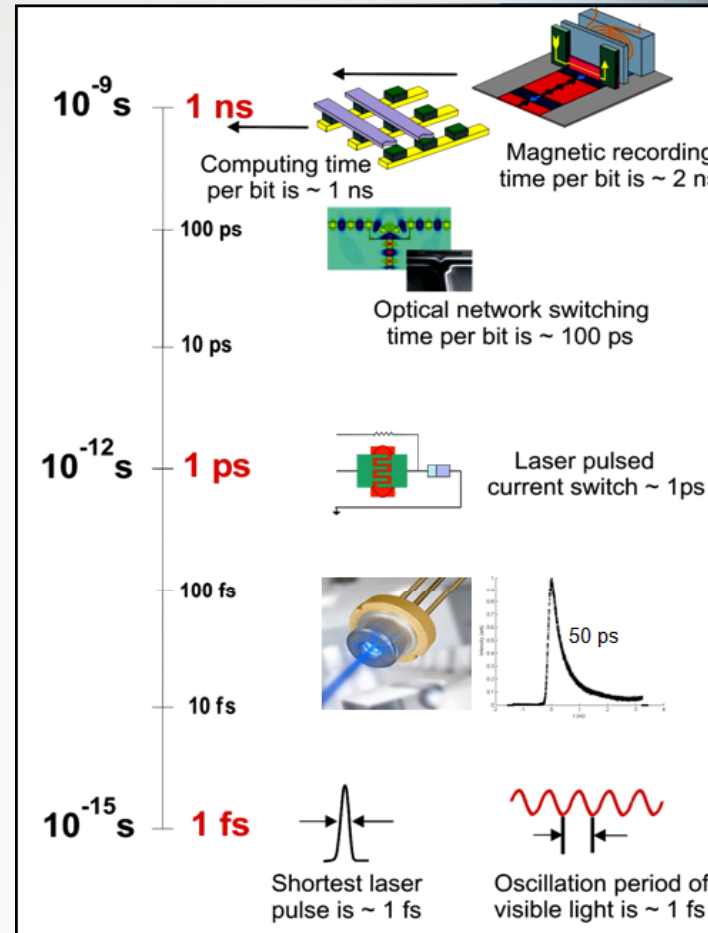
- Introduction
- Tools & techniques
- Applications

Advanced Materials - Tendency

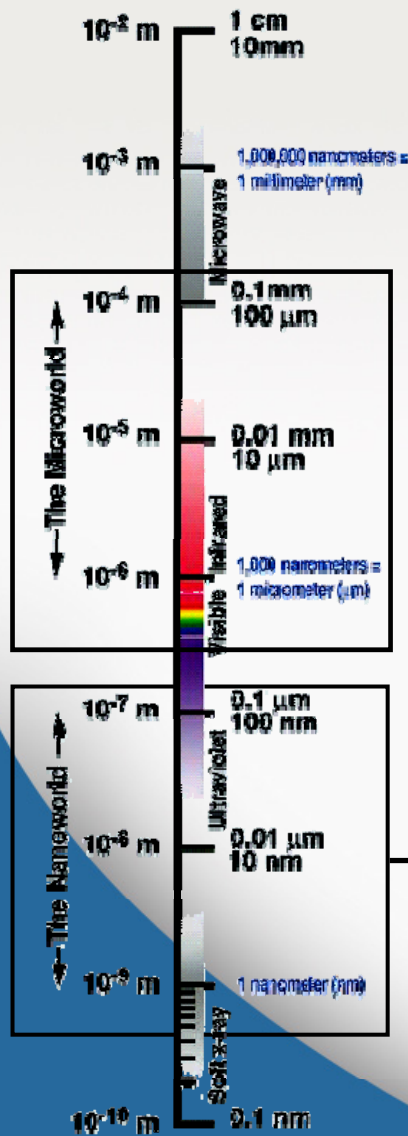
Ultra – Small



Ultra – Fast



New Phenomena



Phenomena :

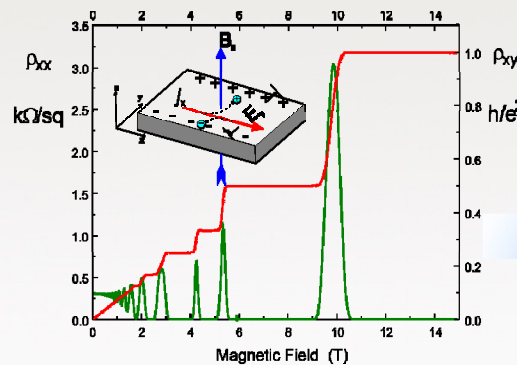
Properties

Chemical
Thermal
Magnetical
Mechanical
Electrical
Optical

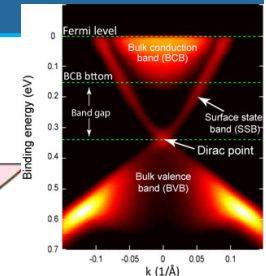
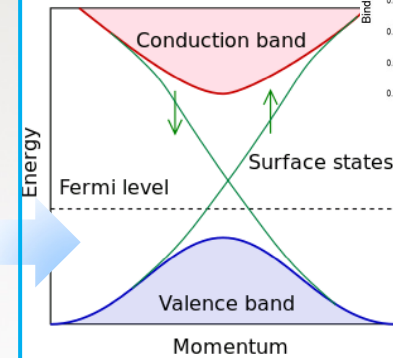
Materials

Biomaterials
Superconductors
Magnetics
Polymers
Composites
Semiconductors
Etc

Quantum Hall Effect

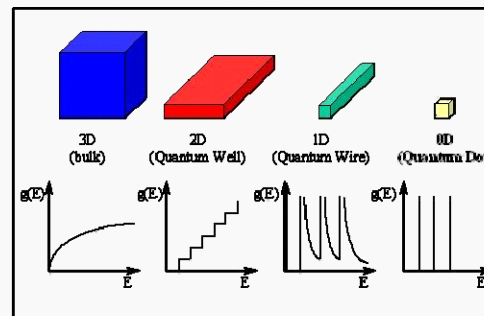


Topological Insulators

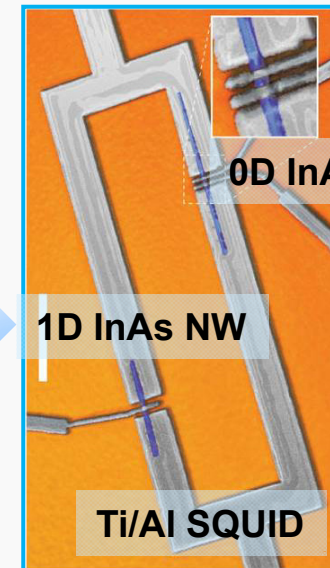
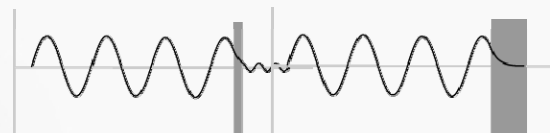


ARPES
LBNL

Spatial Quantum Confinement

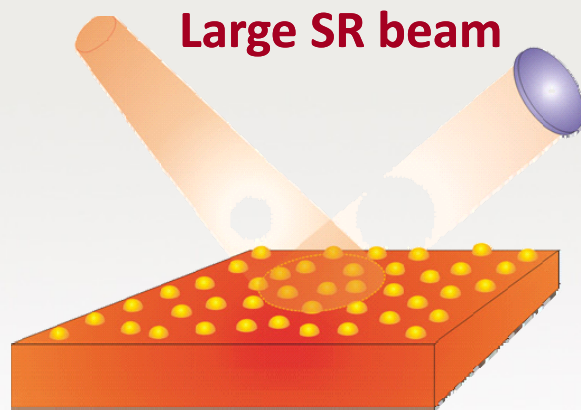


Tunnel Effect



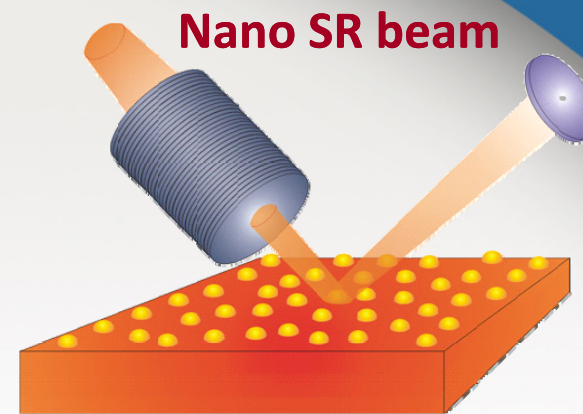
Hybrid SC-SMC

X-ray nanobeams



Average properties

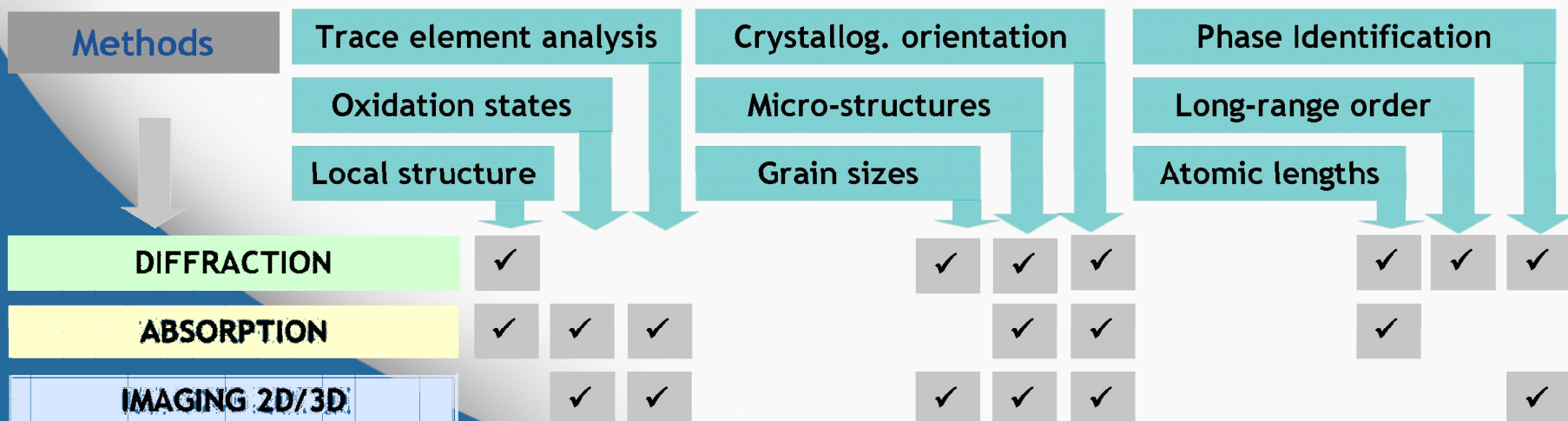
$10^5 - 10^6$ objects illuminated



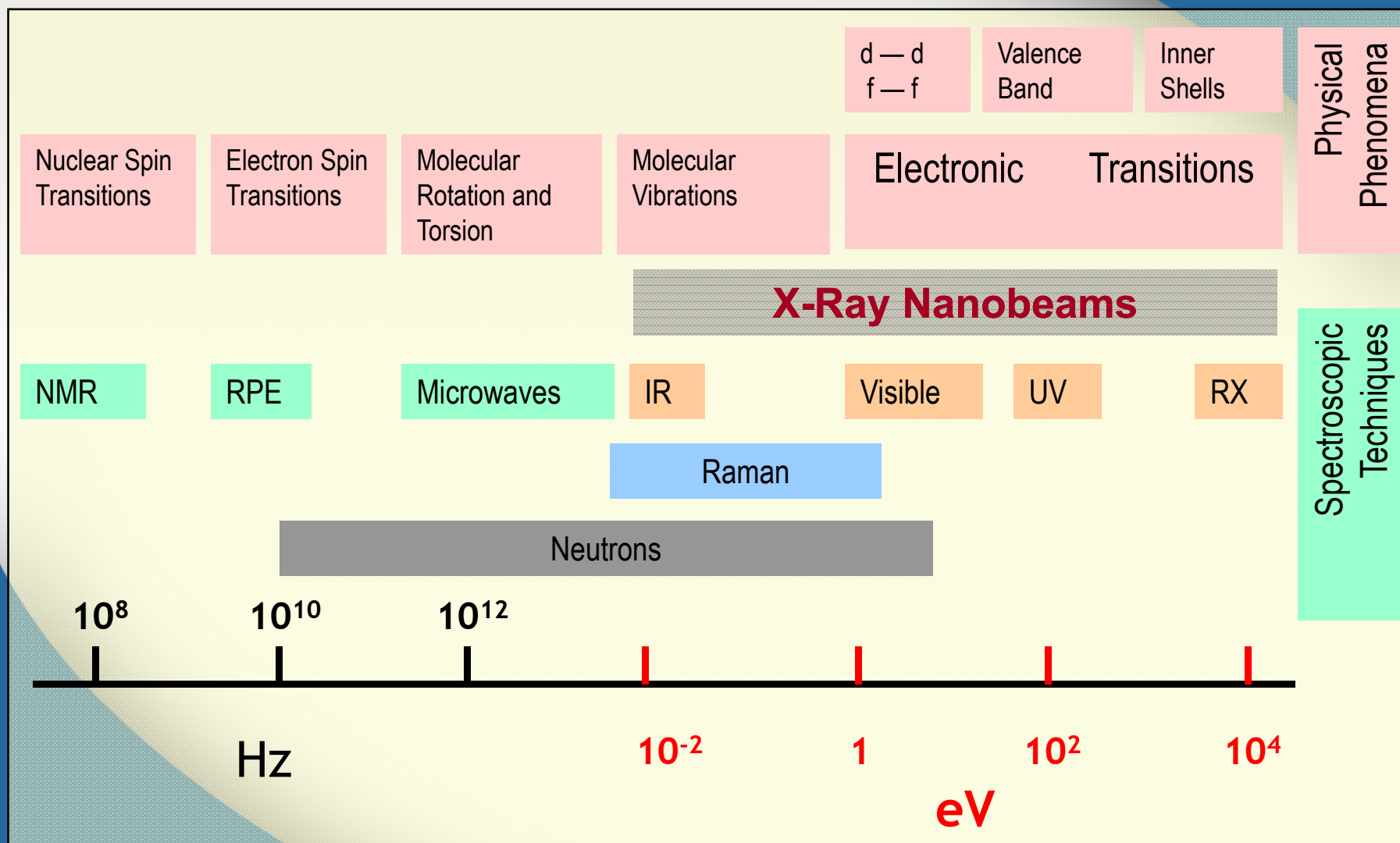
Specific properties

Goal: single nanostructures

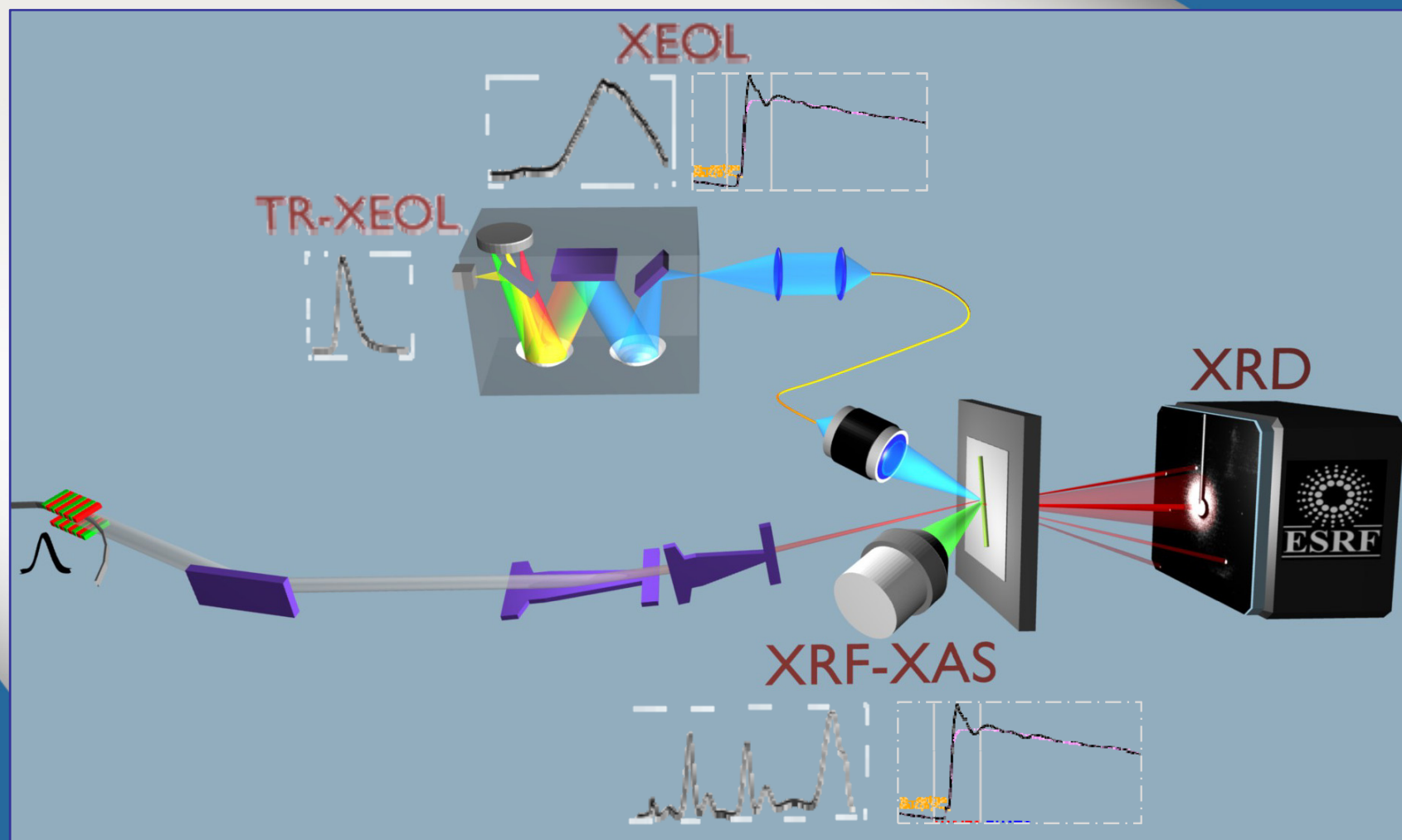
Courtesy: C. Mocuta



Synchrotron Wavelength



High-Resolution X-Ray Nano-Spectroscopy



Multimodal ID16B – NA Scheme: Spectral, Time & Space Resolved Techniques

Talk outline

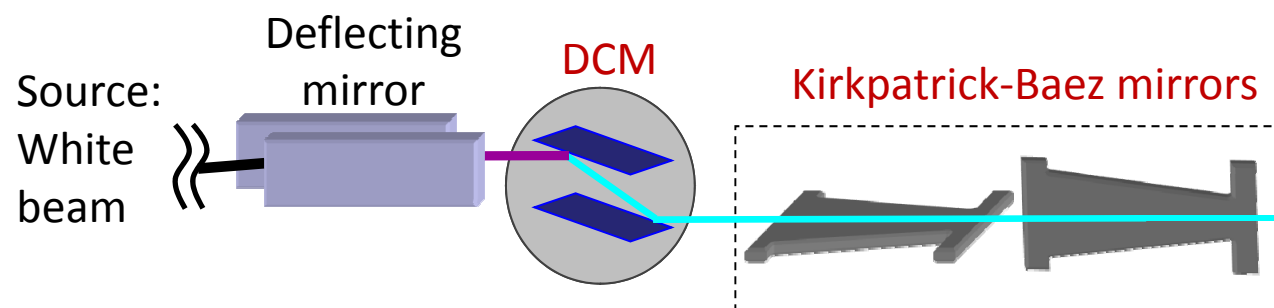
- Introduction: overview
- Tools & techniques: novel methods
- Applications

European Synchrotron Radiation Facility

ESRF: Europe's largest X-ray User Facility



Hard X-Ray Nanoprobe ID16B

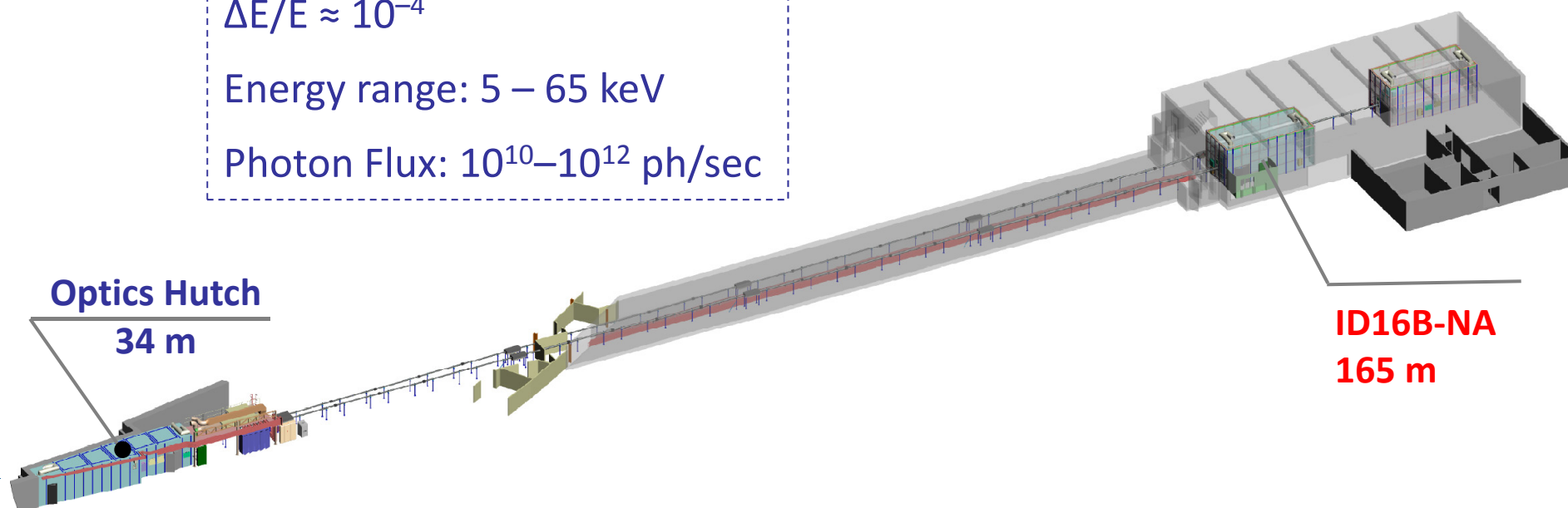
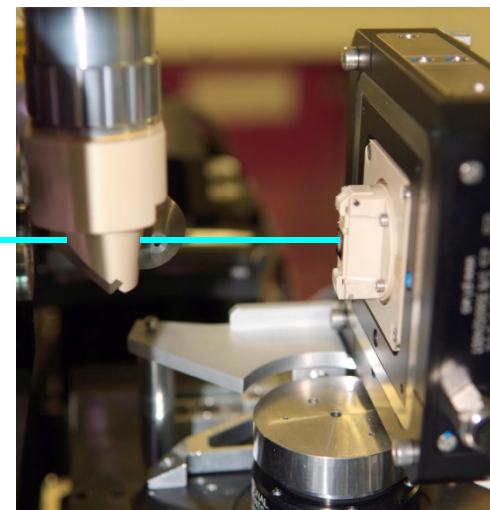


Beam size: $50 \times 50 \text{ nm}^2$

$\Delta E/E \approx 10^{-4}$

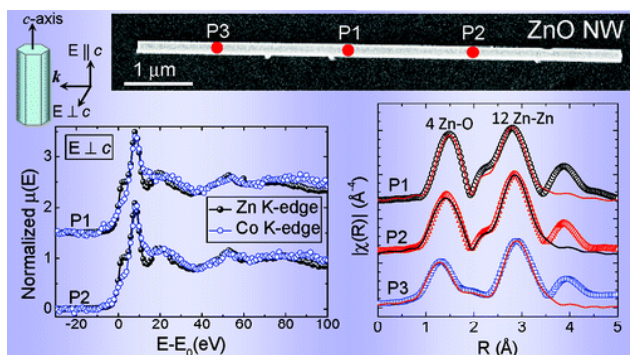
Energy range: 5 – 65 keV

Photon Flux: 10^{10} – 10^{12} ph/sec



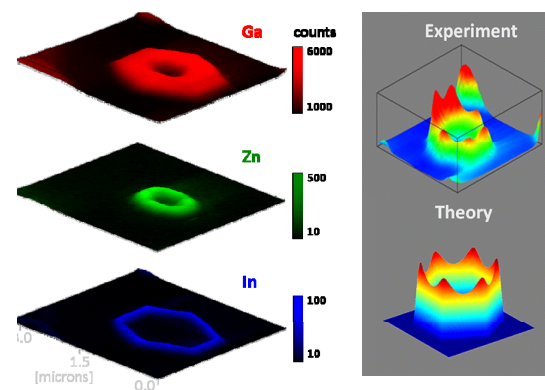
Hard X-Ray Nano-Spectroscopy

Nano-XRF & Nano-XAS



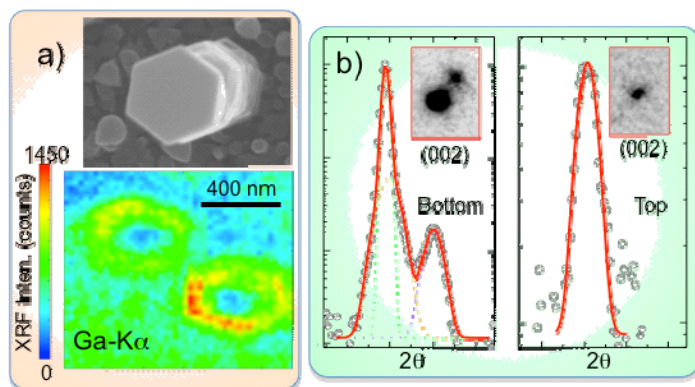
Segura-Ruiz, Martinez-Criado *et al.* Nano Letters 2011

Nano-XRF & Nano-XEOL



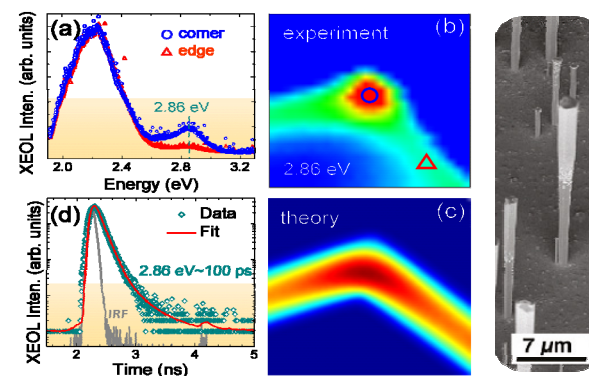
Martinez-Criado *et al.* Nano Letters 2012

Nano-XRF & Nano-XRD



Segura-Ruiz, Martinez-Criado *et al.* Nano Letters 2014

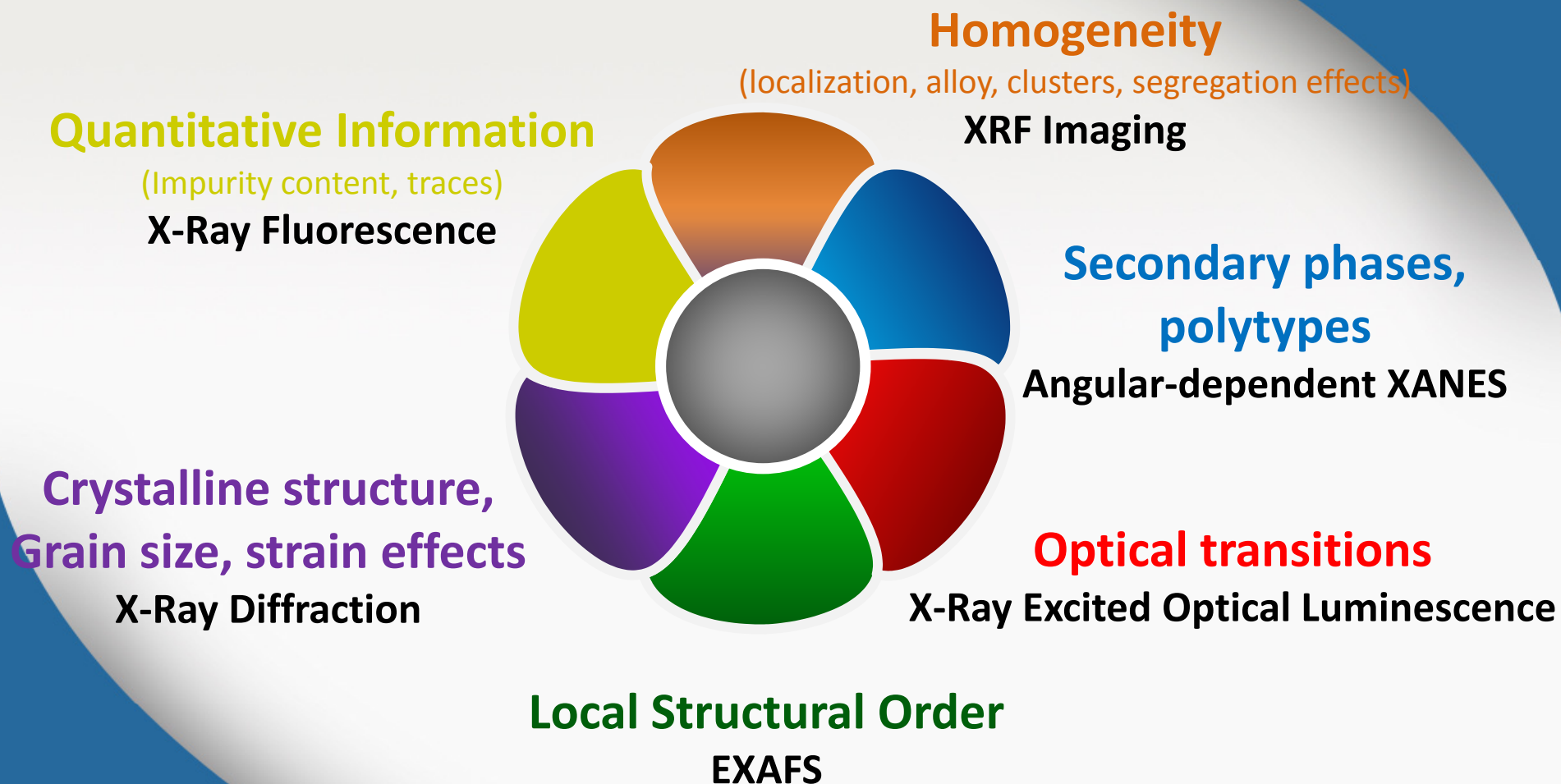
Time-Resolved Nano XEOL



Martinez-Criado *et al.* Advanced Materials 2014

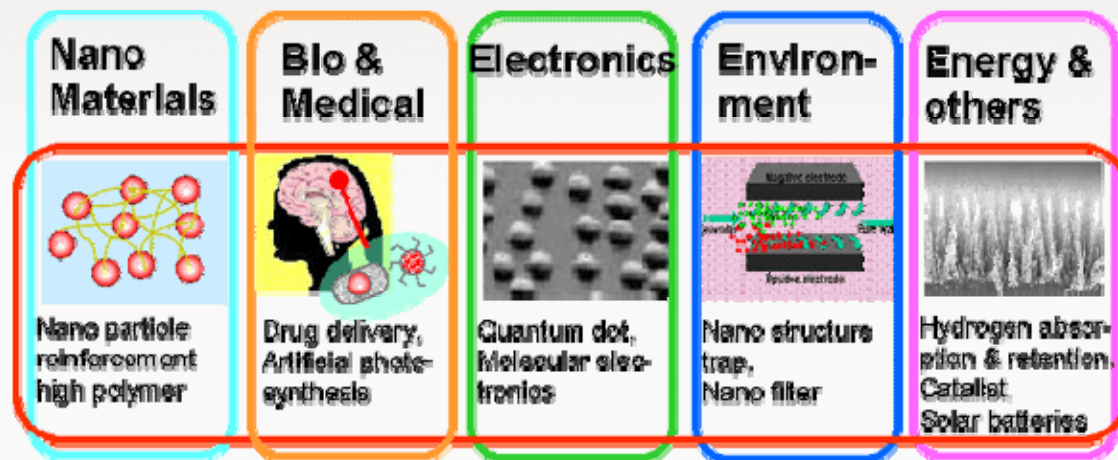
Advanced Hyperspectral Imaging Tools

Hyperspectral Imaging Tools



Talk outline

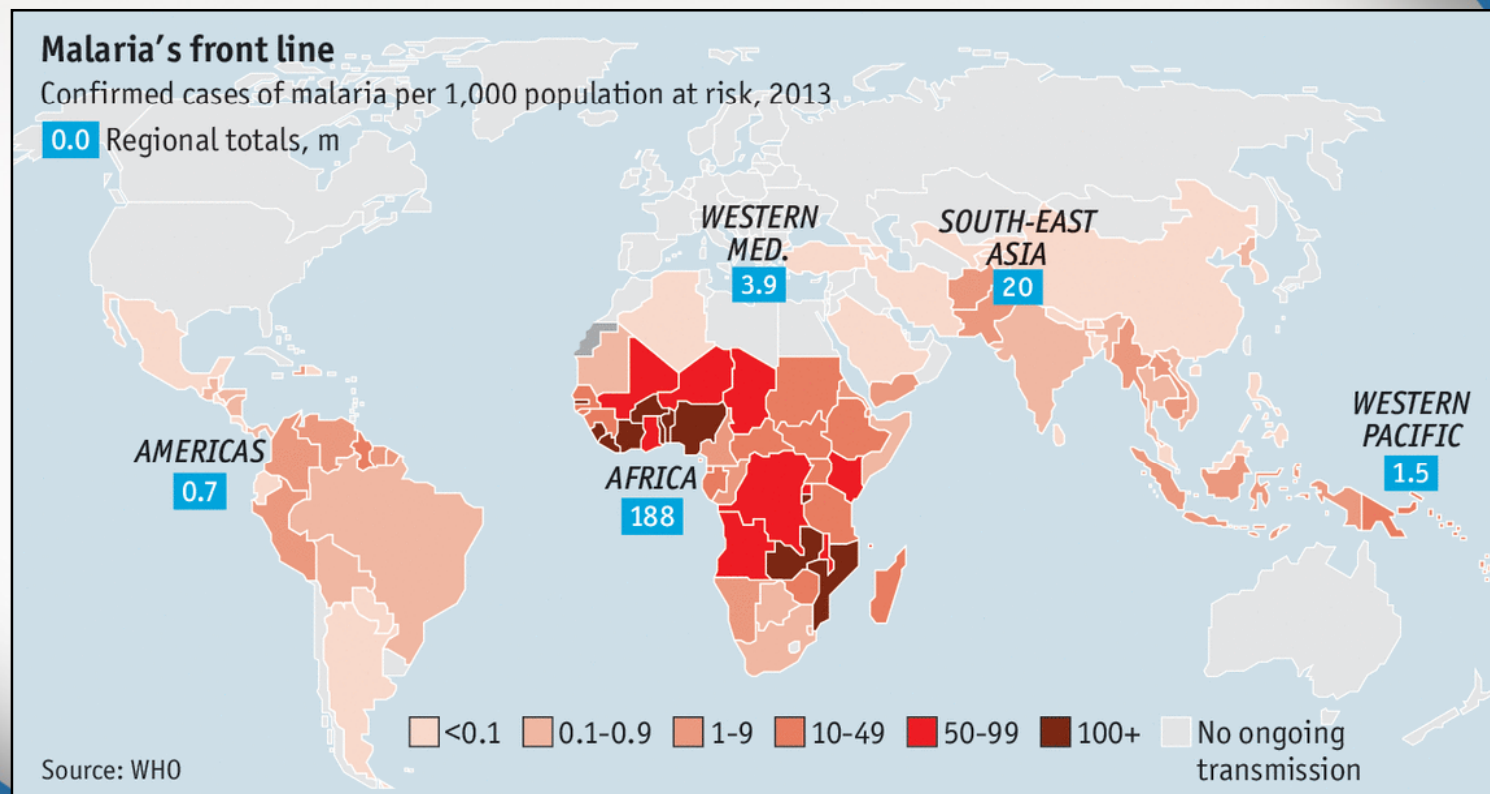
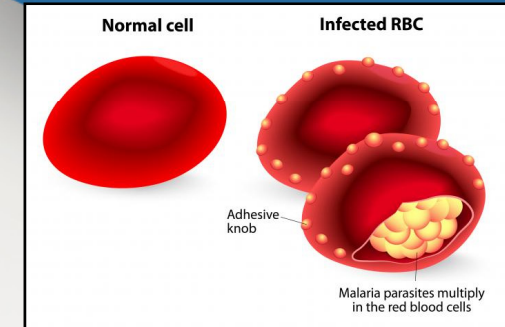
- Introduction: overview
- Tools & techniques: novel methods
- Applications



Bio & Medical Application

Malaria:

300-500 million clinical cases per year
~1.2 million deaths (mostly children under five)
Resistance of main parasite to existing drugs

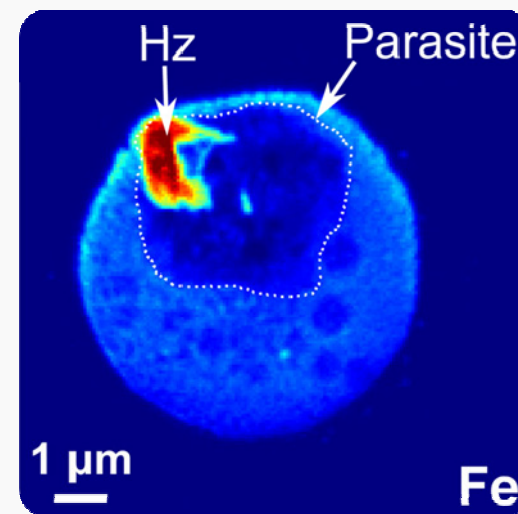
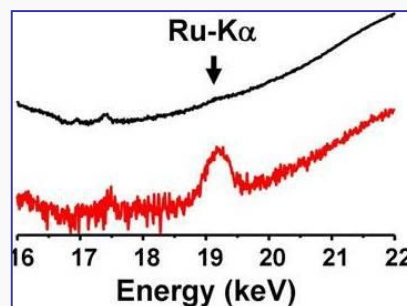
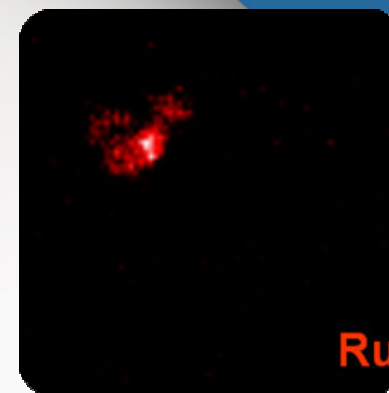
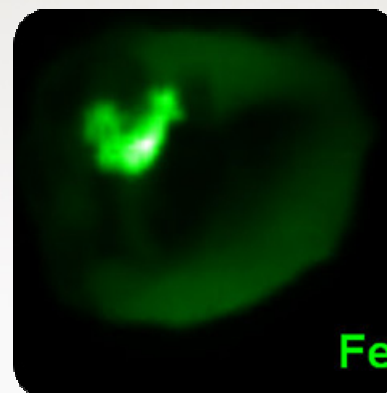
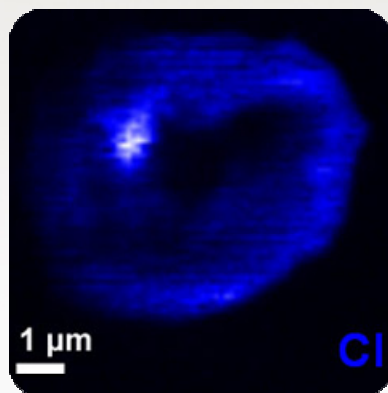


Essential to constantly develop new anti-malarian drugs

Bio & Medical Application

Ferroquine: new synthetic antimalarian compound

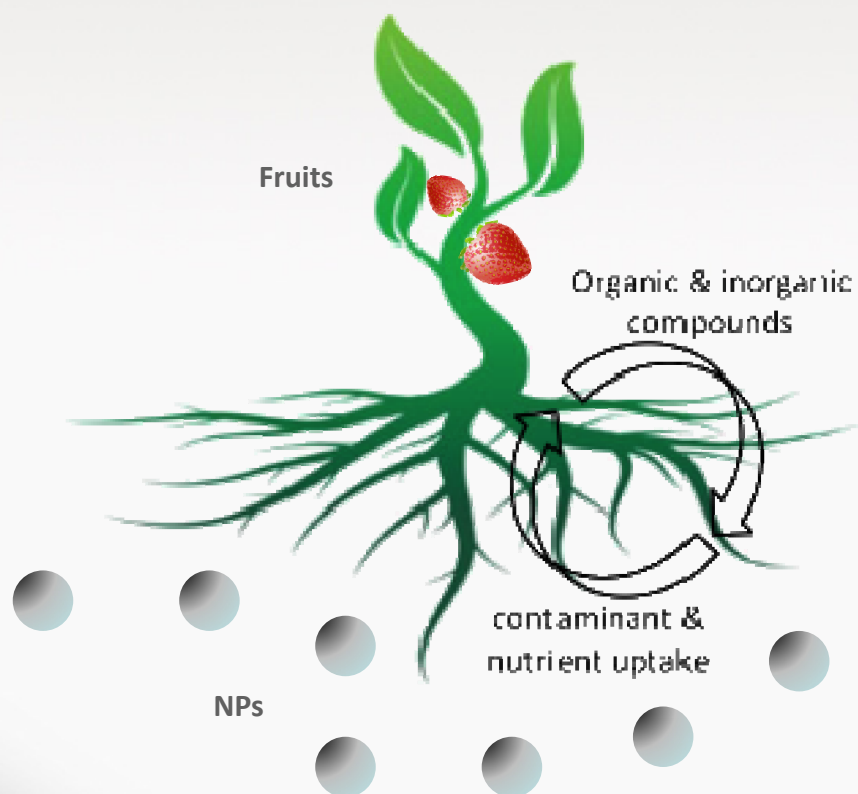
Nano-XRF



The malaria pigment, hemozoin (Hz), has an increased iron content. The ruthenoquine, with similar antimalarian activities to ferroquine, accumulates in the parasitic food vacuole close to its membrane.

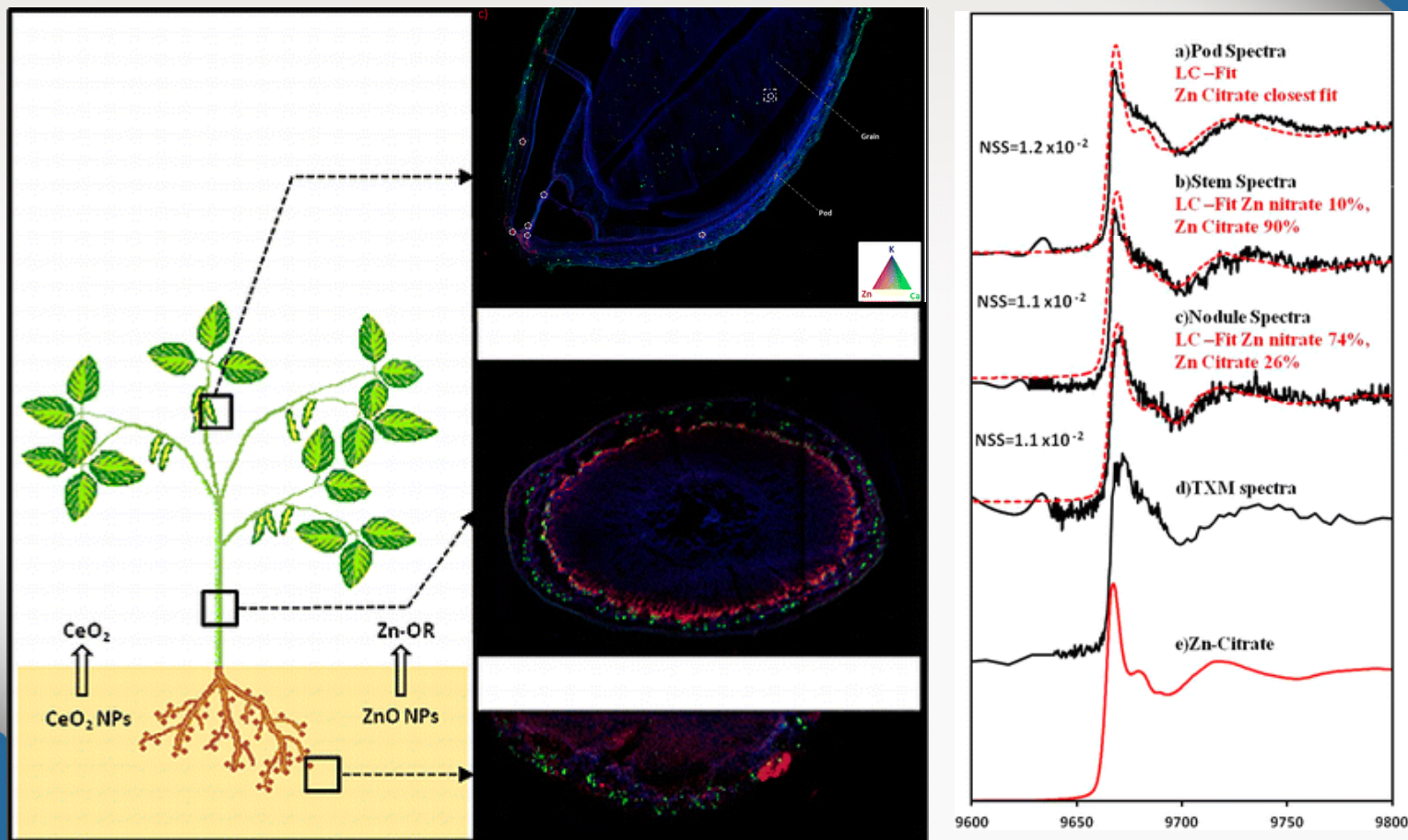
Environmental science

Life cycle of plants grown in nanoparticles contaminated soil



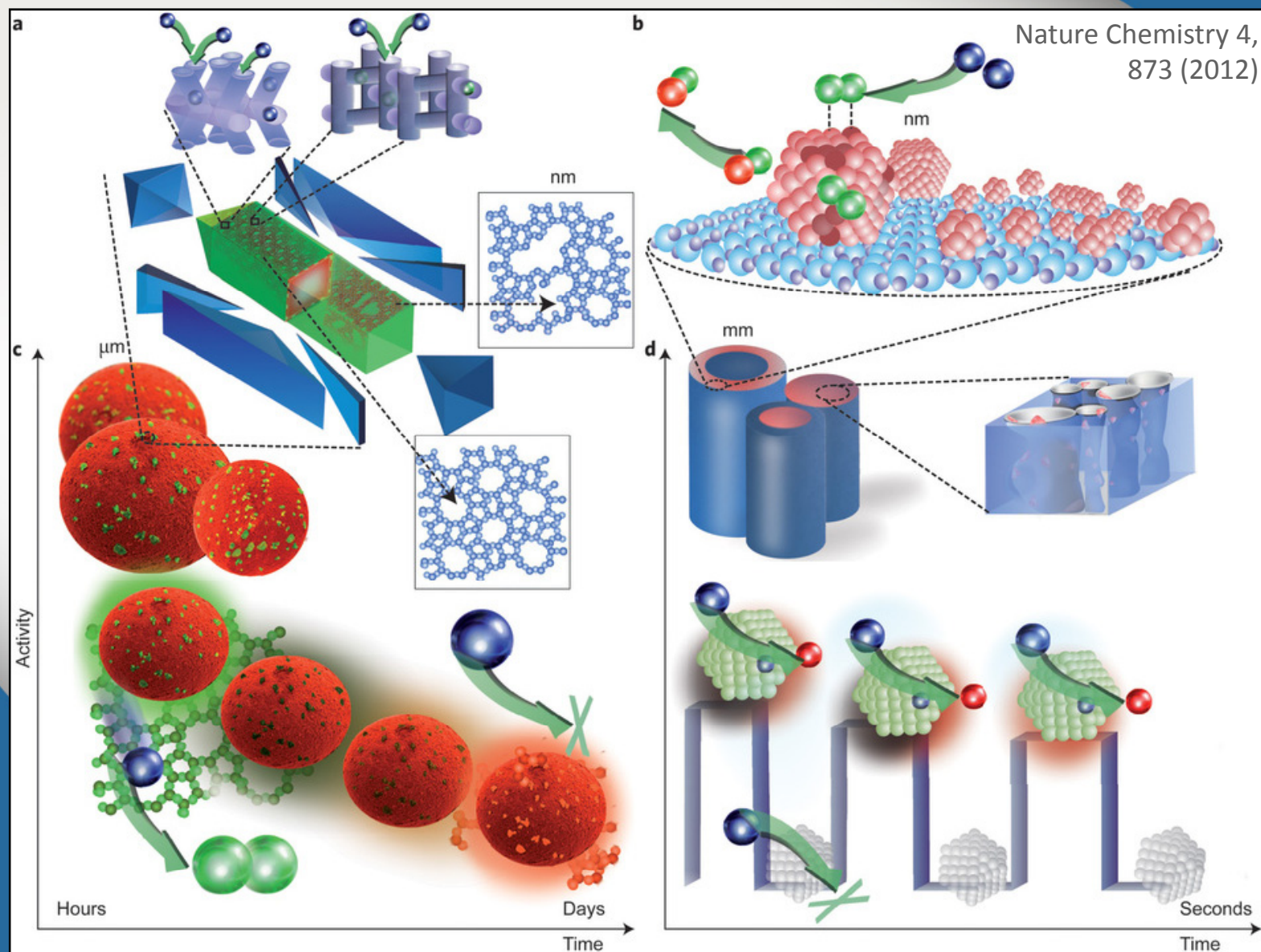
Environmental science

IMPACT of ZnO and CeO₂ nanoparticles (NPs) → soya crop plants → food chain?

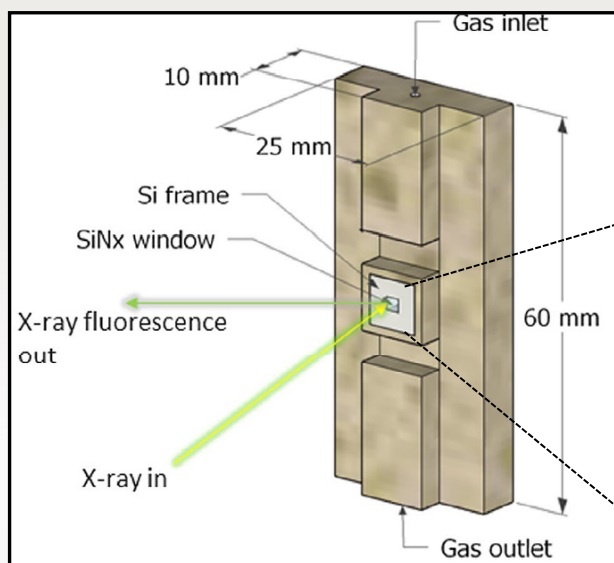


Zinc dissolves and accumulates throughout the plants, whereas Cerium did not

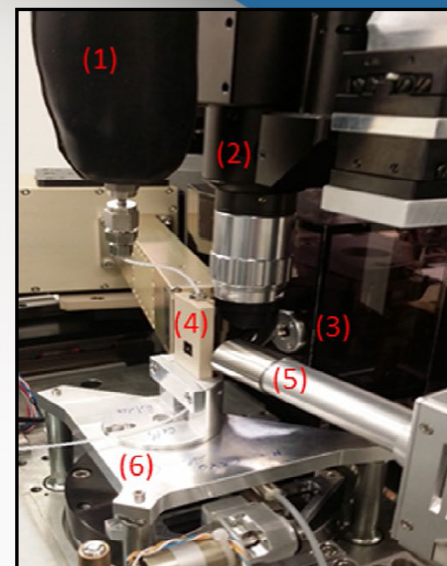
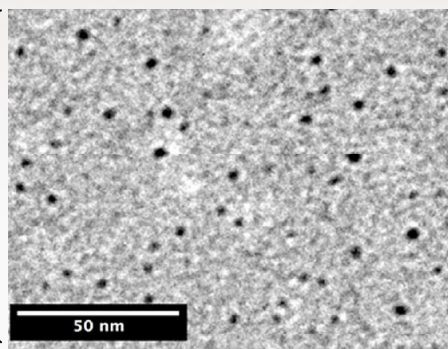
Nano-Materials based Catalysts



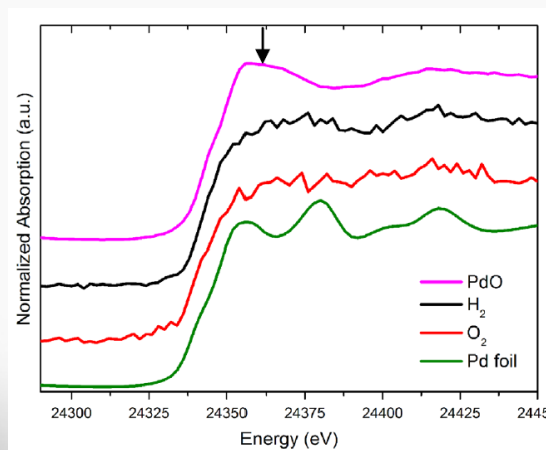
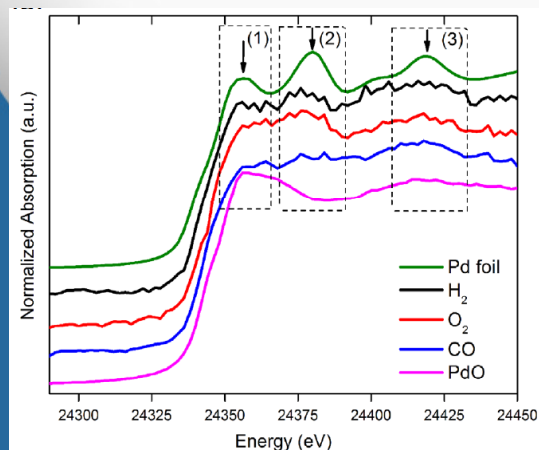
Nano-Materials based Catalysts



Pd nanoparticles



Nano-XANES under realistic catalytic reaction conditions



- Partial reduction & reoxidation
- PdC compounds
- NPs effectively shielded by polymeric species

Electronics - LED

Blue Light Emitting Diodes based on GaN

The Nobel Prize in Physics 2014



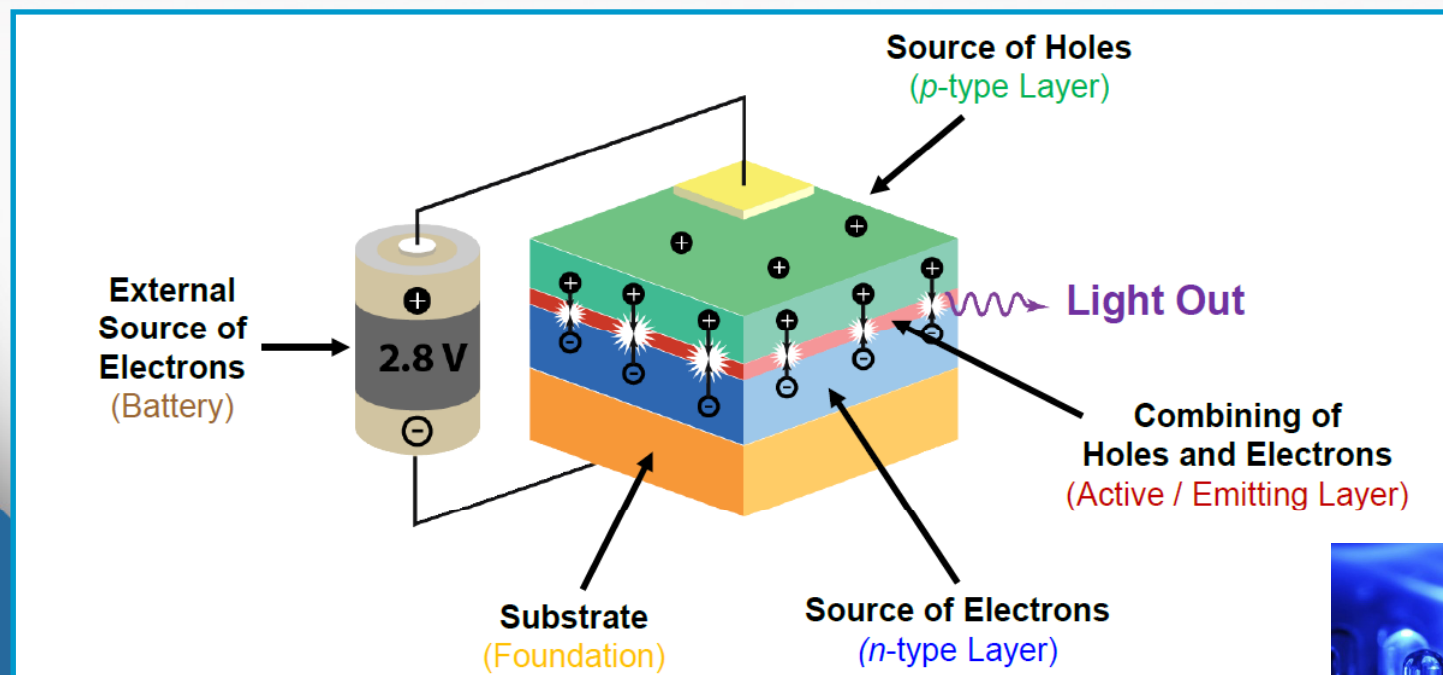
Akasaki



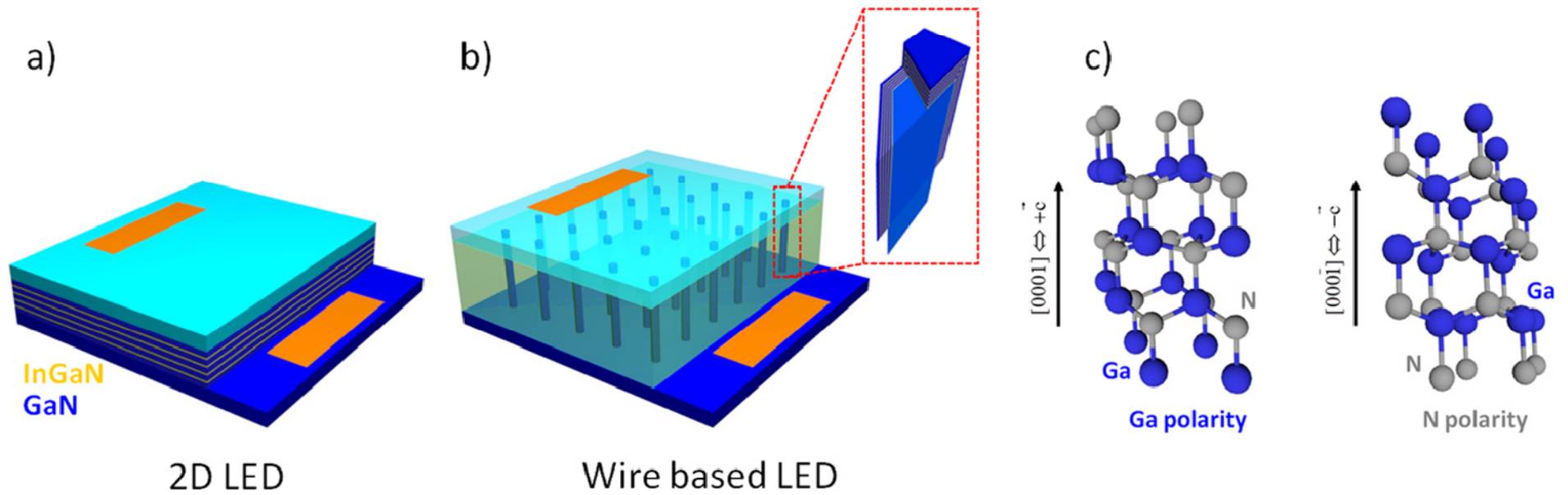
Amano



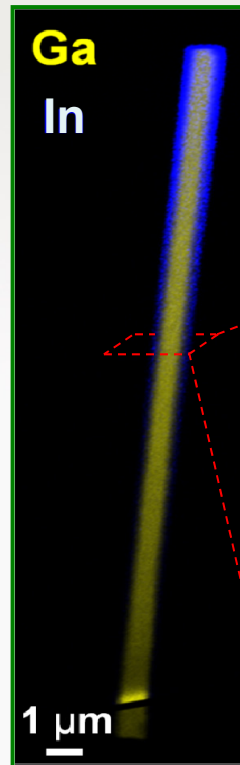
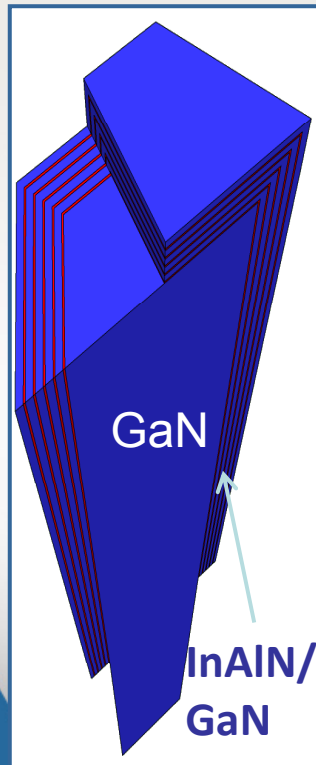
Nakamura



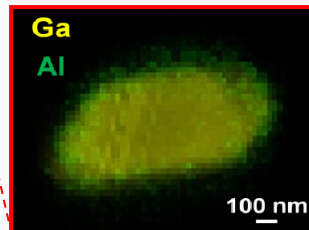
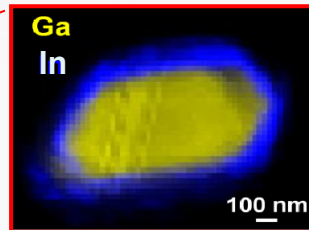
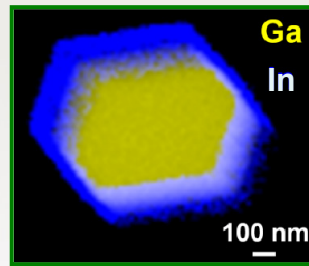
Electronics - LED



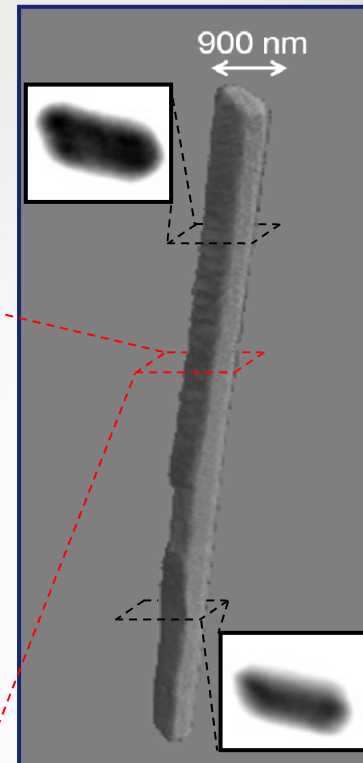
Electronics - LED



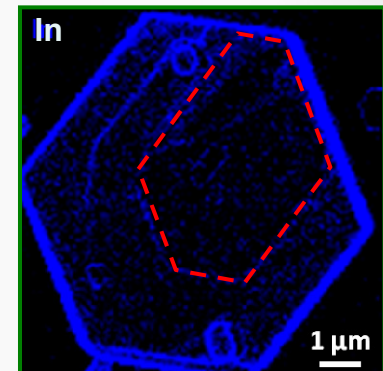
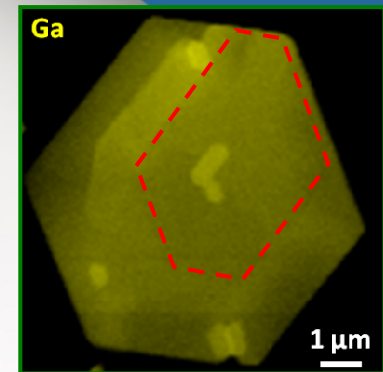
Fluorescence mapping



Fluorescence tomography

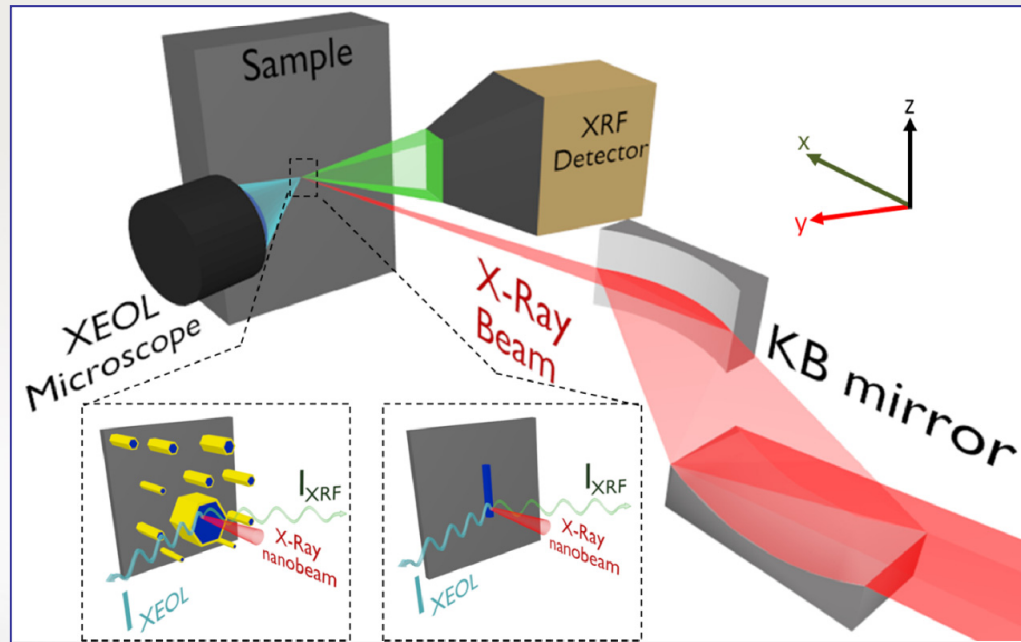


Phase contrast imaging (voxel size 25 nm³)

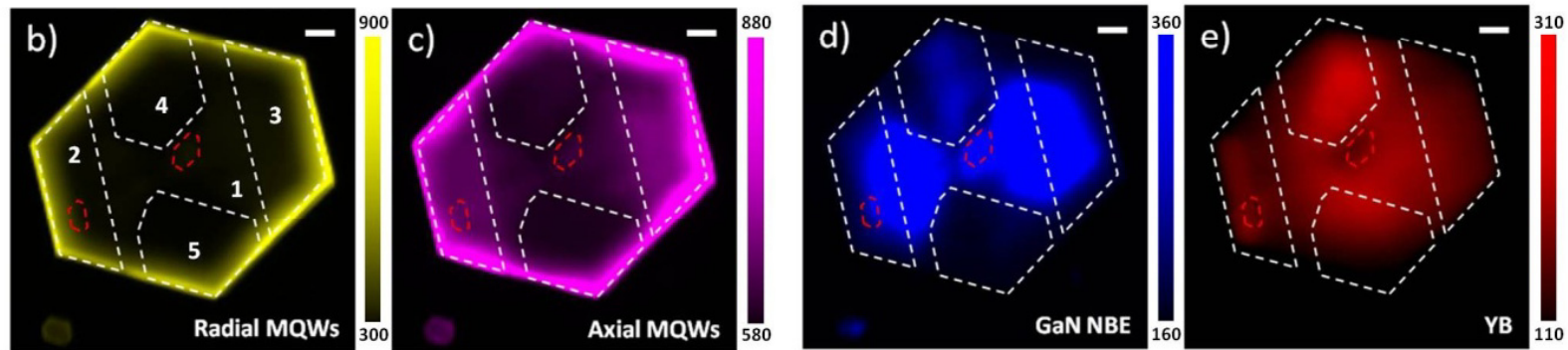
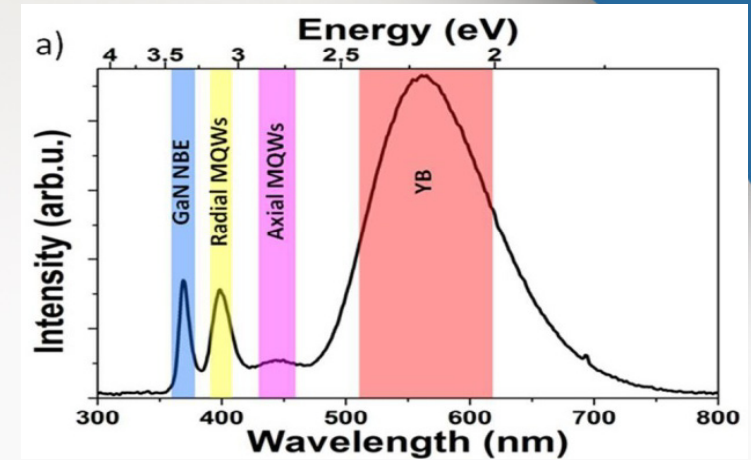


Fluorescence mapping

Electronics - LED



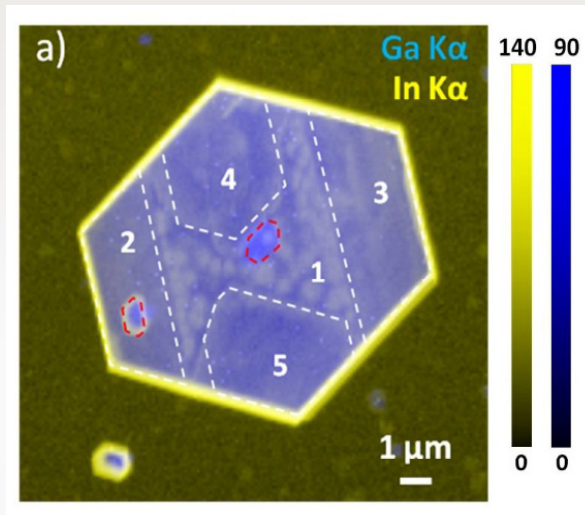
Nano-XEOL



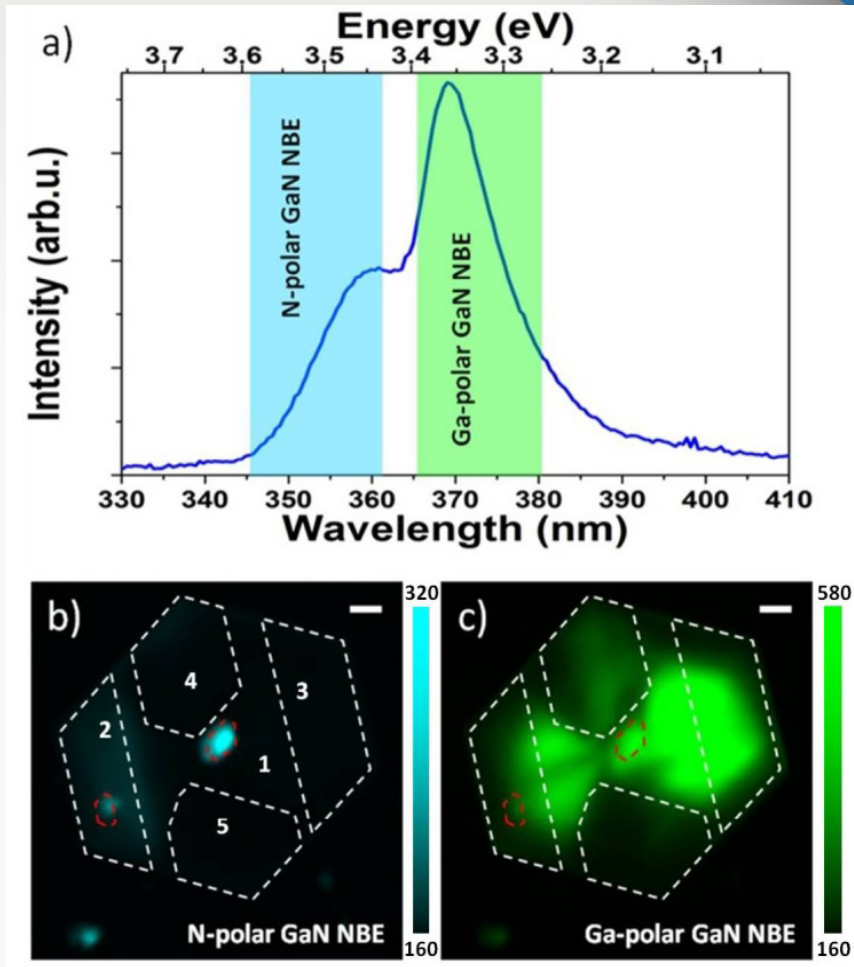
Silane induced N-polarity in wires

Electronics - LED

Nano-XRF



Nano-XEOL



Silane induced N-polarity in wires

Acknowledgments

Marie-Curie ITN *NANOWIRING*:



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Bianchi MENDEZ
Javier PIQUERAS



Andrew BEALE



Jinkyoun YOO
Gyu-Chul Yi



Joel EYMERY

Thank you for your attention

