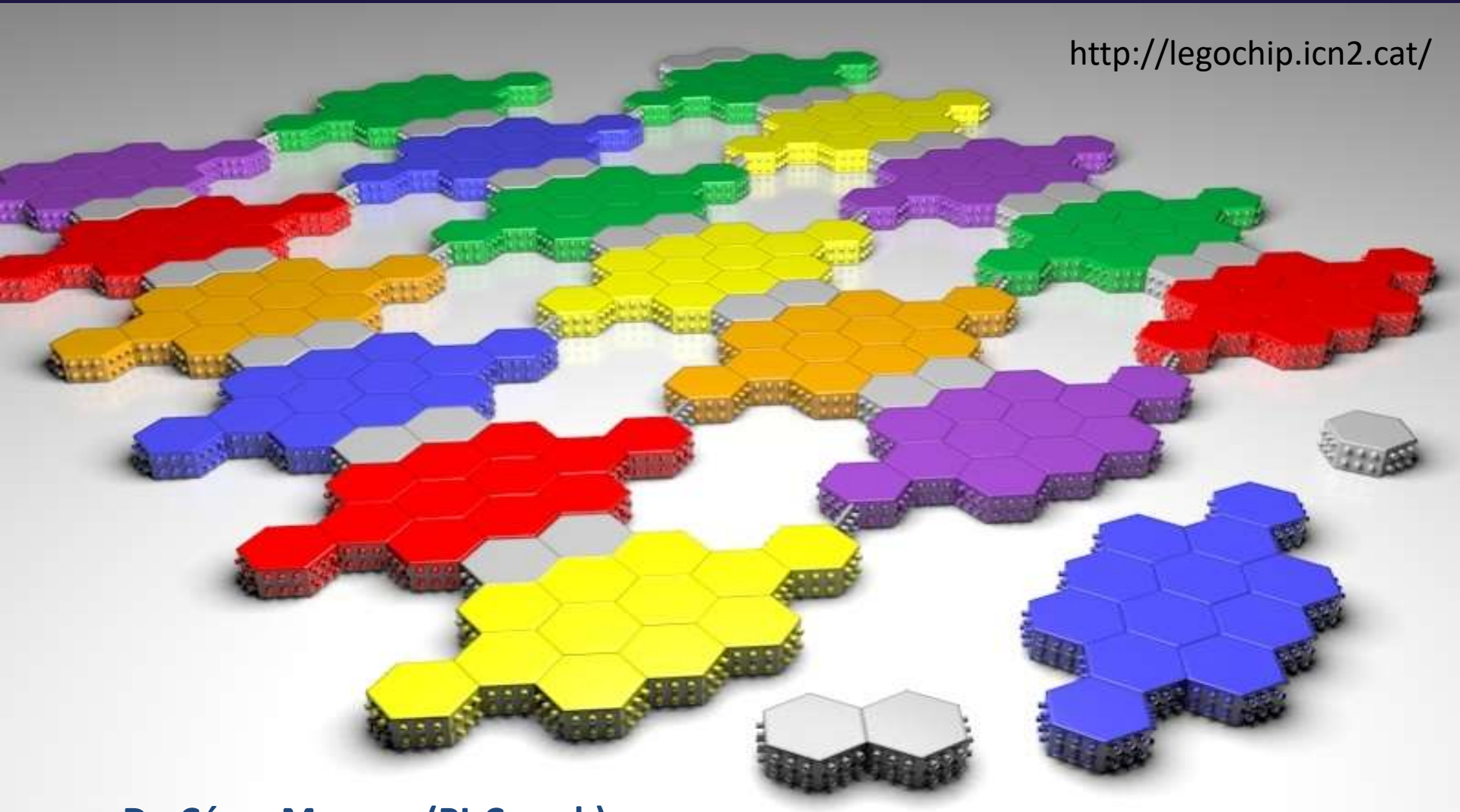
ICN2 Institut Català de Nanociència i Nanotecnologia | USC Universidade de Santiago de Compostela | MANCHESTER 1824 The University of Manchester | Alma Mater Studiorum Università di Bologna

LEGOCHIP Nanoporous Graphene Integration in Operational Nanophotonic Biosensors | FLAG-ERA

http://legochip.icn2.cat/



Dr. César Moreno (PI-Coord.)

Catalan Institute of Nanoscience and Nanotechnology (ICN2), Barcelona

FLAG-ERA 2021 Project Workshop

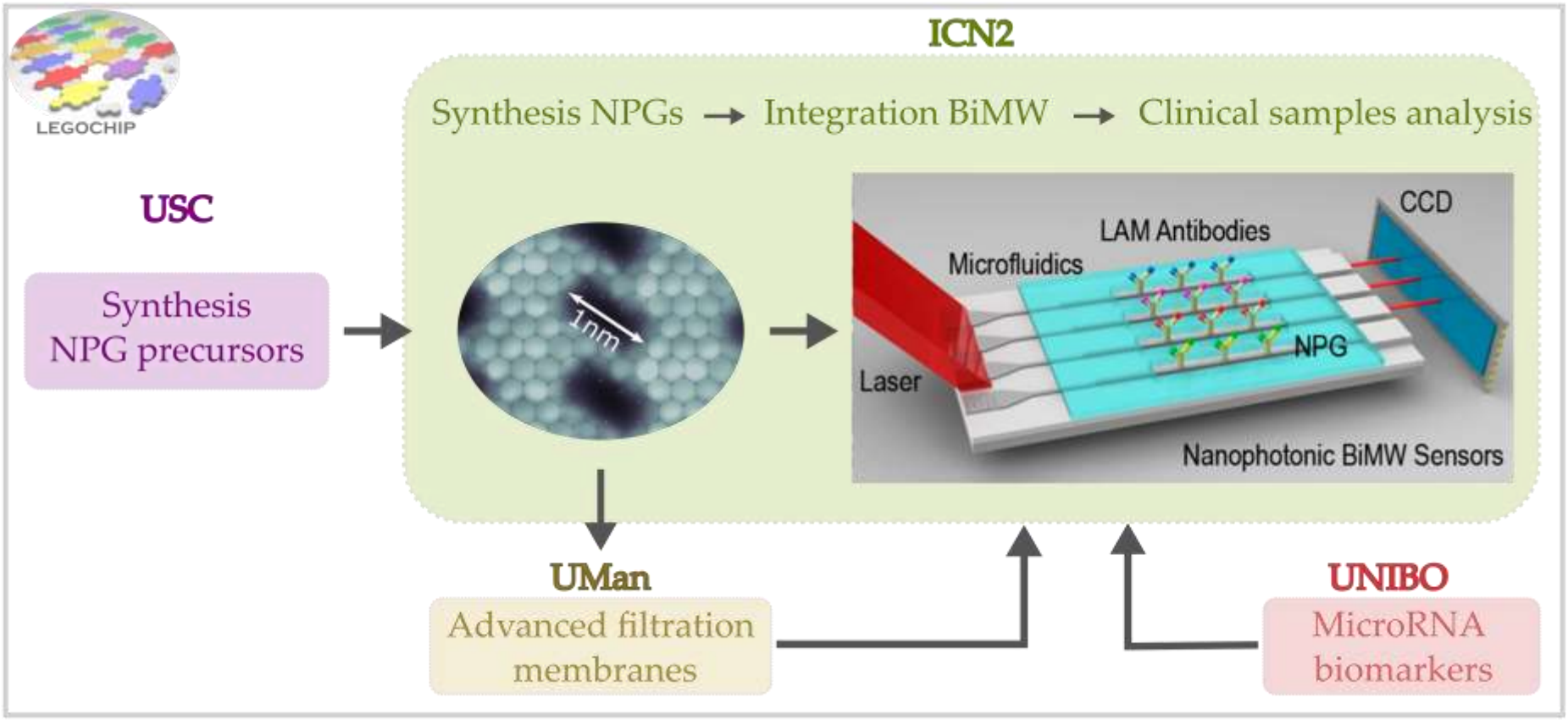
Online

16-18 March 2021

The Concept

LEGOCHIP:

Multifunctional Nanoporous Graphene Integration in Operational Nanophotonic Biosensor Devices



The People

LEGOCHIP
Nanoporous Graphene Integration in Operational Nanophotonic Biosensors

FLAG-ERA

ICN2 Institut Català de Nanociència i Nanotecnologia — Excelencia Severo Ochoa

USC Universidade de Santiago de Compostela

The University of Manchester

Alma Mater Studiorum Università di Bologna

César Moreno
(ICN2, AMS, PI-coord.)

Maria Soler
(ICN2, NanoB2A)

Diego Peña
(USC-CiQUS, PI)

Patricia Gorgojo
(U. Manchester, PI)

Manuela Ferracin
(U. Bologna, PI)

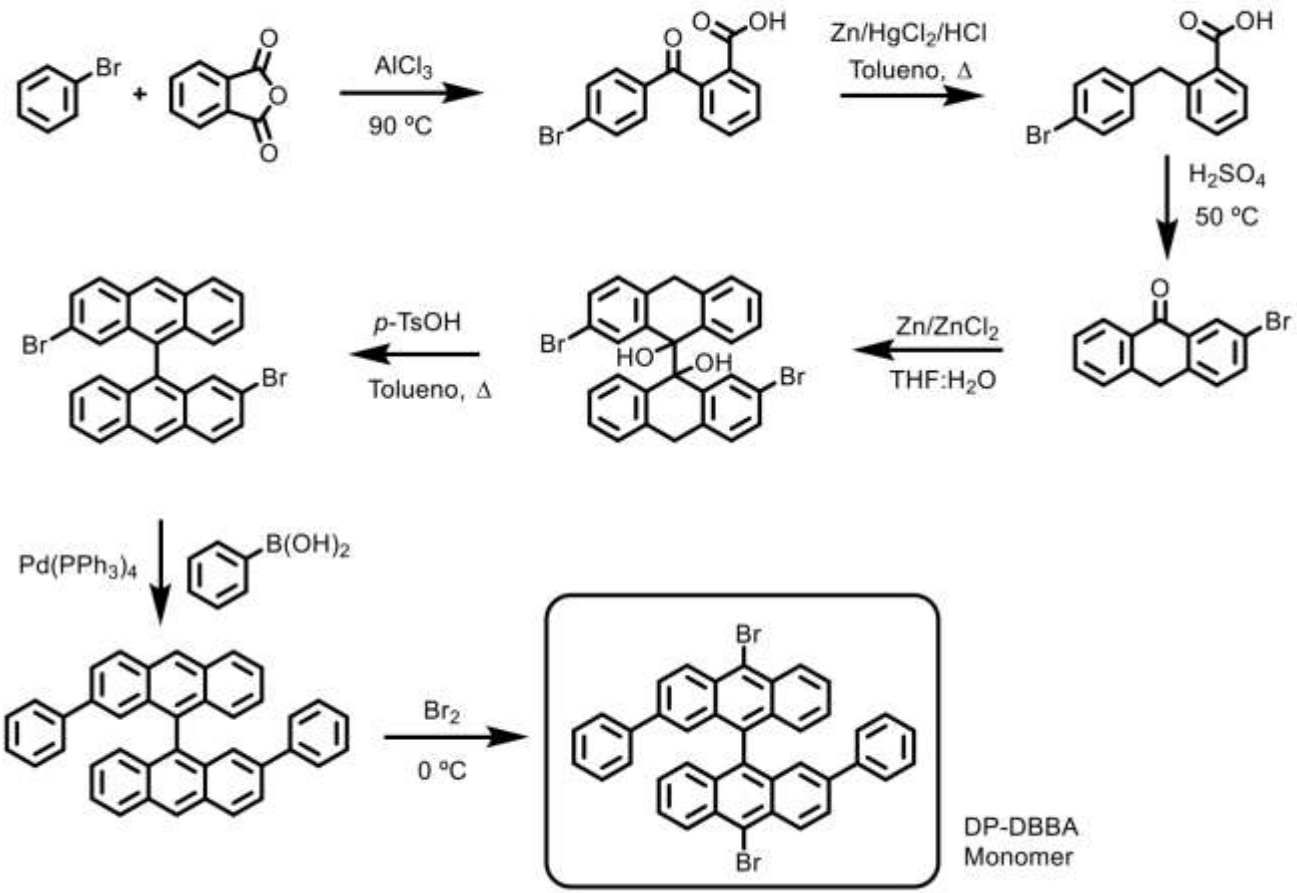
Laura M. Lechuga
(ICN2, NanoB2A, Group Leader)

Aitor Mugarza
(ICN2, AMS, Group Leader)

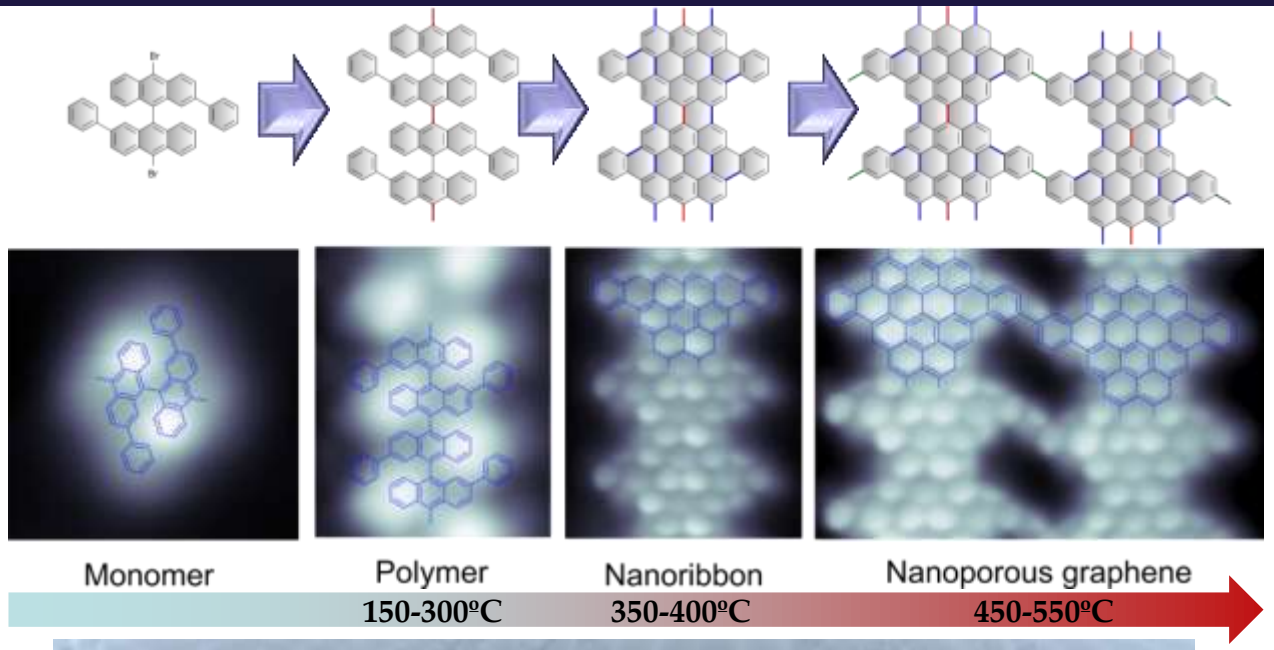
In-solution synthesis

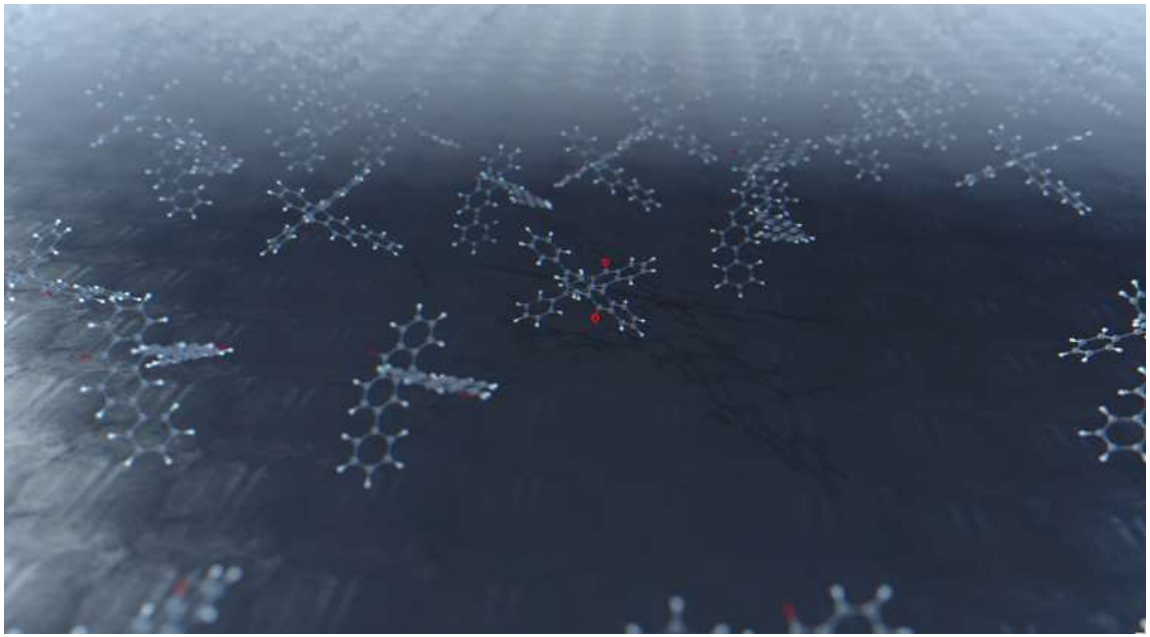
Diego Peña
(USC-CiQUS)

in-solution synthesis



On-surface synthesis

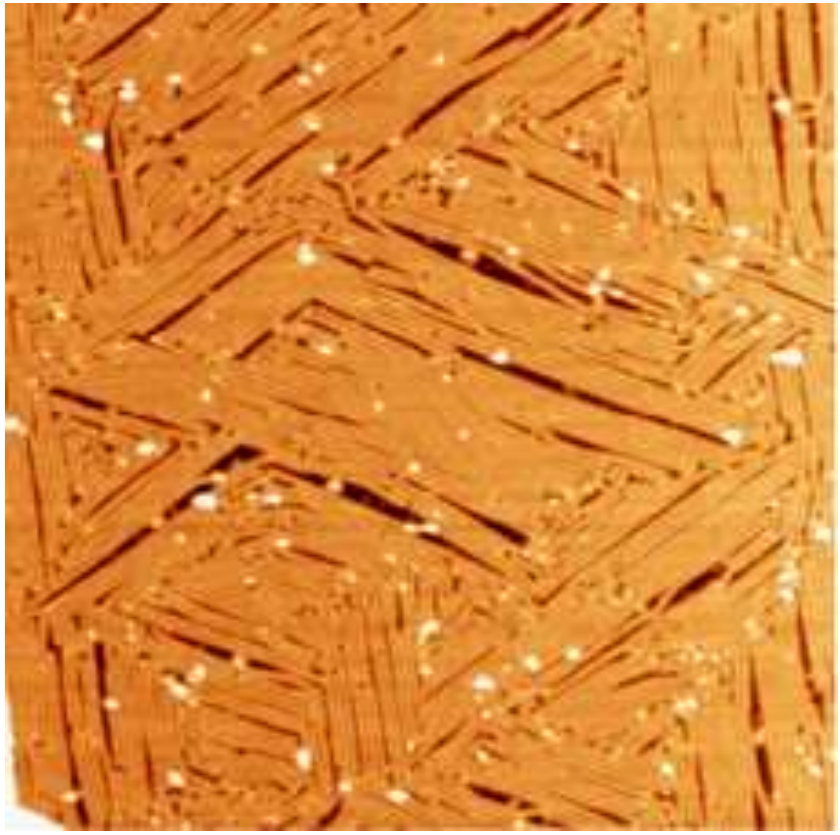


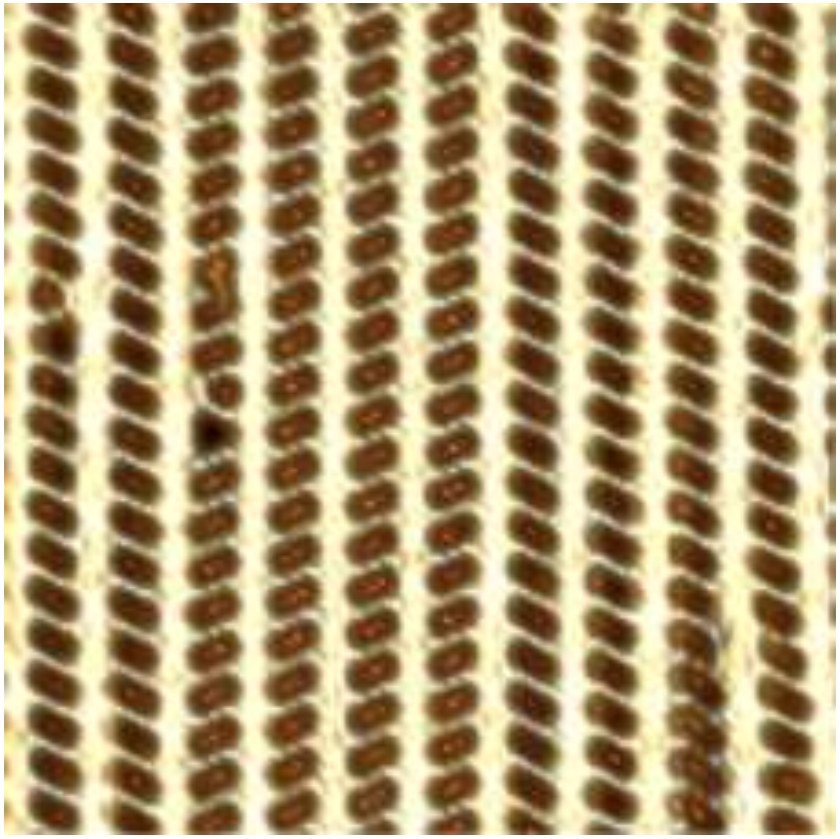


C. Moreno et al. **Science**, 360-6385 (**2018**)

On-surface synthesis

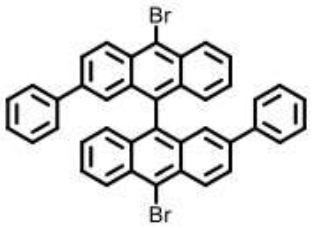
Density of 0.5 10^6 pore/μm^2



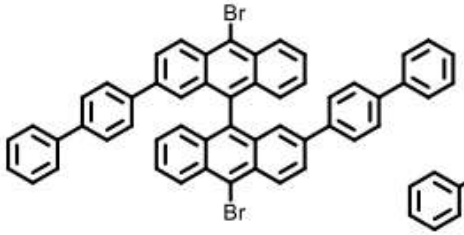


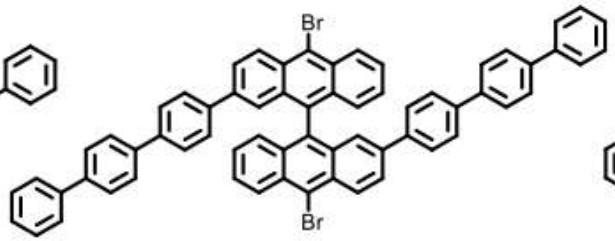
C. Moreno et al.
Science, 360-6385
(**2018**)

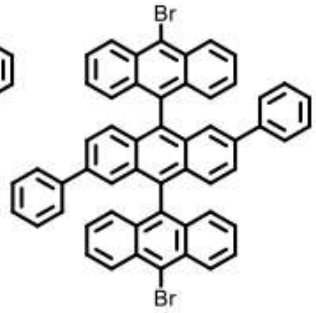
Precursor menu

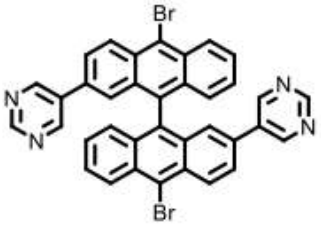


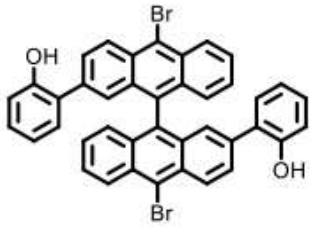
DP-DBBA
Monomer

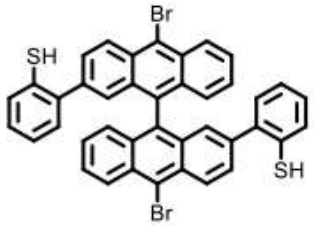


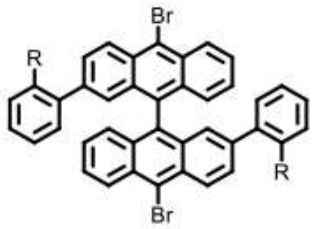




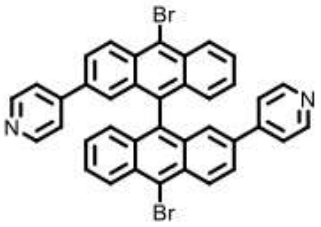


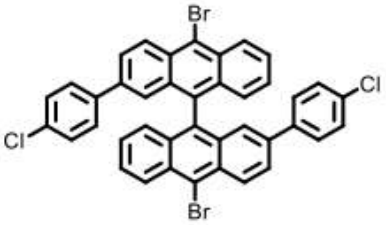


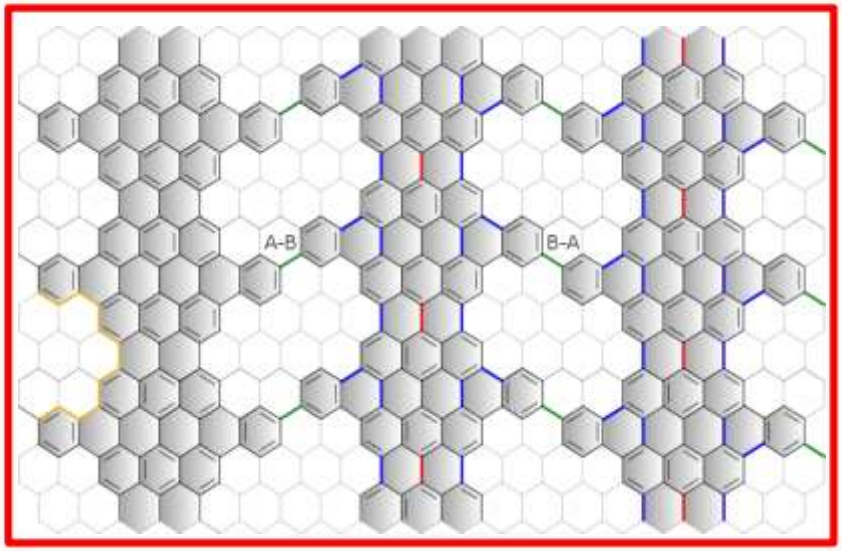




R = CN, CO_2H, NH_2, etc.







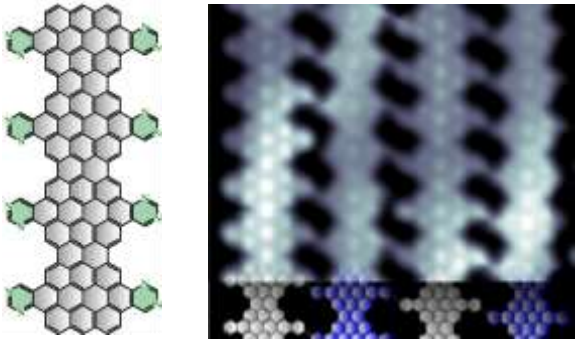
Nanoporous Graphene

Functionalized nanostructures

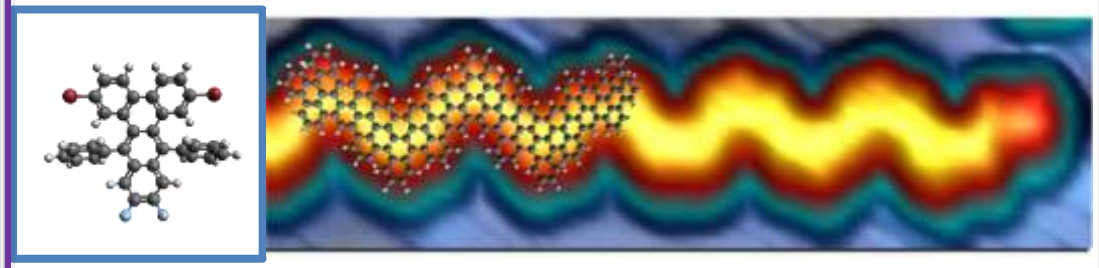
LEGOCHIP Nanoporous Graphene Integration in Operational Nanophotonic Biosensors

FLAG-ERA

-N doped NPG



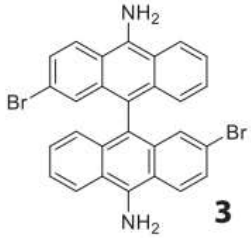
-F doped chevron-type GNR

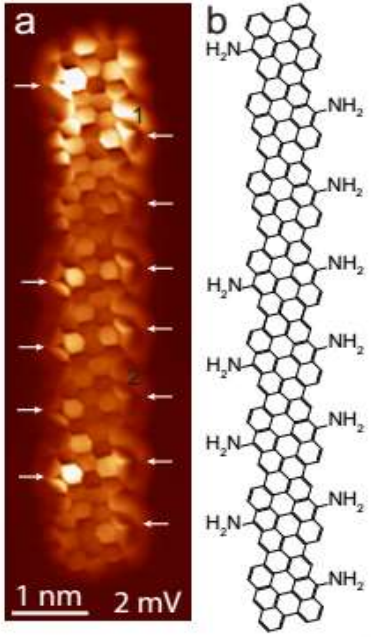


Panighel et al., ACS Nano 2020

❑ **Chemical functionalization**

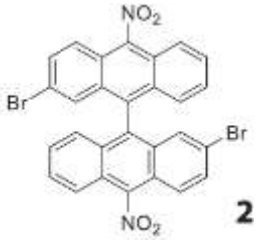
-NH_2 doped chiral GNR

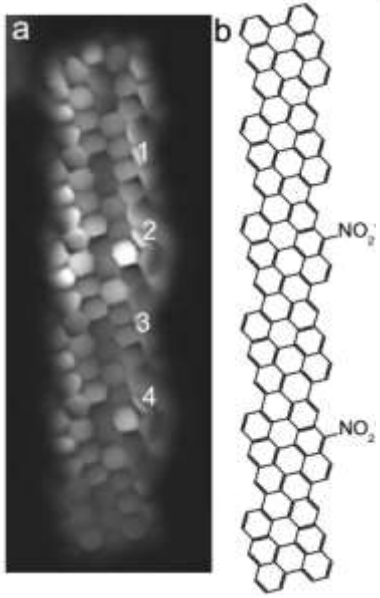




Li et al, ACS Nano 2020

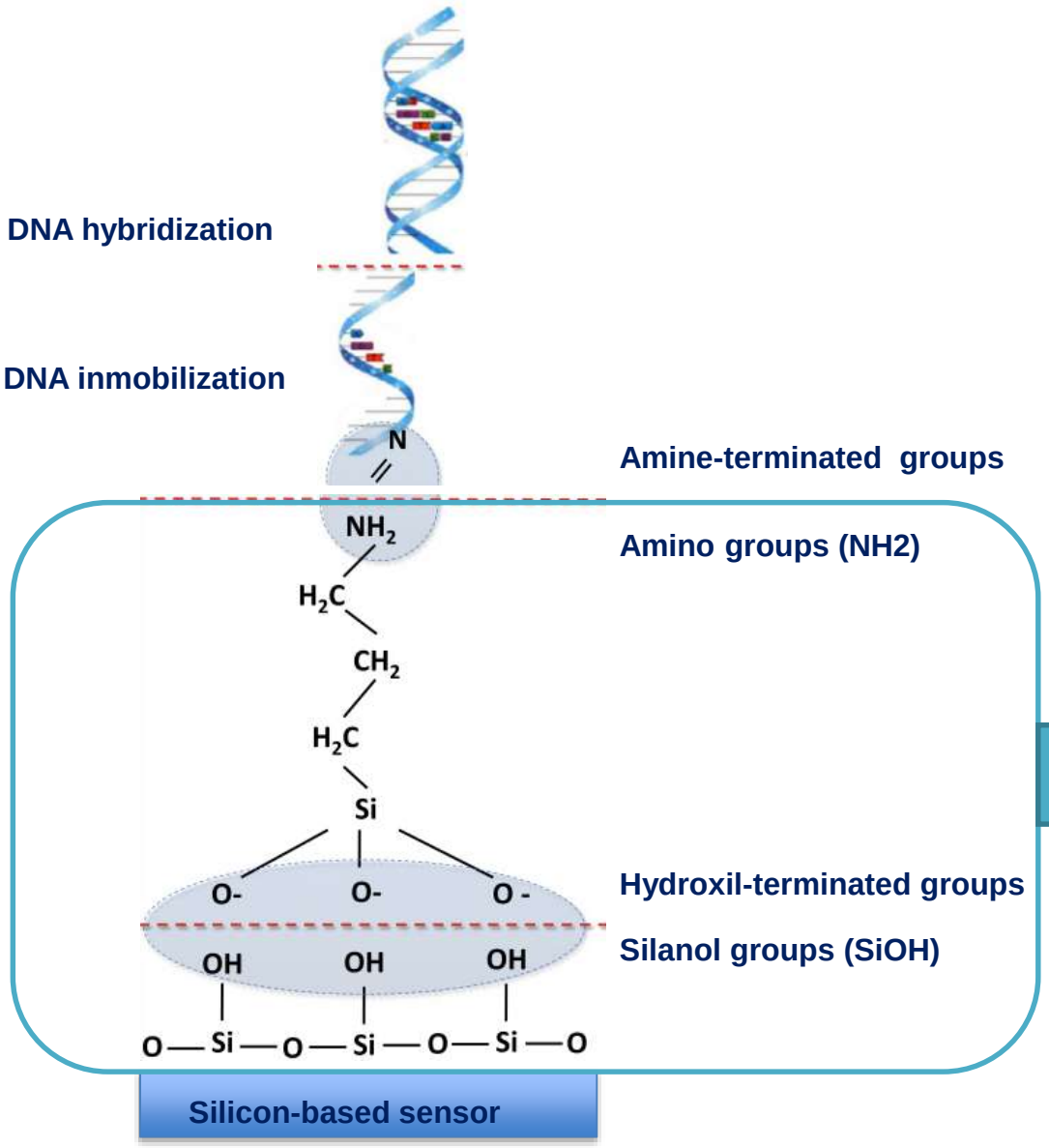
-NO_2 doped chiral GNR





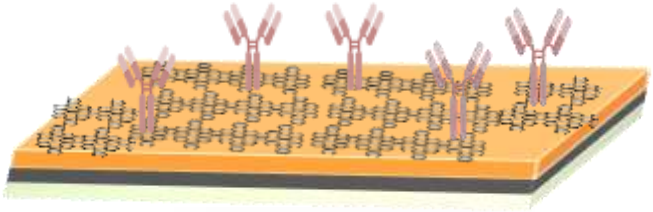
50% NO_2 survives

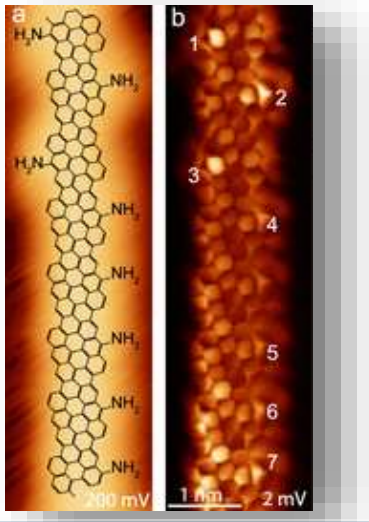
Strategy



LEGOCHIP approach

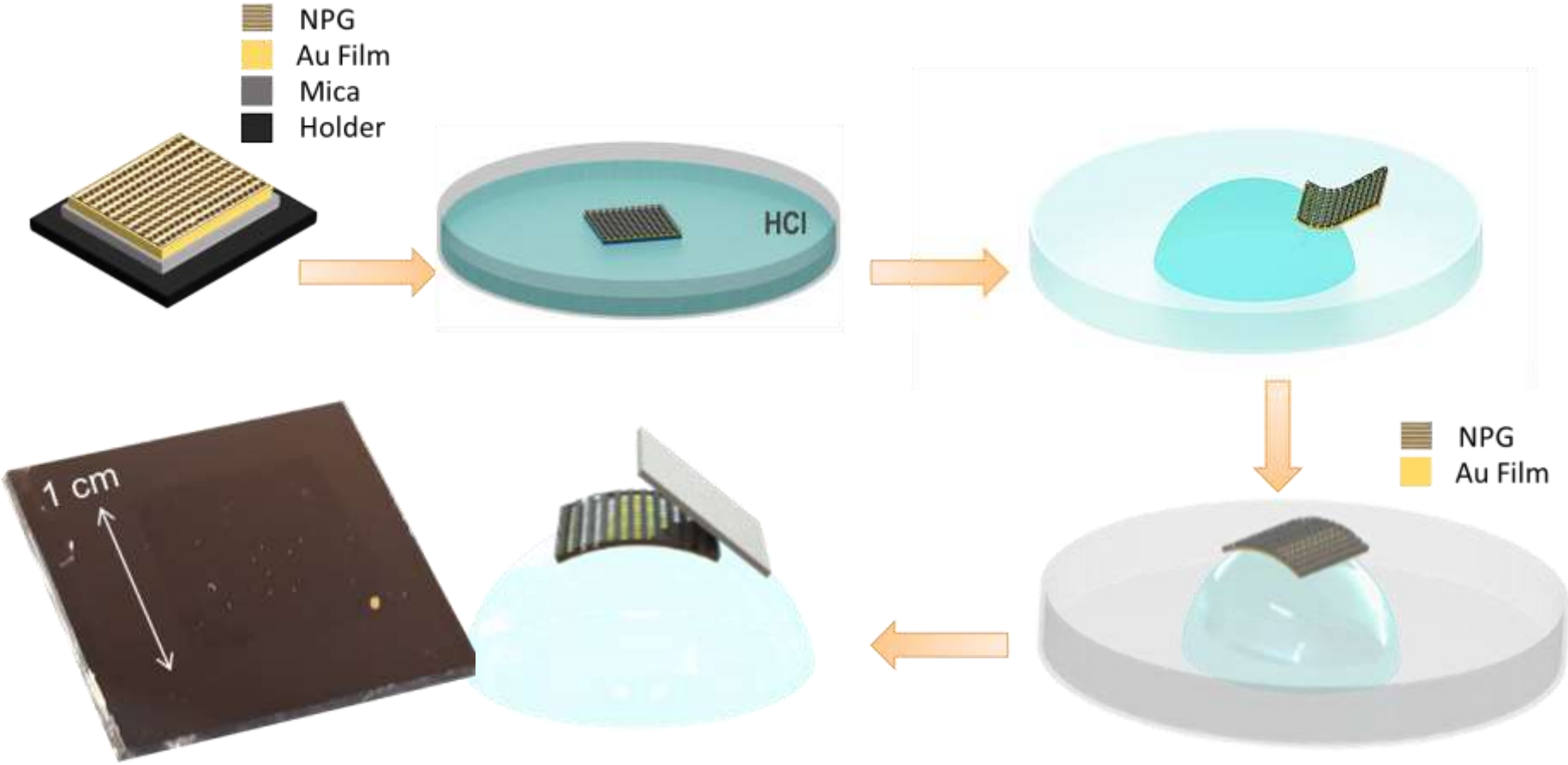
Graphene nanoarchitectures as precise template for controlled biofunctionalization





Silicon-based sensor

Integration of graphene nanoarchitectures: transfer



Wet and polymer-free transfer route of samples until 1x1 cm^2 size by gold etching

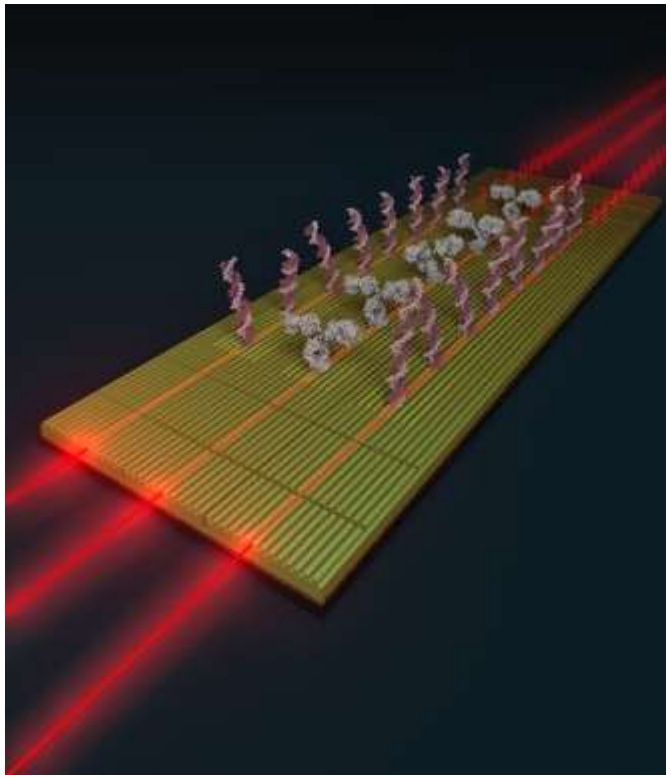
Biosensors

LEGOCHIP
Nanoporous Graphene Integration in Operational Nanophotonic Biosensors

FLAG-ERA

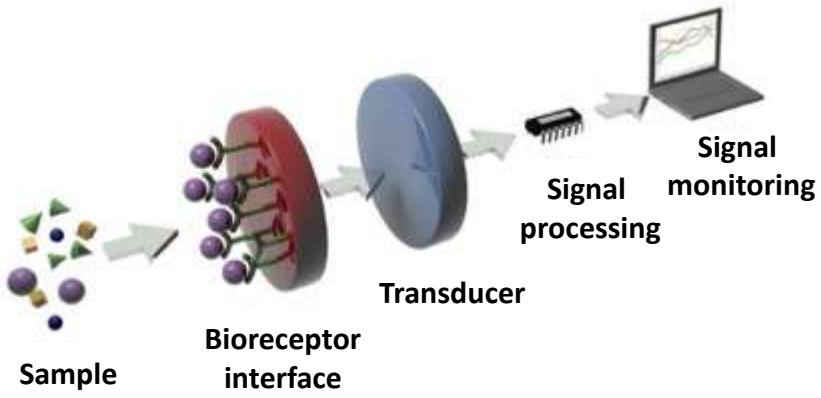
Dr. Maria Soler / Senior researcher
Prof. Laura M. Lechuga / Group leader
Catalan Institute of Nanoscience and Nanotechnology (ICN2)
CSIC, CIBER-BBN and BIST

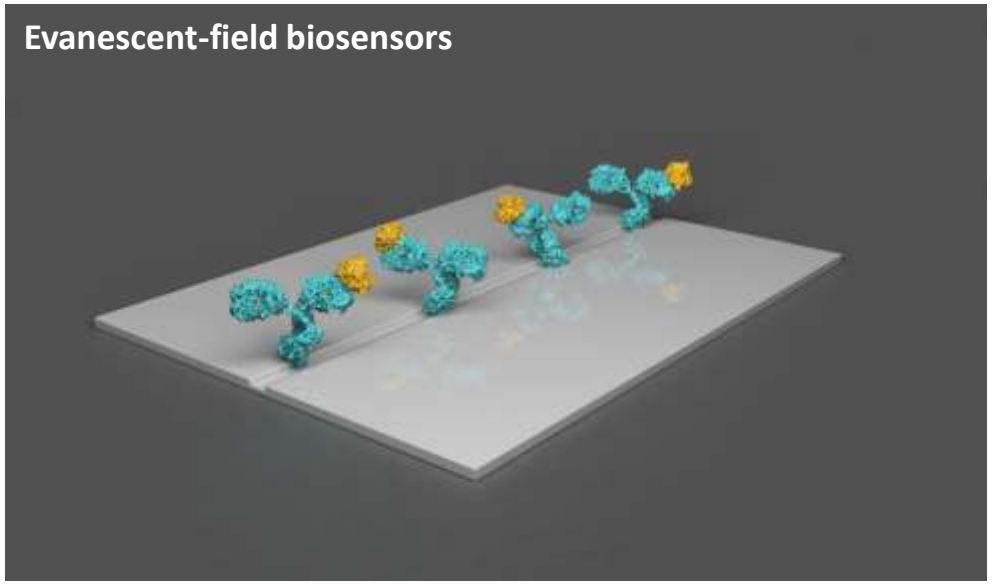
nanob2a.icn2.cat
@nanob2a_group



Biosensors

Optical Biosensors

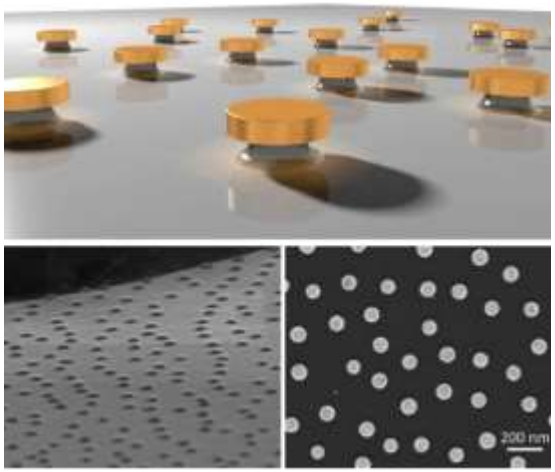




Main Characteristics

- High sensitivity
- Label-free analysis
- Real-time monitoring
- Multiplexing capabilities
- Integrable in POC device
- Low cost and mass production

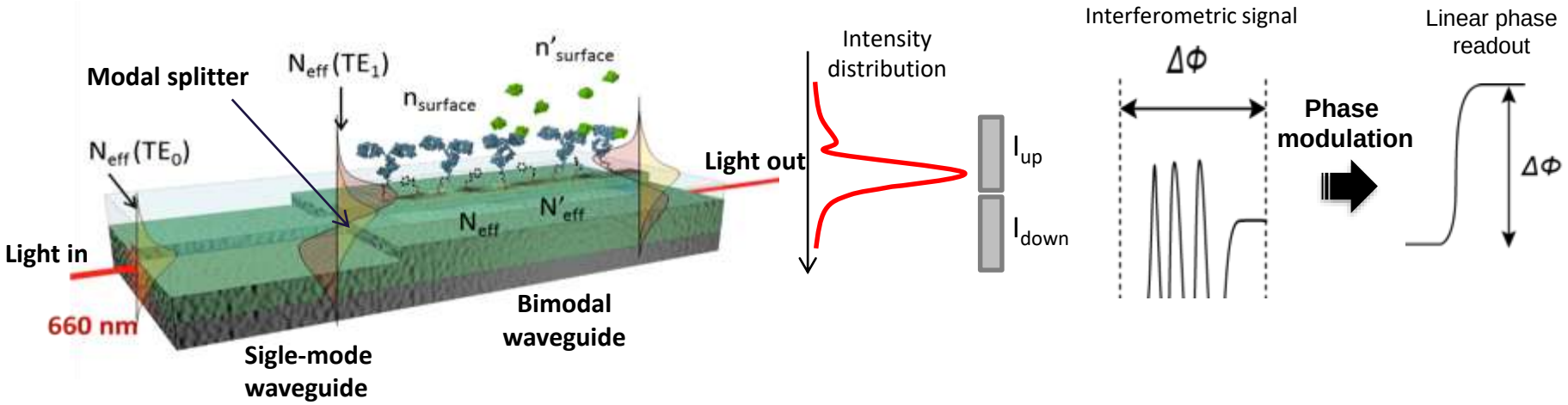
Nanoplasmonics



Silicon Photonics

Bimodal Waveguide (BiMW) interferometer

BiMW interferometer

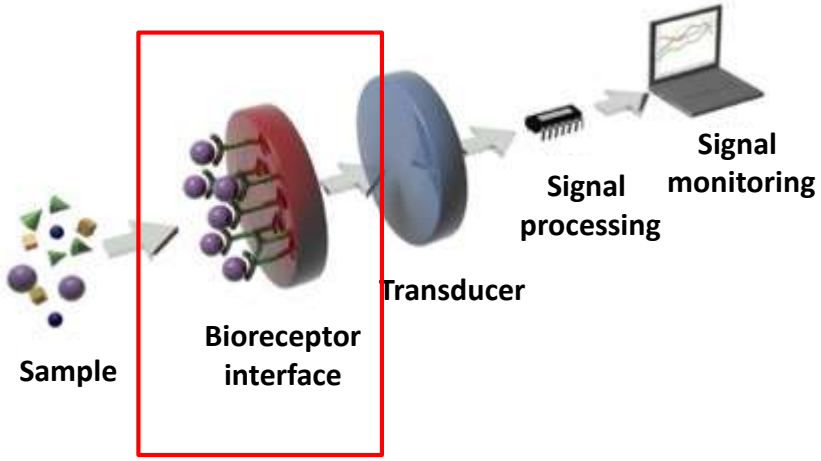


Working principle

- Single channel waveguide interferometer
- Operated on interference of two light modes (fundamental and first order) of the same polarization
- No need anymore of Y-shape splitters (as in MZI or Young Interferometer)
- The modes propagate with different velocities and create an interference pattern at the exit, which intensity distribution depends on the refractive index of the cladding layer through the interaction with the evanescent field.

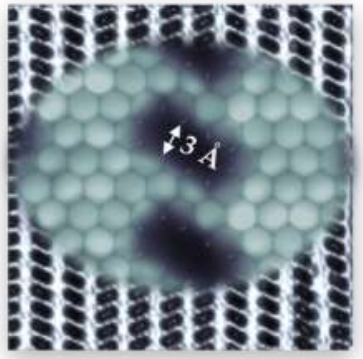
$\Delta n_{min} = 10^{-7} – 10^{-8}$ RIU
LOD protein: pM – fM

Surface Biofunctionalization

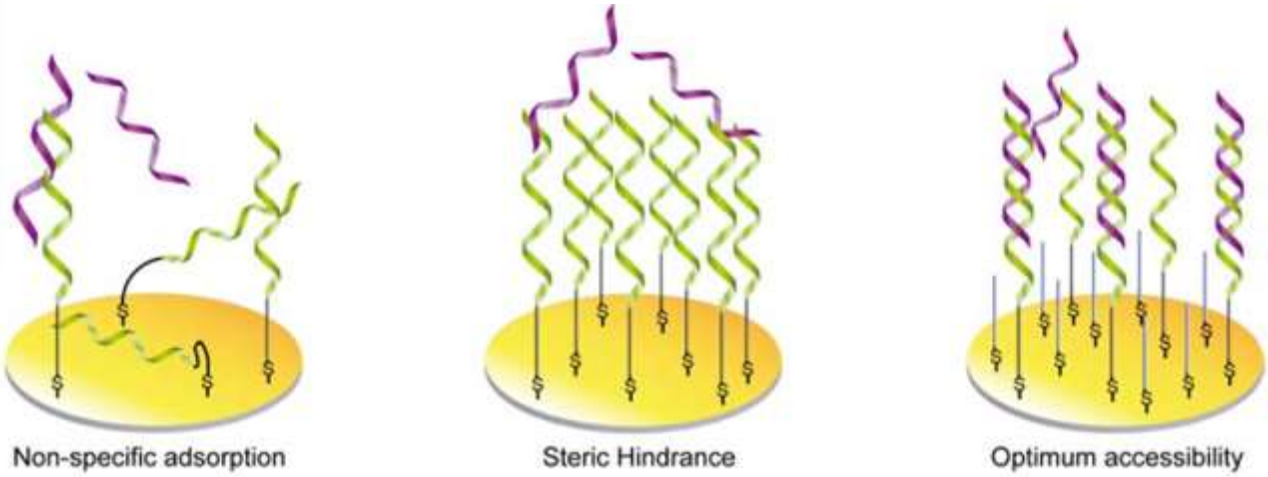


Key factors

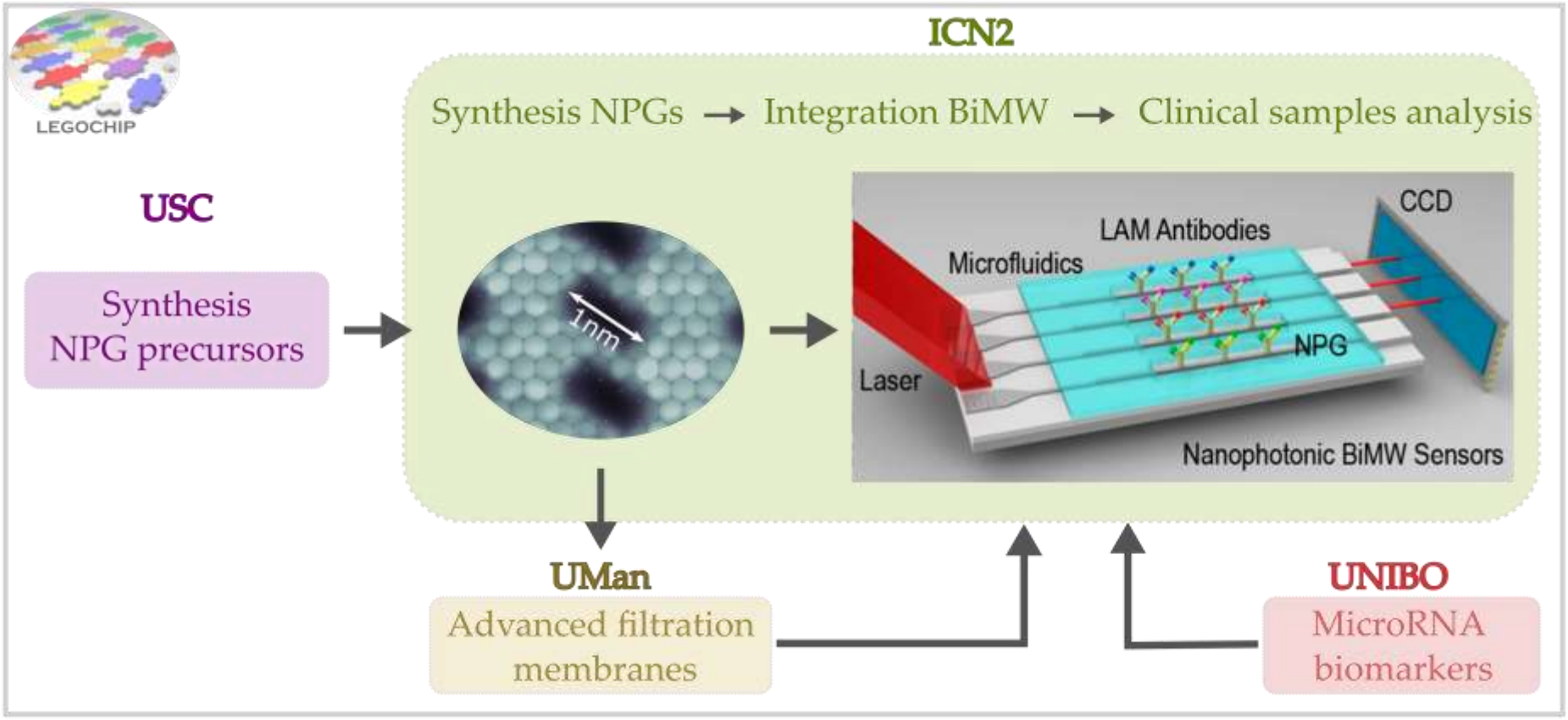
- Stable attachment
- Density control
- Orientation control
- Reproducibility
- Anti-fouling



Importance of Density Control



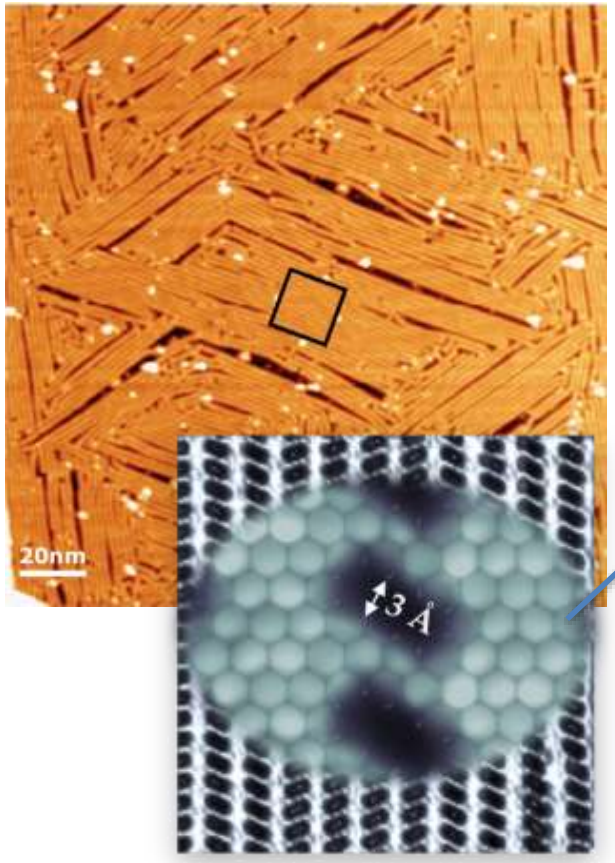
Biological filtration membranes



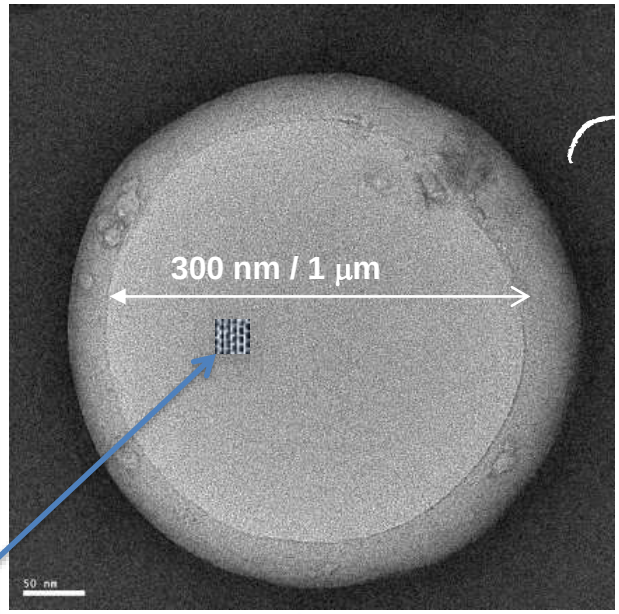
Patricia Gorgojo
(U. Manchester, IP)

Suspended NPG characterization

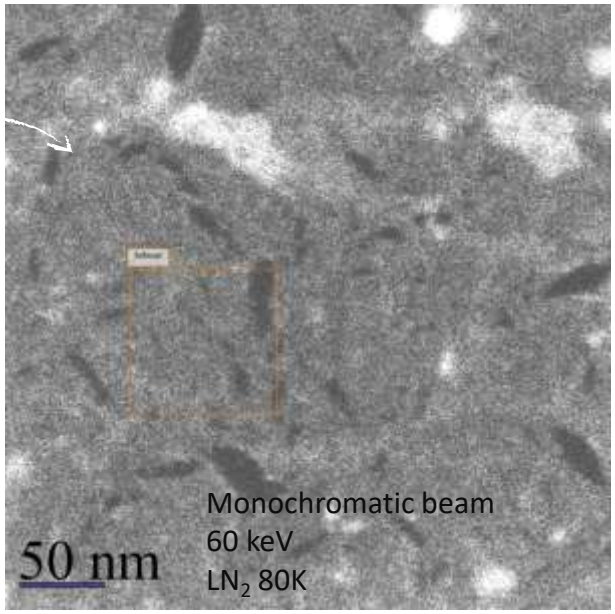
STM – NPG/Au

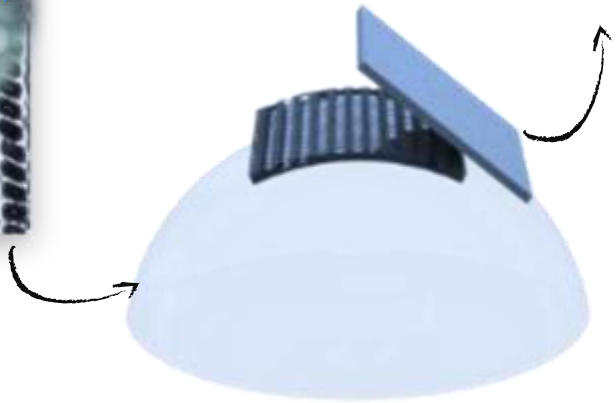


TEM – Suspended NPG/SiN membranes



Cs-TEM



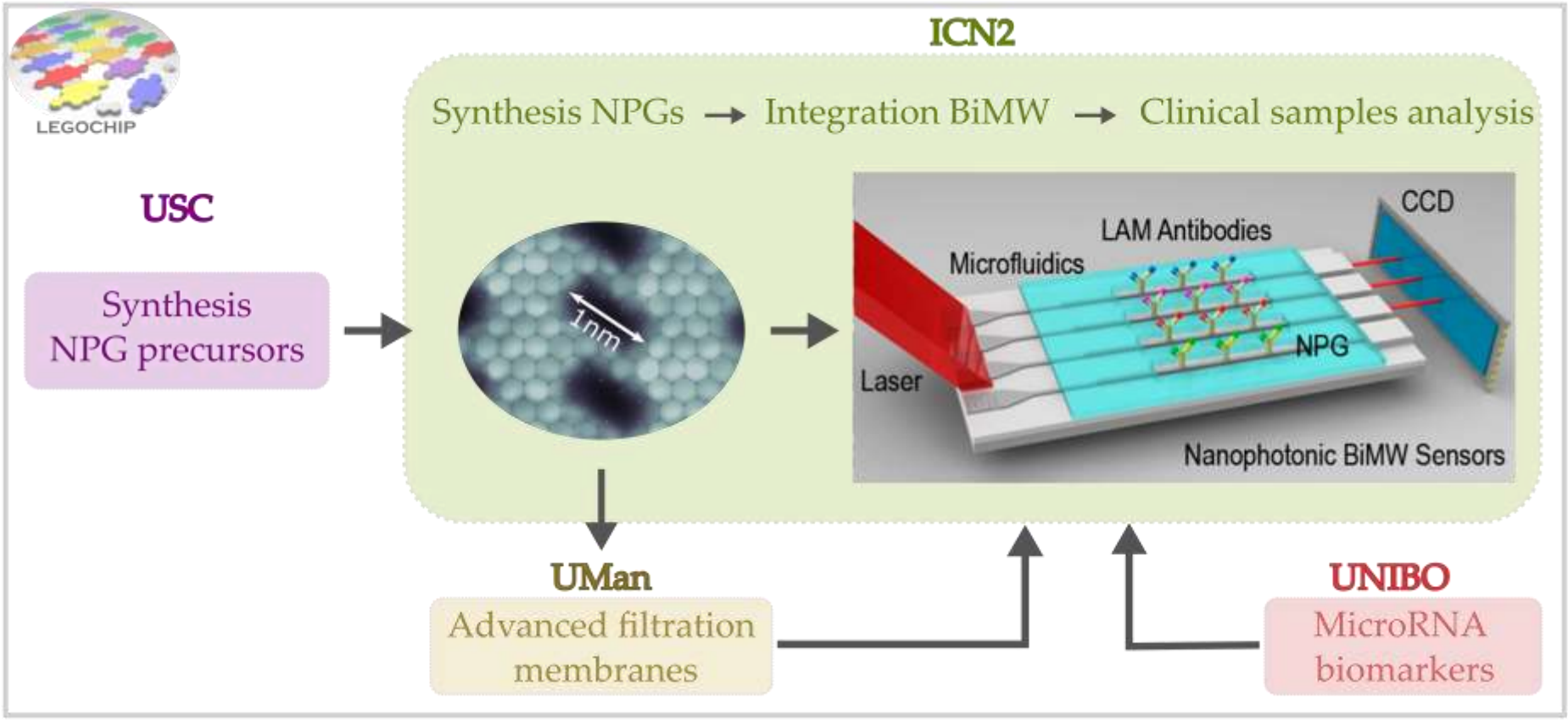


Suspended NPG:

1. **Mechanical integrity**
2. **Clean**

In collaboration with
L. Galvao / M. Kociak, U. Paris-Sud

Next steps



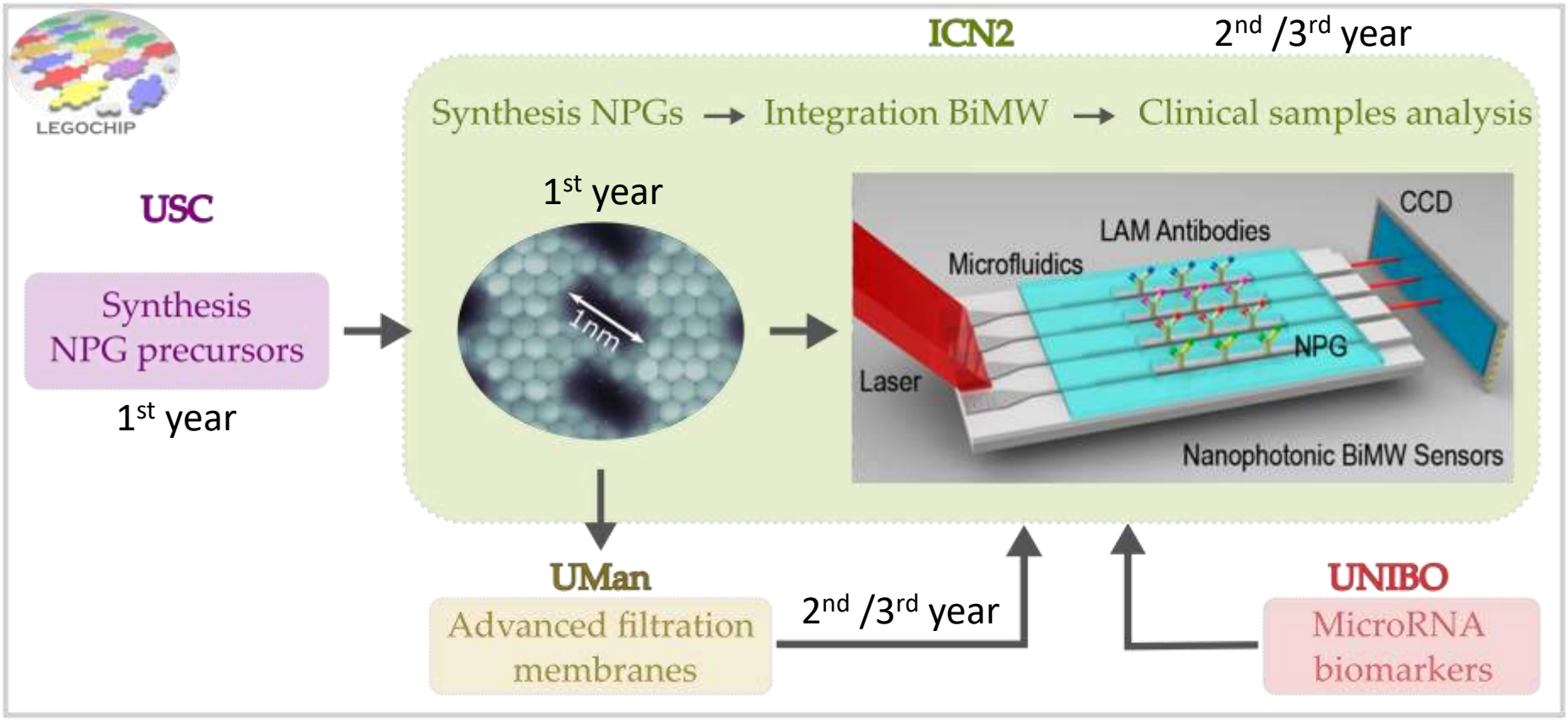
Manuela Ferracin
(U. Bologna, IP)

- ✓ **Selection of novel target microRNA biomarkers for melanoma diagnostics**
- ✓ **Collection of clinical sample in oncological patients. Asked for 6-months extension.**

Summary and next steps

LEGOCHIP:

Multifunctional Nanoporous Graphene Integration in Operational Nanophotonic Biosensor Devices



- ✓ **In-solution synthesis of precursors**
- ✓ **On-surface synthesis of atomically-precise graphene nanoarchitectures**