# Tuning physical properties at the nanoscale through controlled nanostructuring or proximity effects

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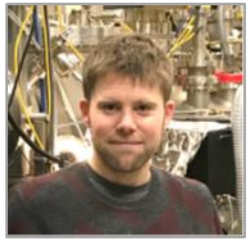

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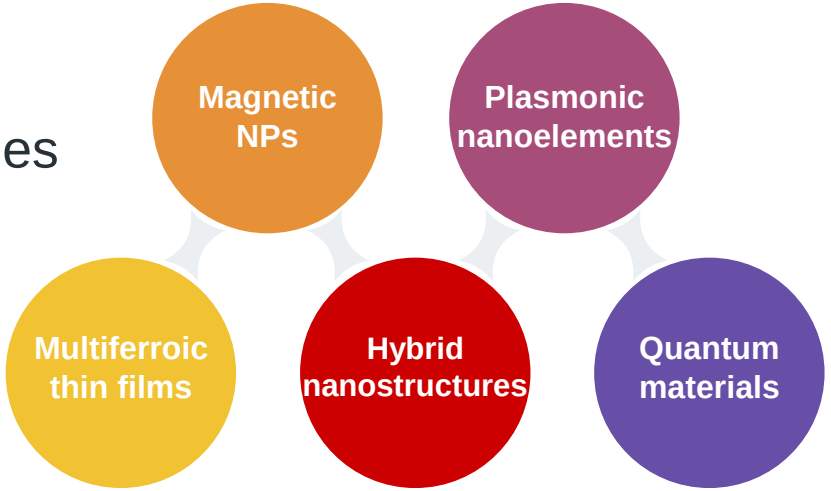
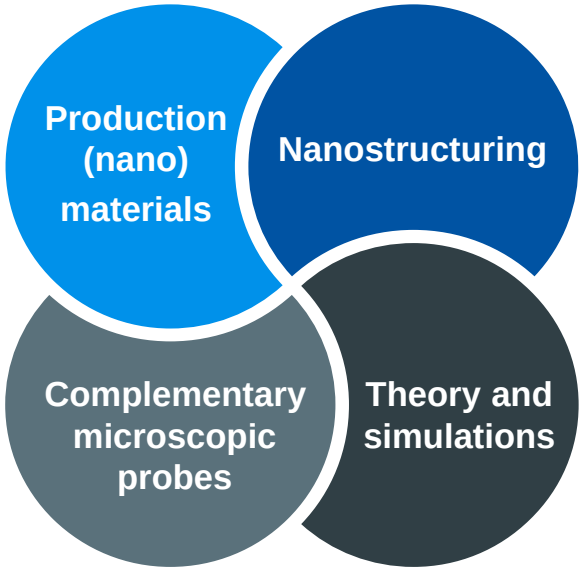
# Nanomaterials

Multifunctional properties of nanostructures




# Synthesis, characterization and modelling

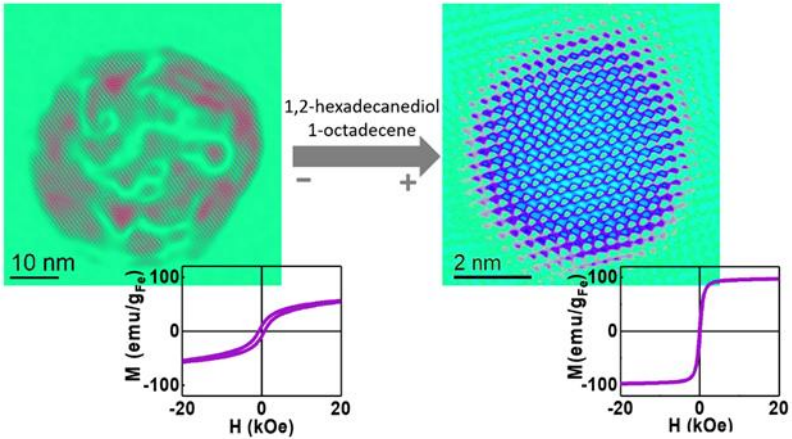
Conventional and local probes

# Controlled nanostructuring

## Production of high-quality nanostructures


### Advanced synthesis of nanostructures

- Size and shape control of magnetic and plasmonic nanostructures
- Wet chemistry routes
- Control of crystallinity
- Functionalization to ensure biocompatibility




Key role of concentration of the surfactant, solvent and/ or reducing agent on morphology, crystallinity, oxidation state, and magnetic properties

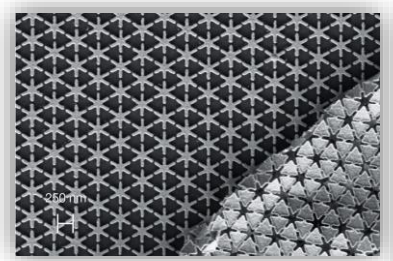
*Selected and recent publications:* Guardia et al., Langmuir **26**, 5843 (2010); Escoda-Torroella et al., Langmuir **37**, 1, 35–45 (2021); Batlle et al, JMMM, **543,** 168594 (2022); Escoda-Torroella et al., PCCP, **25**, 3900-3911 (2023)

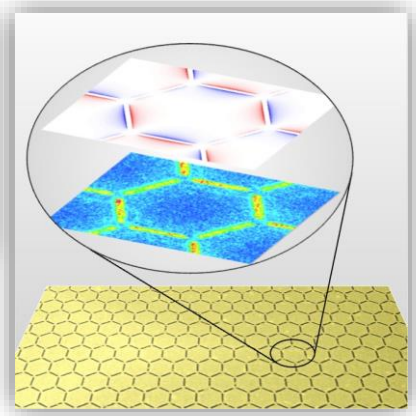
# Controlled nanostructuring

## Production of high-quality nanostructures

### Nanofabrication

- Geometrically frustrated networks of plasmonic nanoelements
- Chiral plasmonic nanostructures



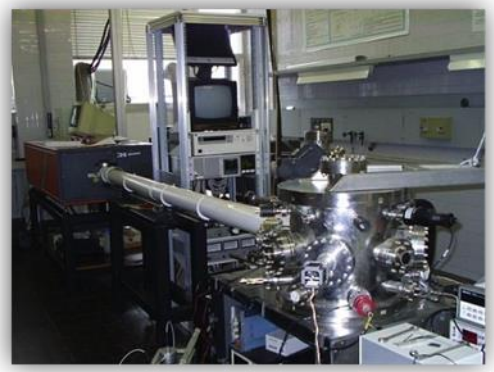



Collaboration
Prof. Francesc Perez Murano
IMB-CNM, Barcelona

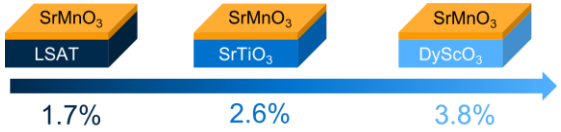
*Selected publications:* Conde-Rubio et al., Opt. Express **26**, 20211 (2018); Conde-Rubio et al., Sci. Rep. **9**, 3529 (2019); Rodríguez-Álvarez et al., accepted in ACS Nano (2023)

### Thin film growth

- Epitaxial growth by pulsed laser deposition
- Ferroelectric-ferroelastic-magnetic epitaxial heterostructures



Prof. Manuel Varela's Lab (Department of Applied Physics, UB)

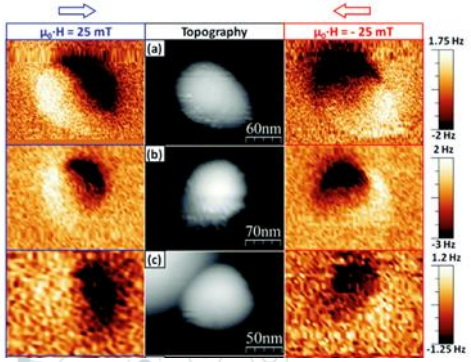


# Complementary probes

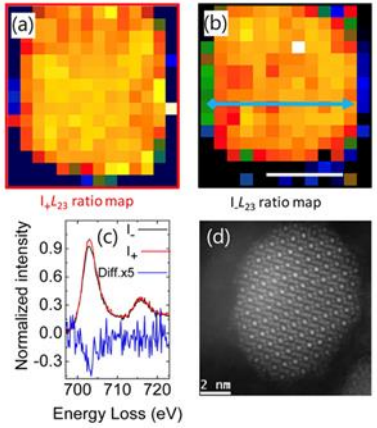
Conventional and advanced characterization tools

## Microscopy and local probes

- Analysis of individual nanostructures
- Detailed structural characteristics
- Distribution of defects, vacancies
- Spatially-resolved composition
- Surface modifications



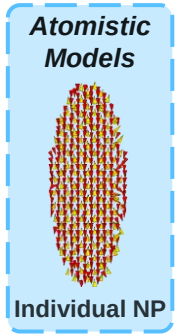

*Nanoscale 7, 8110 (2015)*

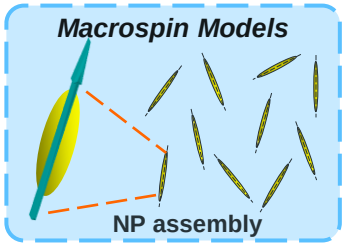


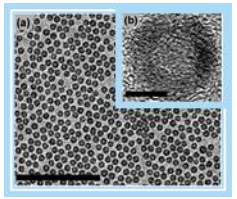

*Nanoletters* 12, 2499 (2012)

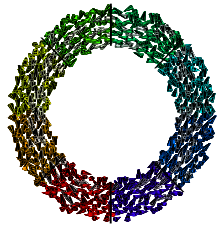
## Theoretical modelling and simulations

- Hysteresis modeling
- NP assemblies: effect of geometries and spatial distributions
- Magnetic configurations in nanotubes



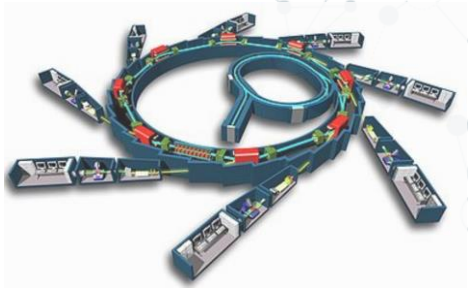



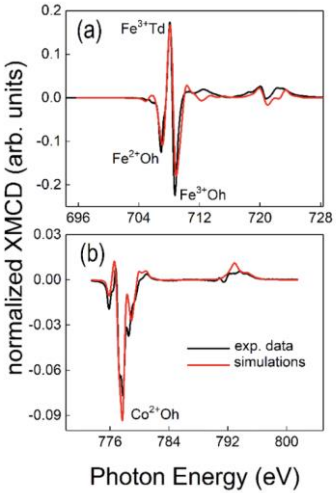
# Complementary probes

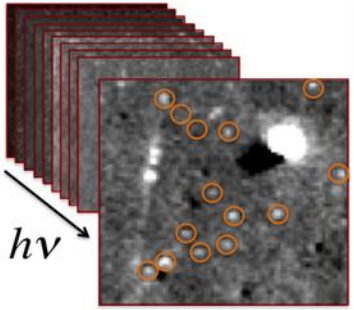
Conventional and advanced characterization tools

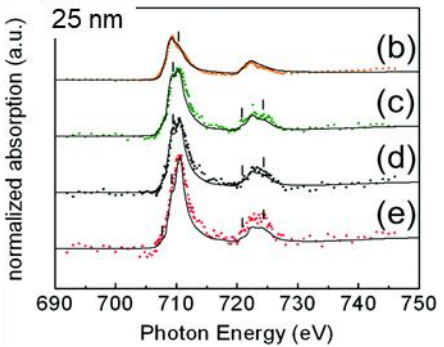
## Synchrotron-based X-ray absorption spectroscopy and microscopy



- Techniques: XAS, XMCD, XMLD, XPEEM, MTXM, XFMR, ARPES
- Information about composition, bonds, valence, coordination
- Surface/interface sensitivity
- Depth selective
- Coupling mechanisms
- External stimuli (H, E, T, p…)
- Spatial resolution (few nm)
- Single-particle spectroscopy



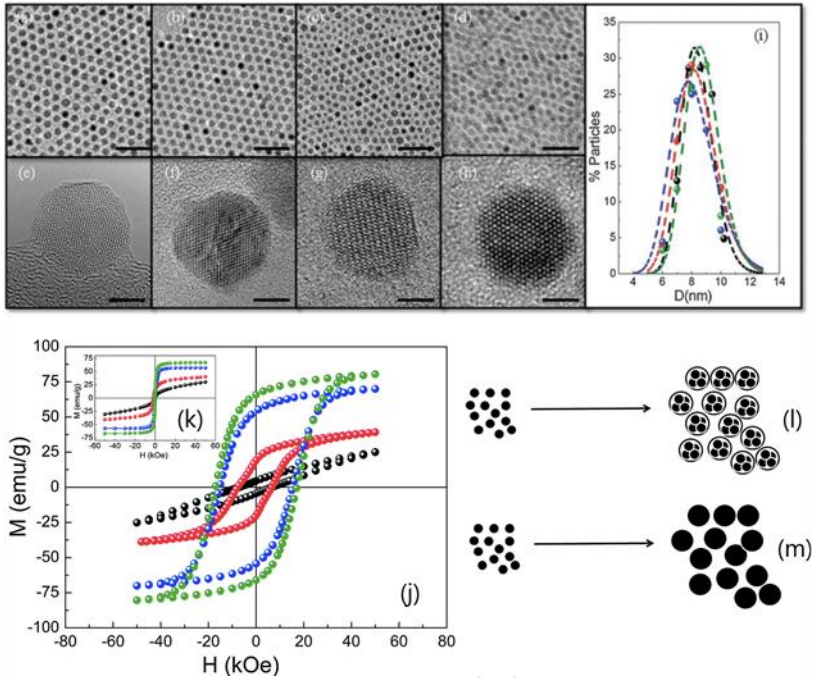



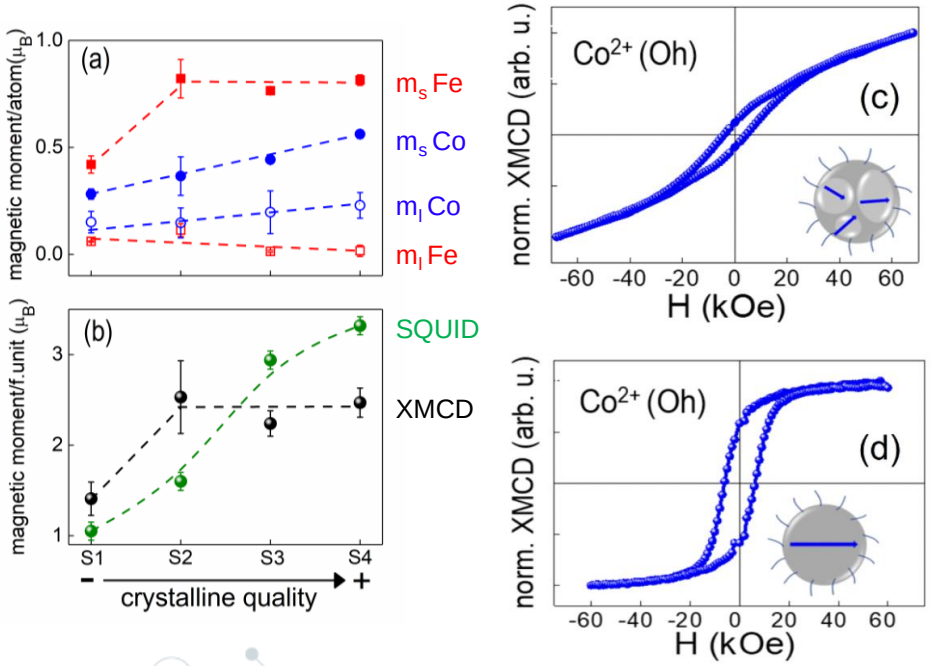

*Selected publications:* A. Fraile Rodríguez et al, PRL **104**, 127201 (2010); A. Balan et al, PRL **112**, 107201 (2014); C. Moya et al, J. Phys. Chem. C **125**, 691 (2021); A. Fraile Rodríguez et al, J. Mater. Chem. C **6**, 875 (2018); I. Valmianski, et al, Nanoscale, 13, 4985 (2021)

# Selected case: Co-ferrite NPs

## Tuning crystal quality and magnetic properties




Moya *et al*, J. Mater. Chem. C 3, 4522 (2015)
Moya *et al*, Phys. Chem. Chem. Phys. 17, 13143 (2015)




Moya *et al*, J. Phys. Chem. C 125, 691 (2021)

# External collaborators

## Selection

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# Our approach

## Complementary microscopic probes

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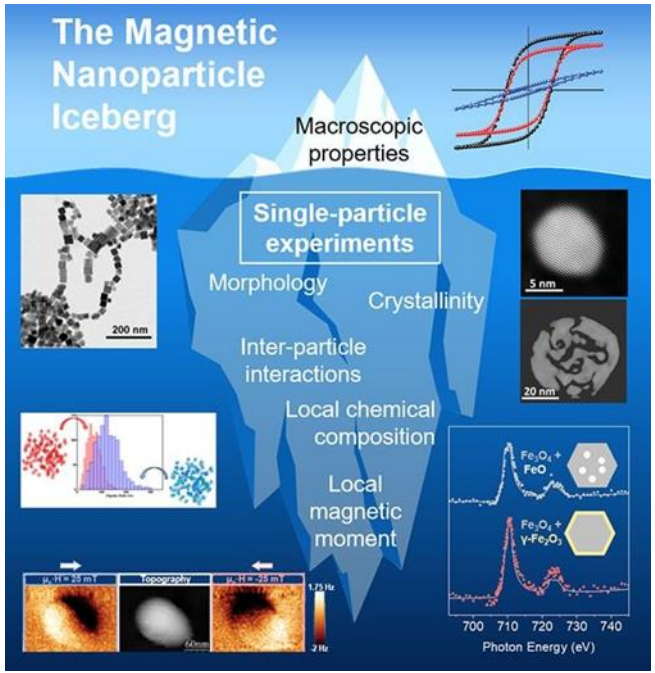


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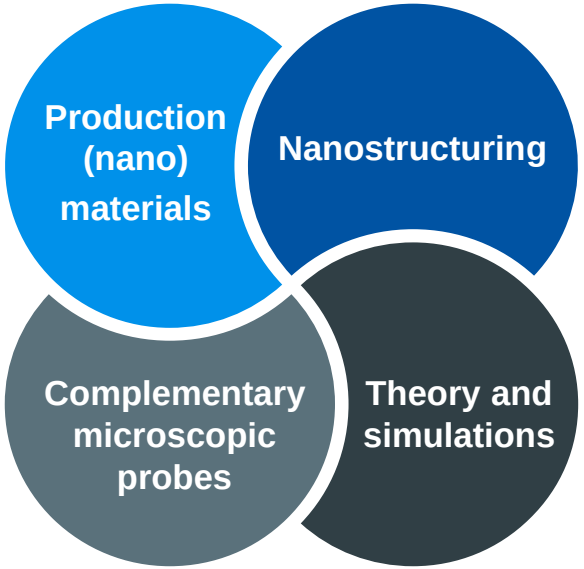
Batlle et al., JMMM, 543, 168594 (2022)

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# Thanks!

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# Current research topics

- Enhanced functionalities in nanoparticles and hybrid nanostructures.
- Proximity effects in hybrid nanostructures and thin film heterostructures.
- Geometrically frustrated networks of plasmonic nanoelements.
- Chiral plasmonic nanostructures.
- Electric field control of magnetism using ferroelectric-ferroelastic-magnetic epitaxial heterostructures.
- Theoretical modelling and simulations of magnetic nanosystems.