



Graphene in the EU

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2D FOUNDRY



Graphene experience and capabilities at ICMM

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Graphene Flagship goal:

*Bring **graphene***

disruptive technologies

from European laboratories

*to Europeans in **ten years***

space of time

FLAGSHIP ROADMAP

Platform

One Atom Thin

Linear spectrum

Strength

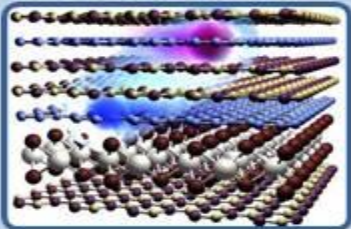
Graphene

High mobility

Highly flexible

Unique optical properties

Hybrid 2d structures



Industrial
Academic

2013

Industrial workshare
Academic workshare



Components

- Transistors
 - Spin valves
 - Flexible displays
 - RF tags
 - Ultra-light batteries
 - Solar cells
 - Ultrafast lasers
 - Composite materials
 - Prostheses
 - Sensors
 - ...



Production techniques

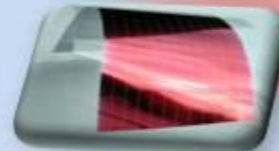
- Large scale synthesis
- On demand growth
- Nanoribbons
- Growth on flexible substrates
- Inks
- Interfaces
- Doping
- Superstructures
- Toxicology
- ...



2016

System Integration

- Flexible electronic
- Superfast optical communication
- Ultrafast low-power electronics
- Self-powered devices
- Automotive
- ...



Industrial workshare
Academic workshare

4

2023

Vision beyond 2023

ICT

- Faster
- Cheaper
- Flexible

Energy storage and conversion

- Efficient
- Cost effective
- Renewable
- Sustainable

Health

- Cost effective
- Bio compatible

- Societal benefits
- Jobs
- Education

About the Graphene Flagship

- **A total budget of €1 billion, of which the EC funds 50%;** the remaining 50% is funded by national sources and by flagship partners
- Coordinated by Chalmers University of Technology, Gothenburg, Sweden
- The project does not interfere with national programmes or other EU initiatives but **it is aligned.**

2D FOUNDRY



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MATERIALS SCIENCE FACTORY
FACTORIA DE CIENCIA DE MATERIALES

Instituto de Ciencia
de Materiales de Madrid



CSIC

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

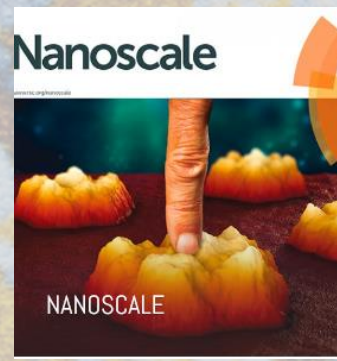
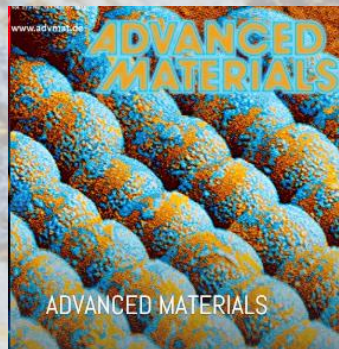
MATERIALS SCIENCE FACTORY FACTORÍA DE CIENCIA DE MATERIALES

Quantifiable scientific excellence in
Materials Science and Nanotechnology

Materials Chemistry for energy and sustainability
Nanotechnology to address society needs
Quantum Materials and technologies
Singular characterization techniques

30 PI researchers
218 papers in 2016-2017
Average IF 6.6
12 M€ of competitive funding
3 ERC grantees

<http://www.icmm.csic.es/factoria-ciencia-materiales/>



2D FOUNDRY



Magnetotransport lab



Local probe lab

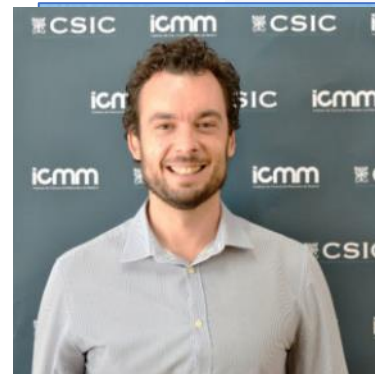
Andres Castellanos-Gomez



Mar García-Hernández



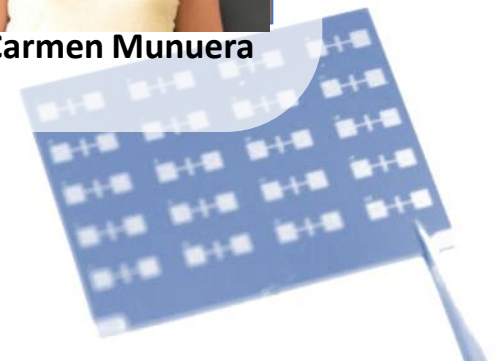
Federico Mompeán



Optoelectronic lab



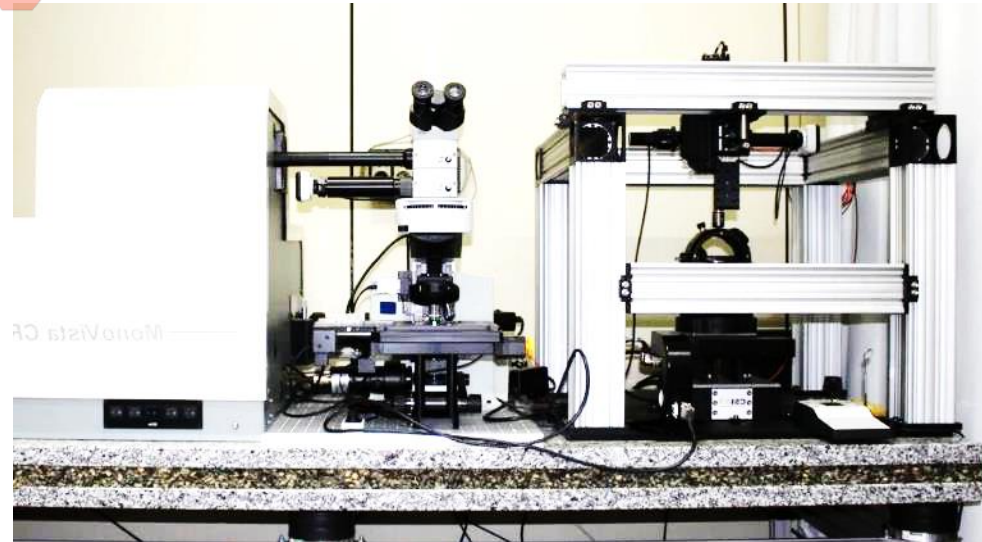
Carmen Munuera



2D FOUNDRY

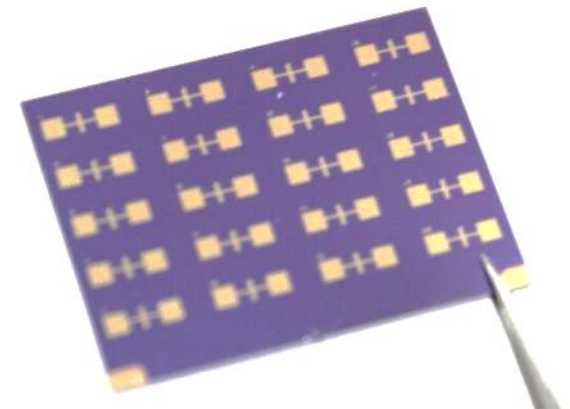


Magnetotransport lab



Local probe lab

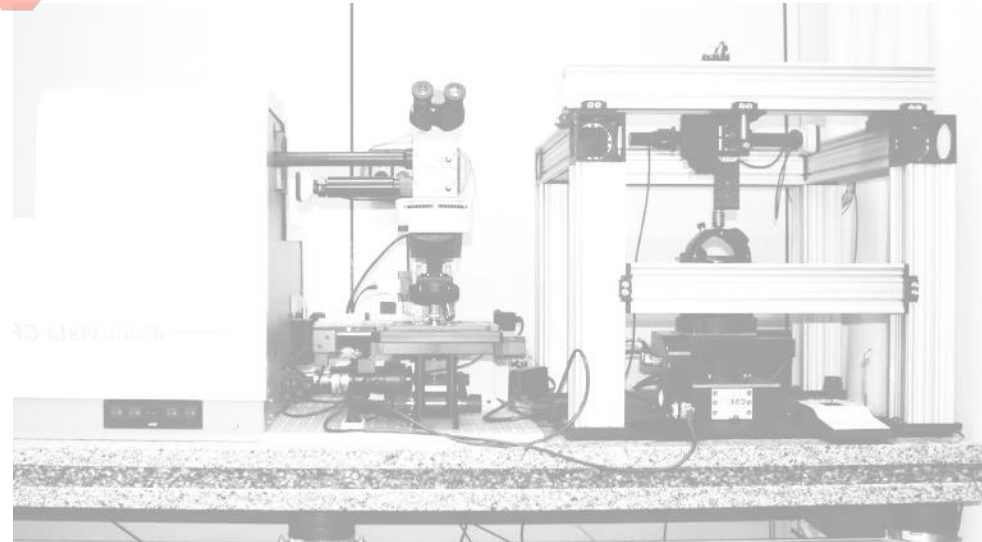
Optoelectronic lab



2D FOUNDRY



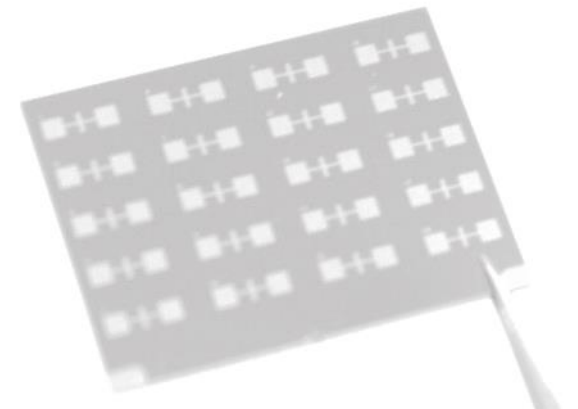
Magnetotransport lab



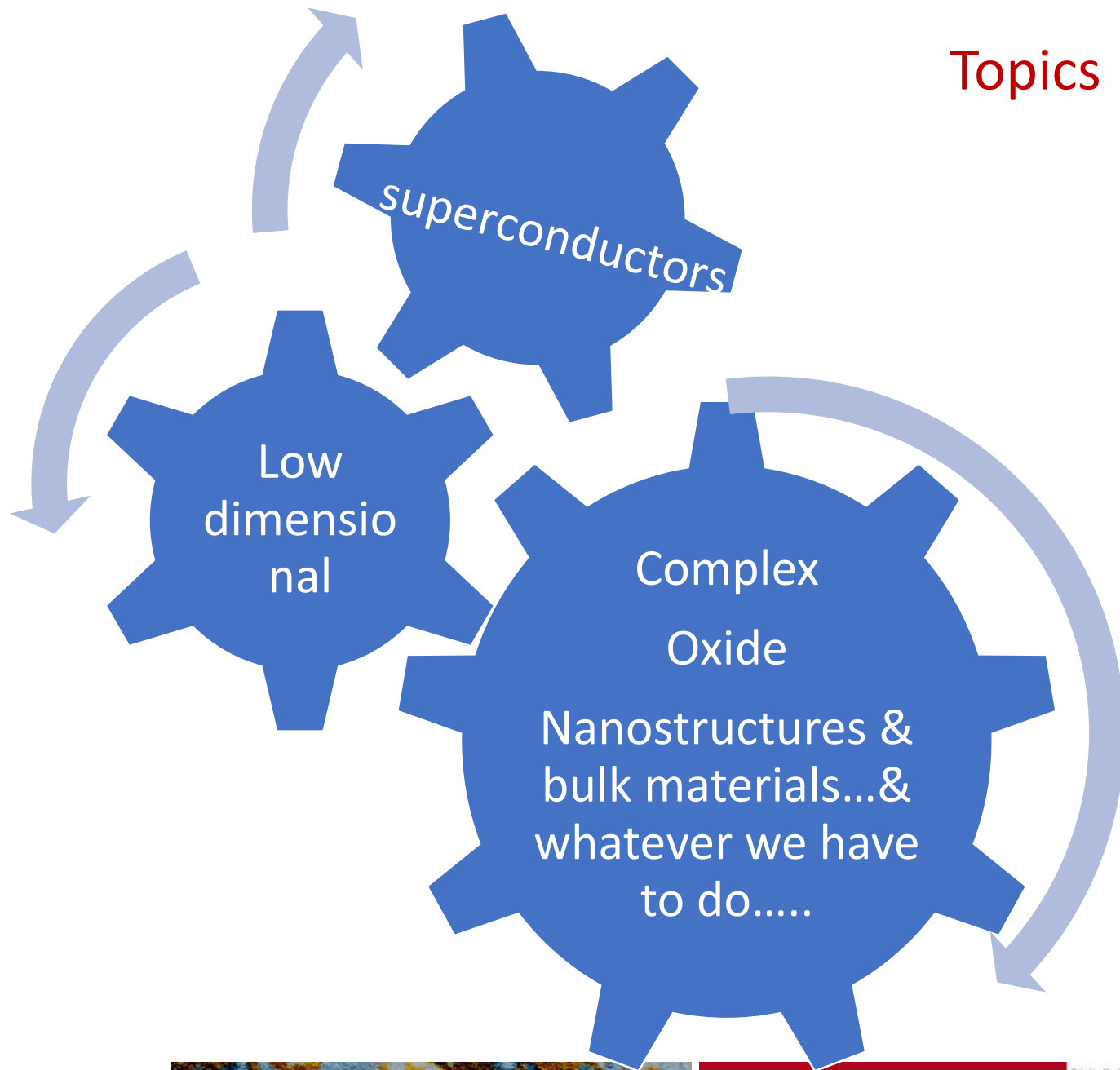
Local probe lab



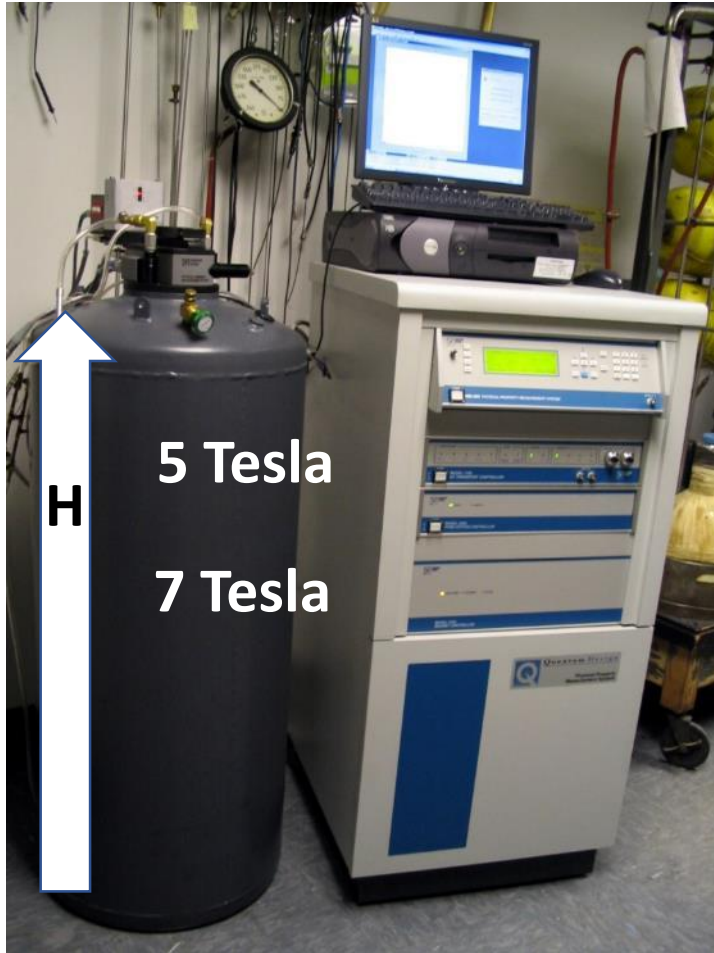
Optoelectronic lab



Topics



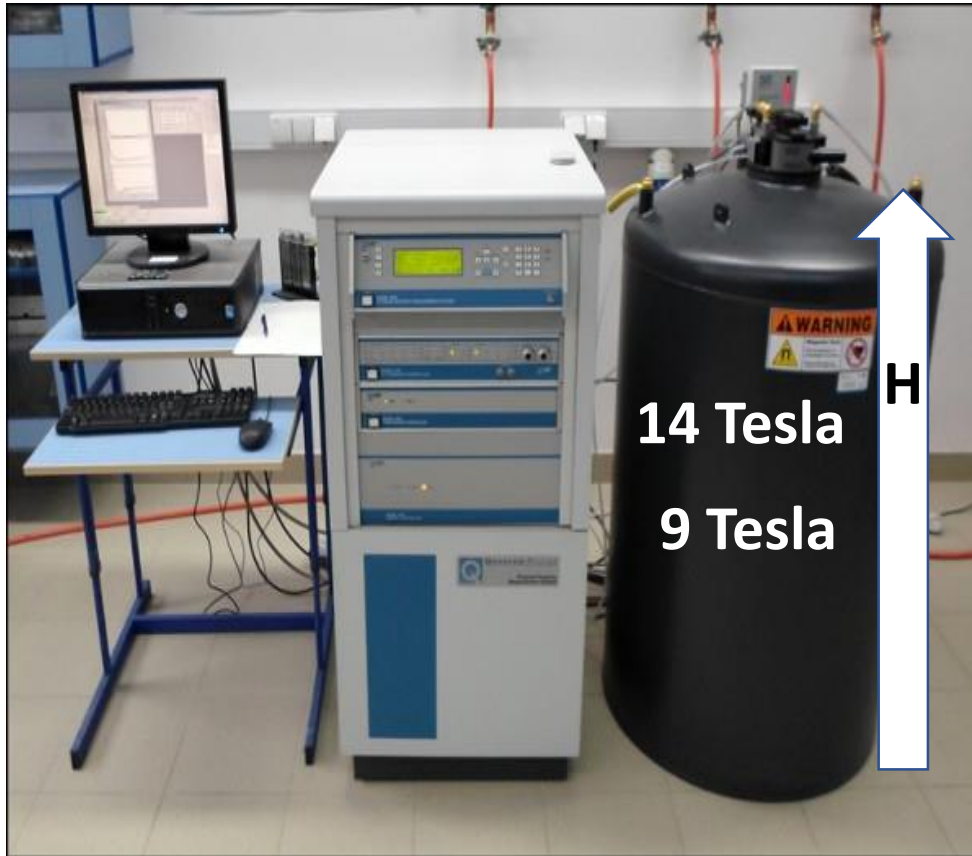
MACROSCOPIC MEASUREMENTS I: Squid magnetometry and VSM, Torque (inserts of PPMS)



- 2 SQUID magnetometers (DC-AC)
- 1.8K-800K
- 5Tesla , 1 Oe trapped field
- 7 tesla, 10 Oe trapped field
- Bulk, thin films, heterostructures, single crystals

MACROSCOPIC MEASUREMENTS II

of macroscopic samples and of microdevices



- 2 PPMS (1.8 K-400K) HV:
- Electrical resistance DC/AC
- Hall
- HR rotor
- Specific Heat (quasiadiabatic)
- Seebeck
- Impedance Spectroscopy

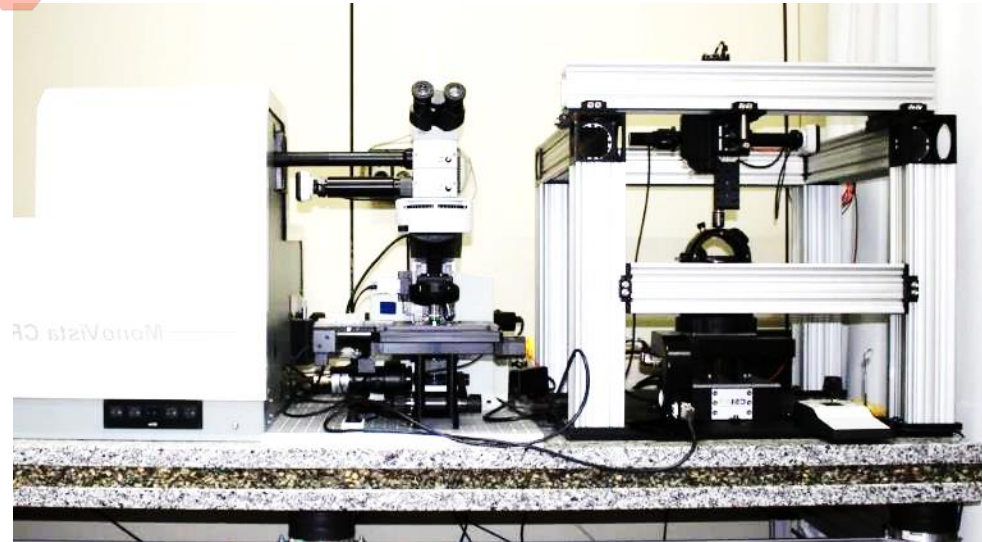
Collaborative Research with industrial partners

- Graphene Composites
 - Tintas Azubialde
 - Cromogenia
 - Nanoinnova
 - Polymec...
- Grupo industrial español con interes en grafeno: Alianza española en grafeno (Codigo de buenas practicas)
- Lead & coordinate the Graphene normalization group Graphenet

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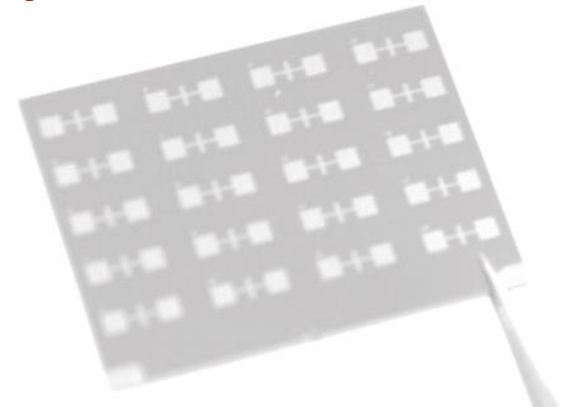
Magnetotransport lab



Local probe lab



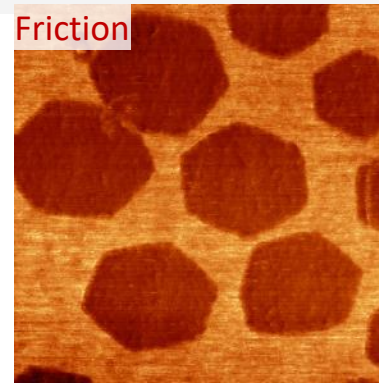
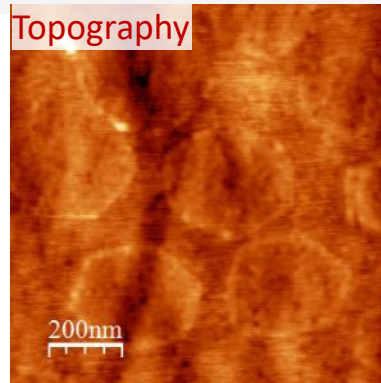
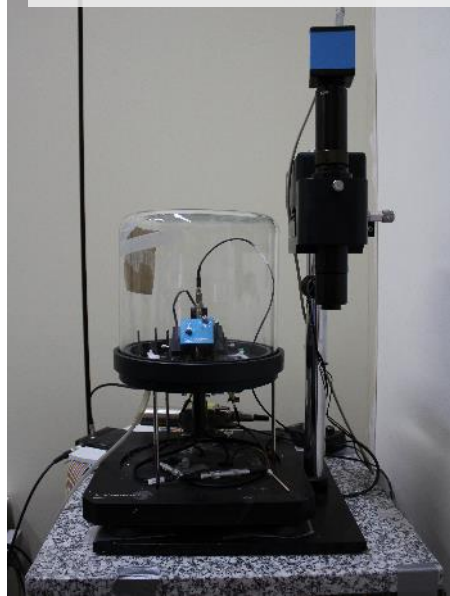
Optoelectronic lab



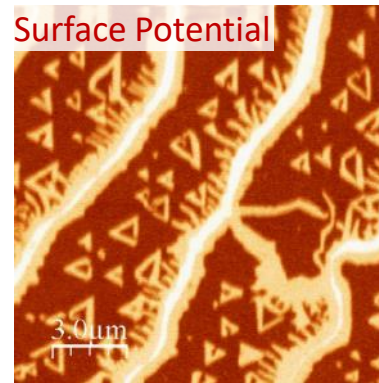
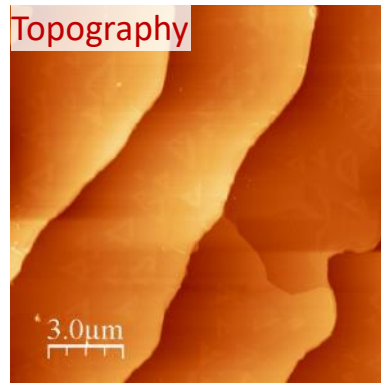
Multifunctional SPM characterization

Local Probe lab

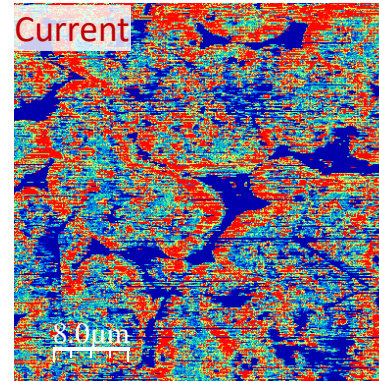
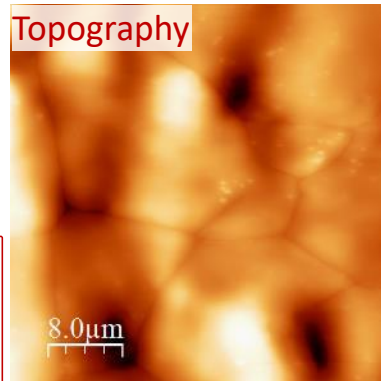
Experimental skills



Mechanical properties:
friction, adhesion, stiffness



Electrostatic properties:
surface potential maps



Transport properties:
current/resistance maps

2 RT SPM

Multiple measuring modes
Controlled atmosphere (RH)

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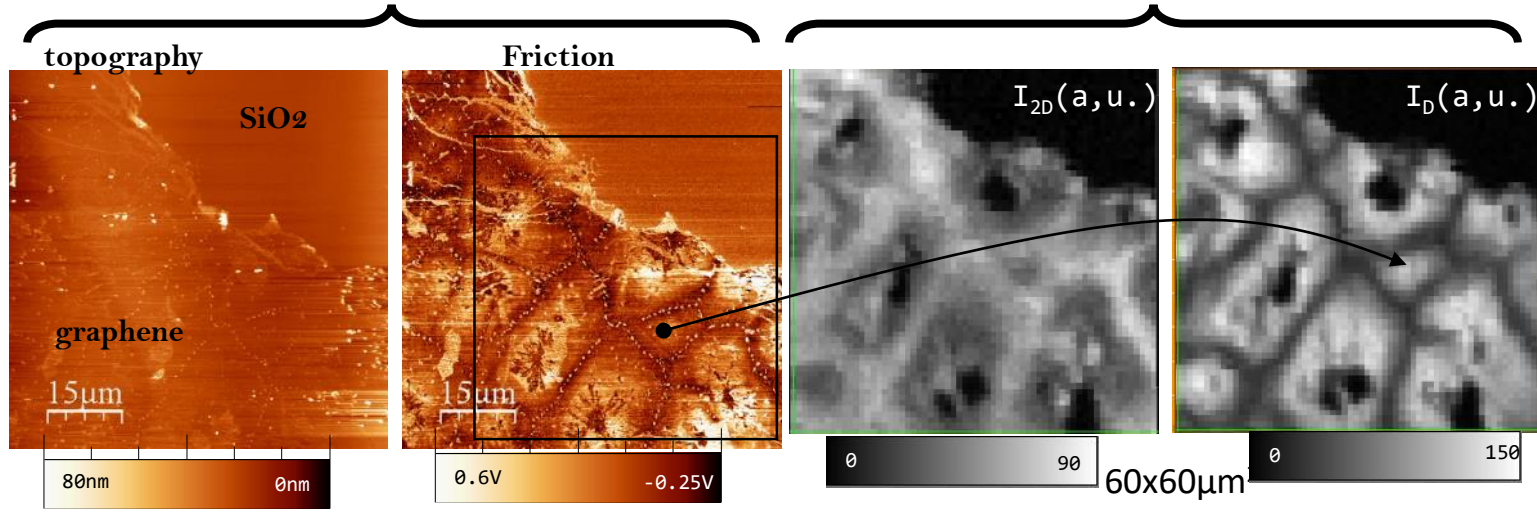
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1 SPM + confocal Raman (532nm)
 co-localized SPM and Raman measurements
 Multiple SPM modes
 Raman actual lateral resolution $\sim 1\mu\text{m}$

SPM

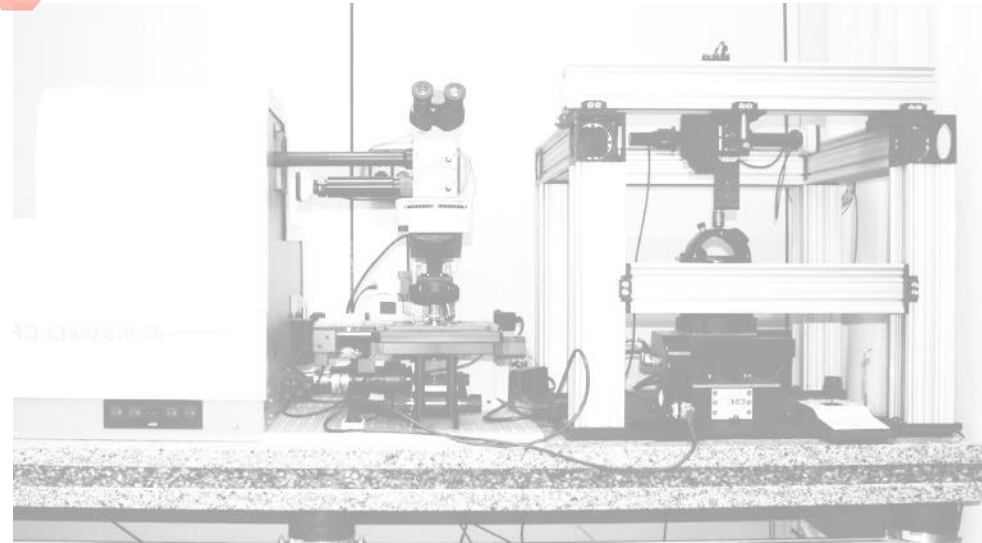
Confocal Raman



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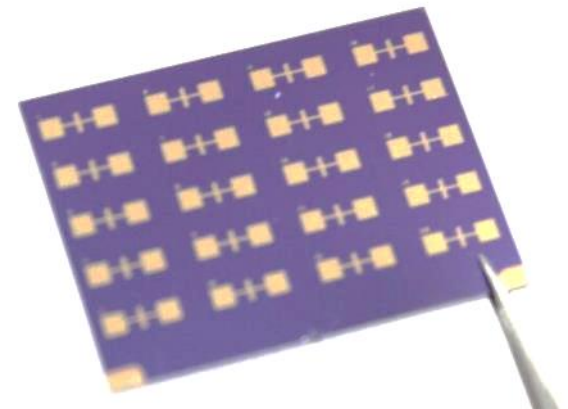
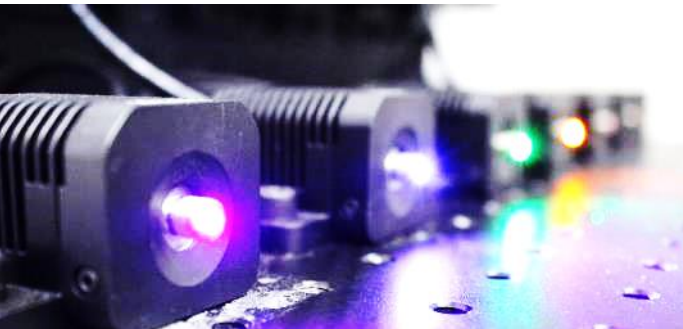


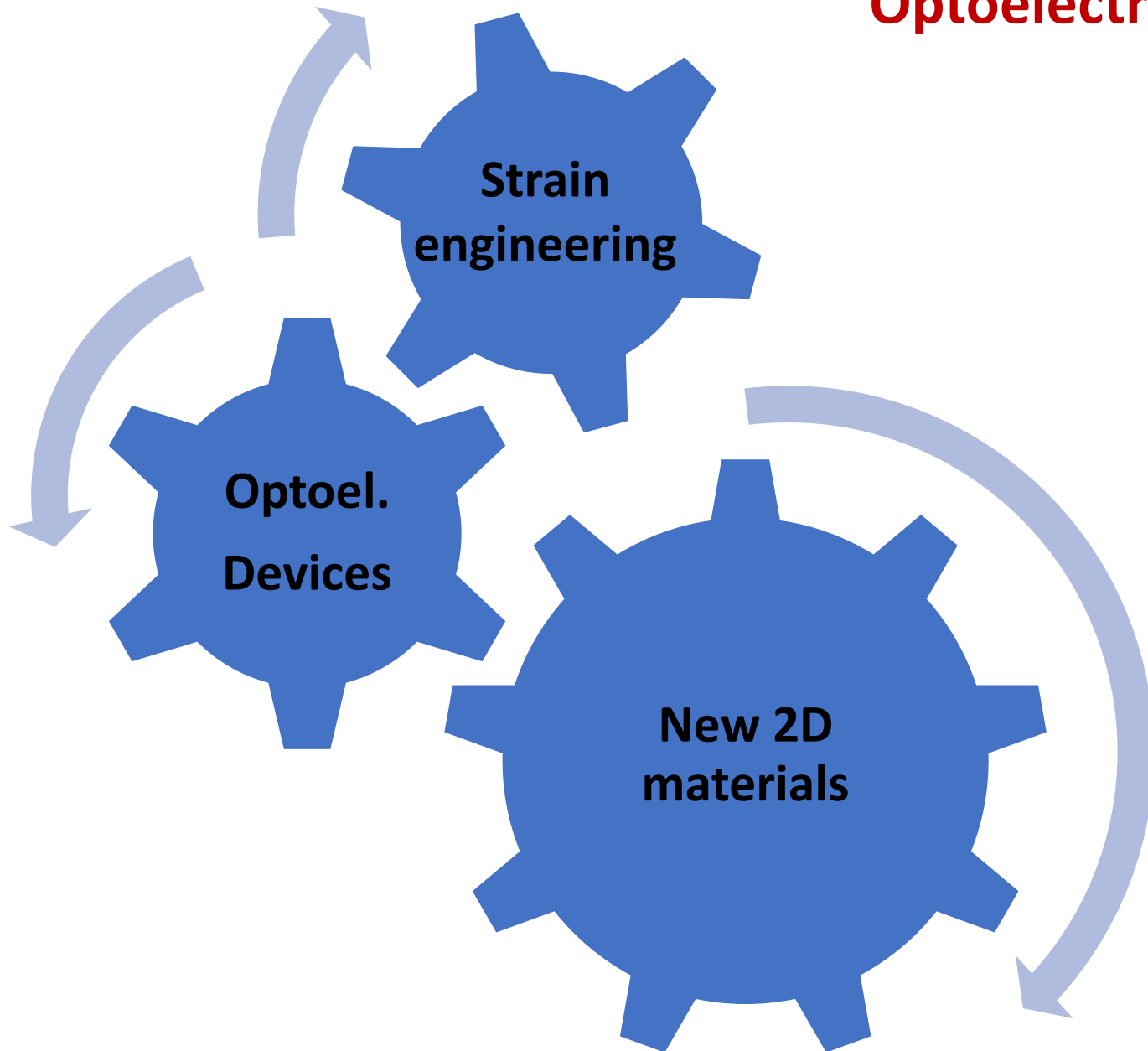
Magnetotransport lab



Local probe lab

Optoelectronic lab

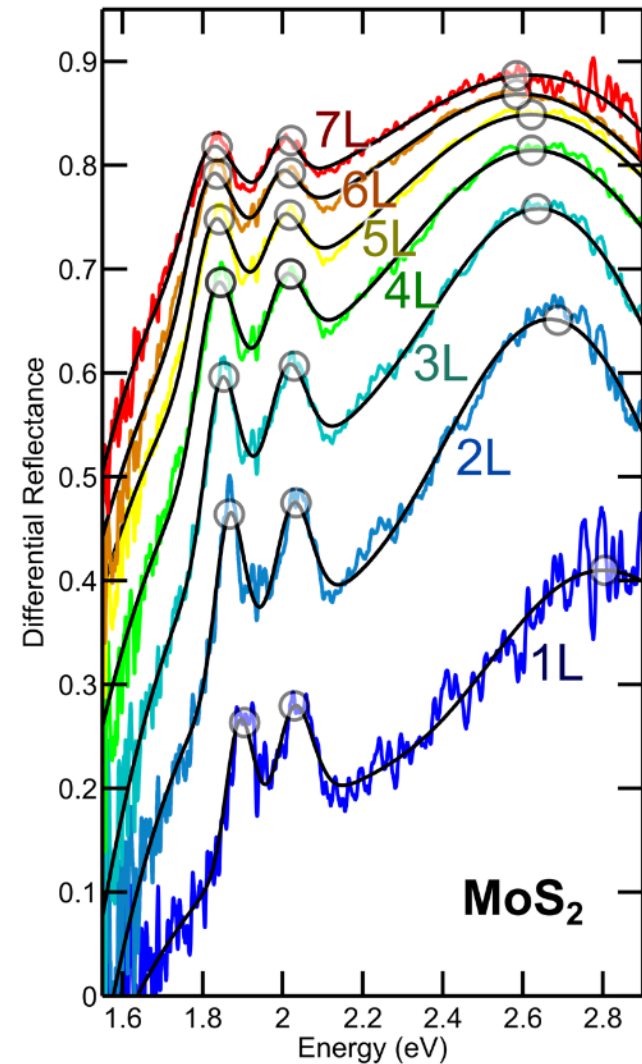
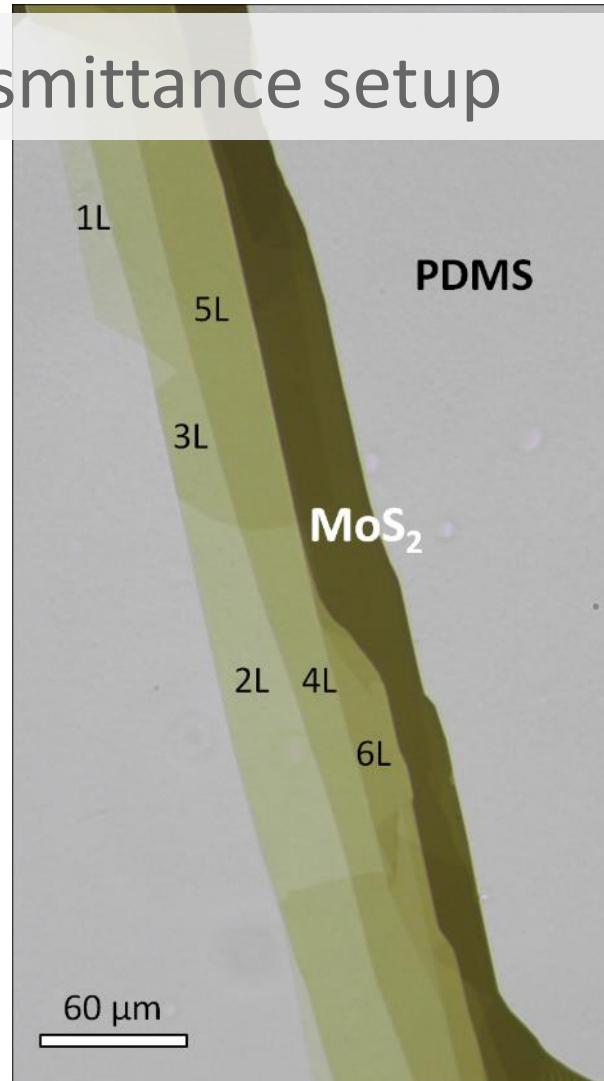




Optoelectronic lab

Experimental skills

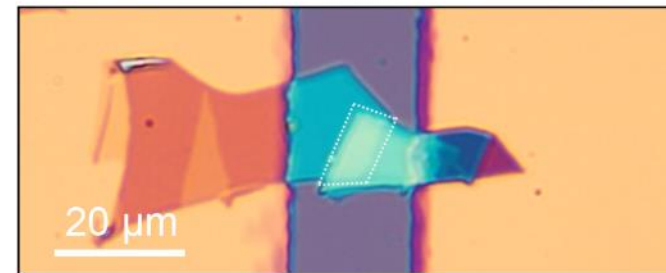
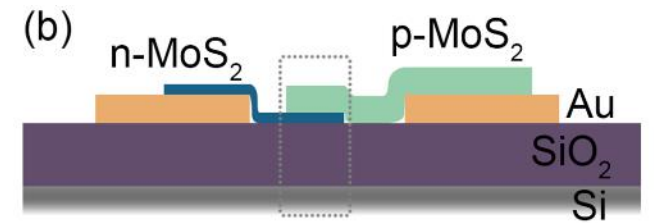
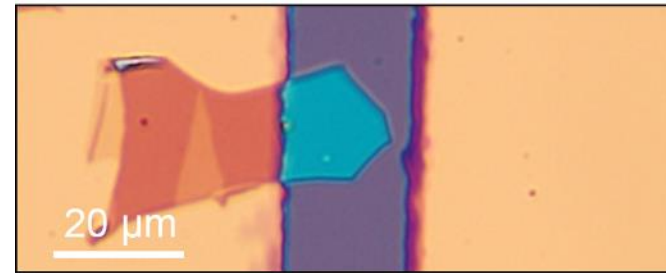
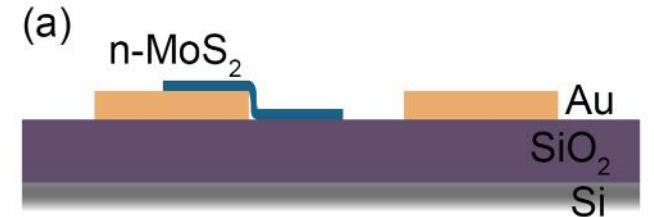
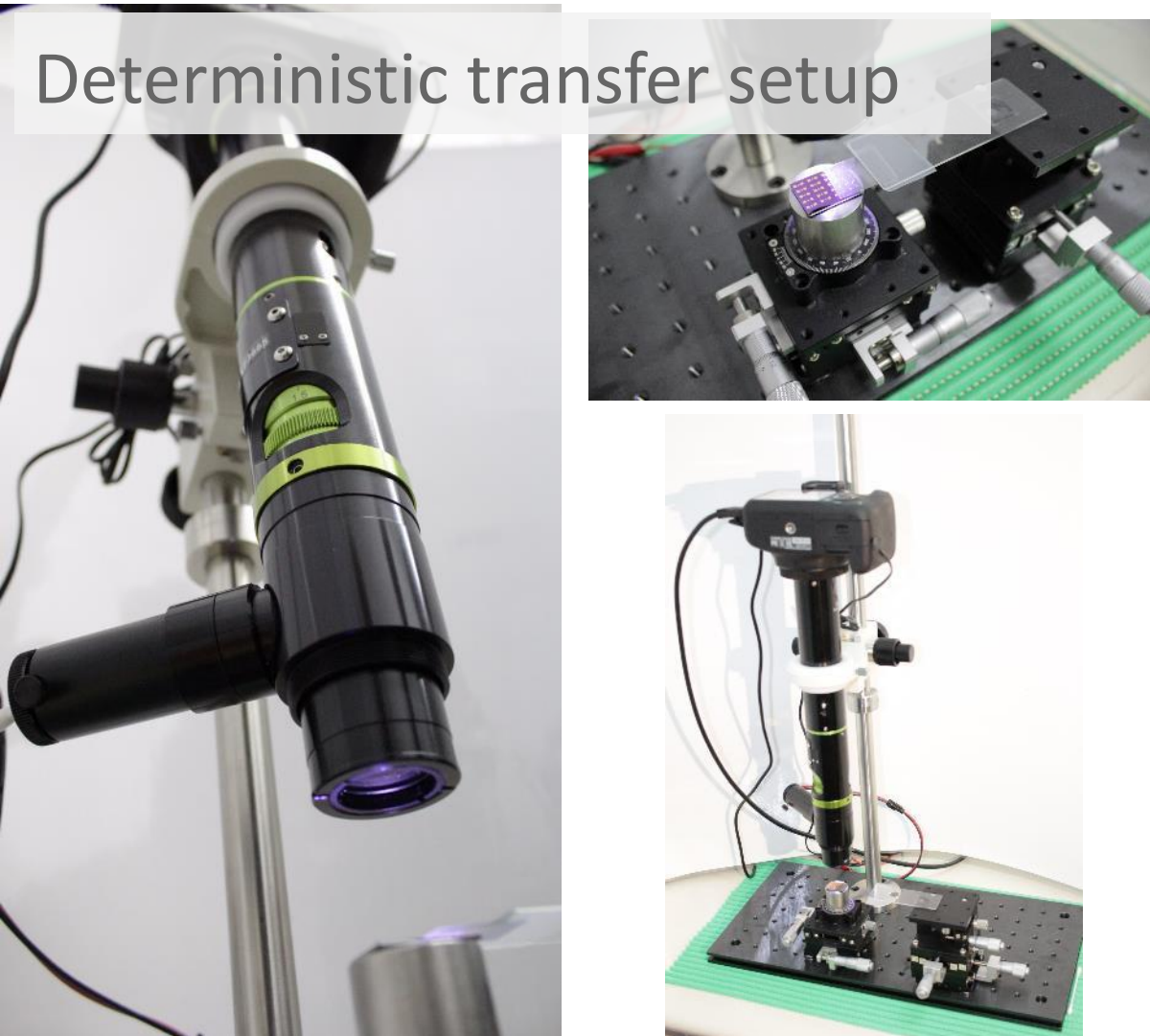
μ -reflectance/transmittance setup



Optoelectronic lab

Experimental skills

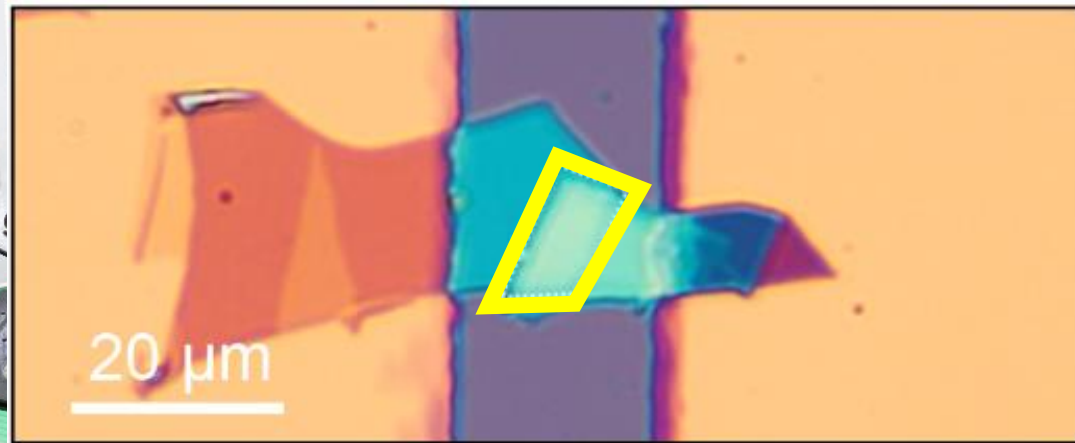
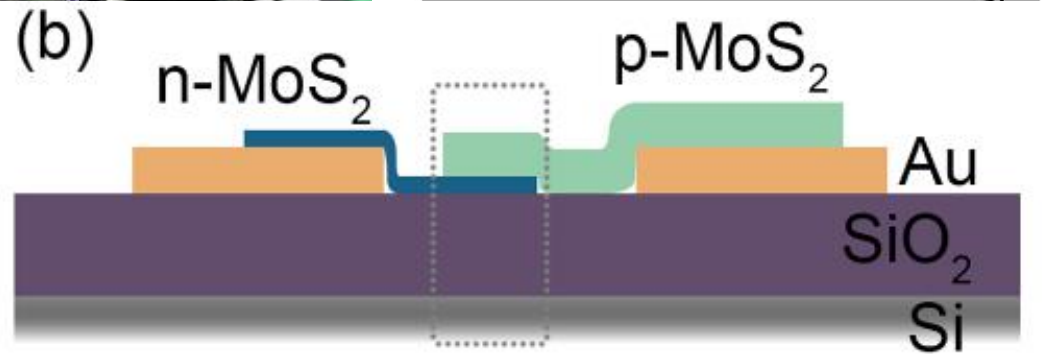
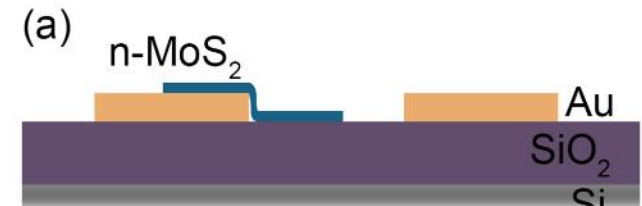
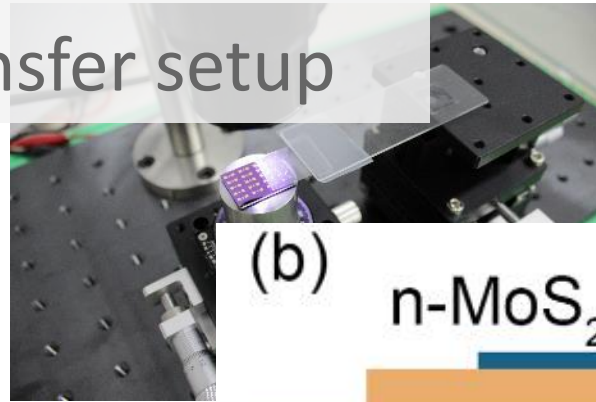
Deterministic transfer setup



Optoelectronic lab

Experimental skills

Deterministic transfer setup



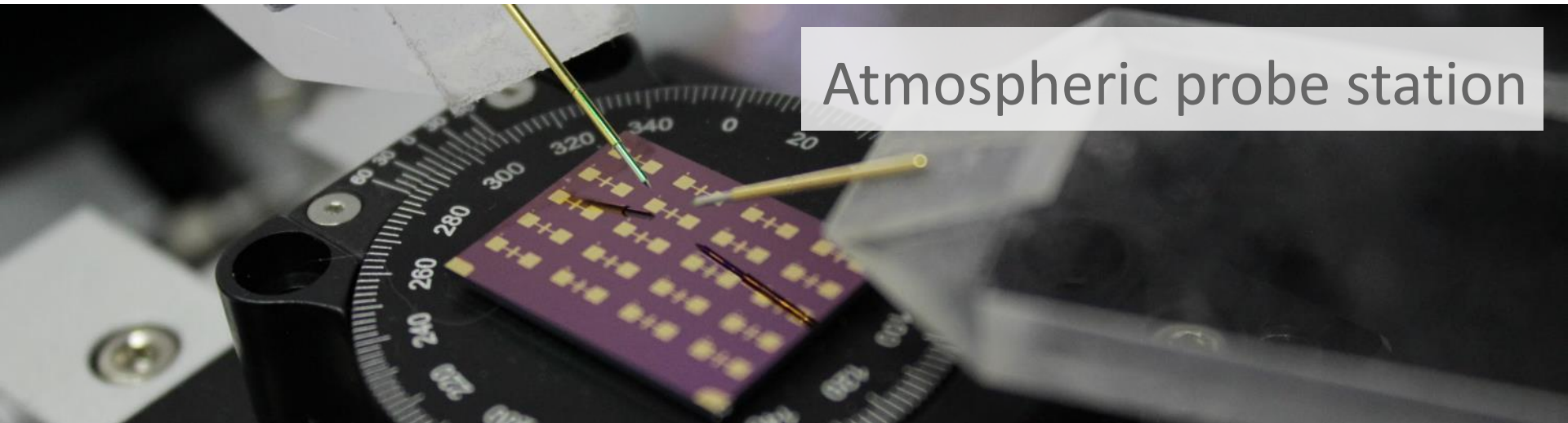
Optoelectronic lab

Experimental skills

Fiber coupled light sources



Atmospheric probe station



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