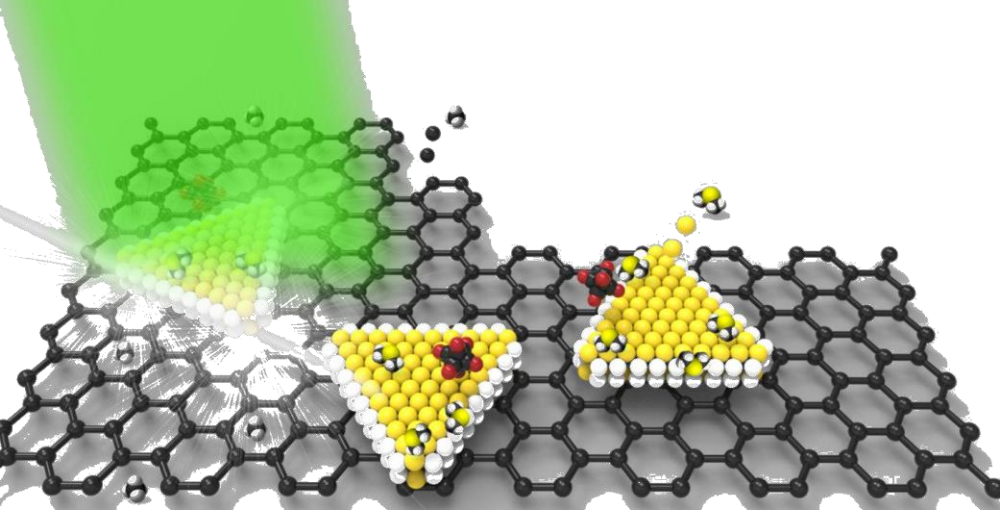


Annual report

1st year of PhD in Nanosciences

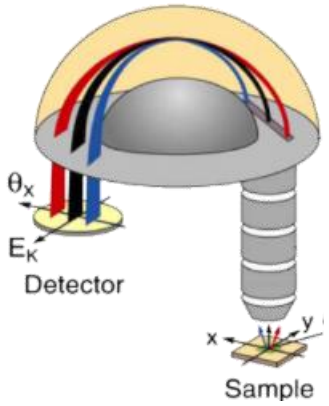
PhD Student: *Giulia Piccinini*

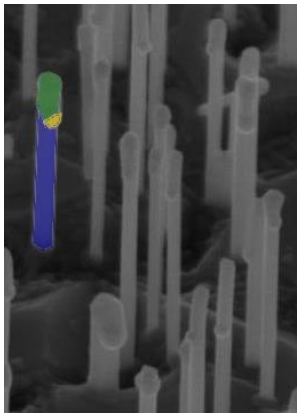
External Supervisor: *Camilla Coletti*

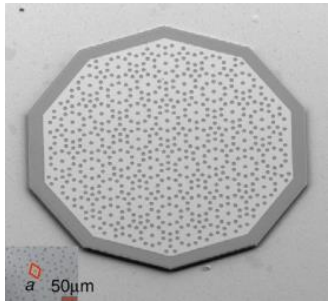
Courses

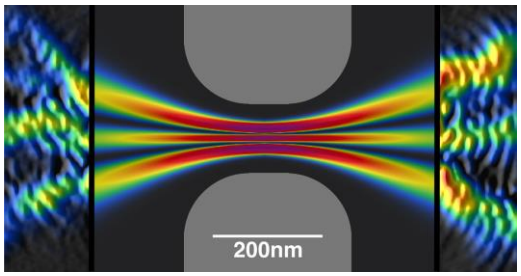
Nanostructured Materials (Dec 2018-May 2019 → **40 h**)
S. Heun, L. Sorba

Program:
semiconductors, growth techniques, defects, fabrication, nanostructures, characterization, 2D electron systems, QDs, nanowires







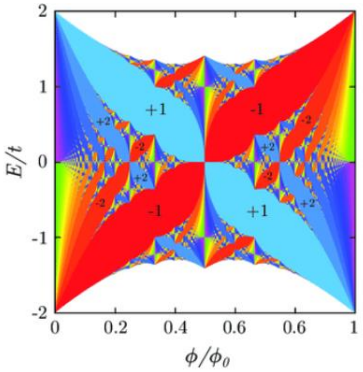


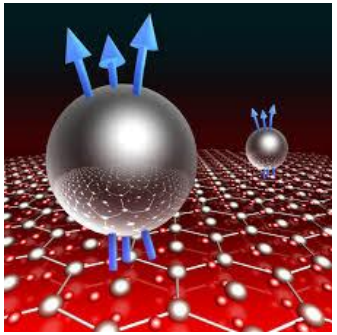
Physics of nanostructures (Apr-Jun 2019 → **44 h**)
F. Rossella, M. S. Vitiello, S. Roddaro

Program:
- Optical properties of semiconductor heterostructures
- 1D and 0D systems

Seminars in Condensed matter physics (Apr-Jun 2019 → **44 h**)
F. Taddei, G. C. La Rocca, F. Rossella, M. S. Vitiello

Program:
- Topological phases of matter (I. Carusotto and L. Mazza)
- Coherent dynamics and quantum transport in nanostructures (F. Taddei)

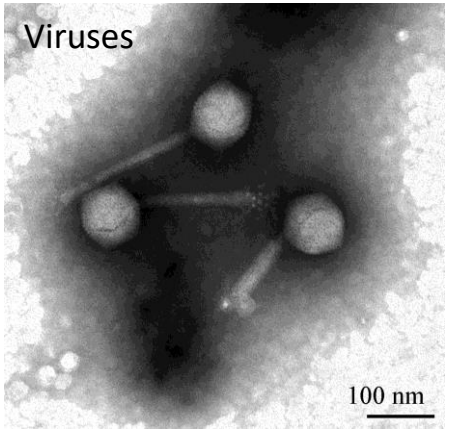




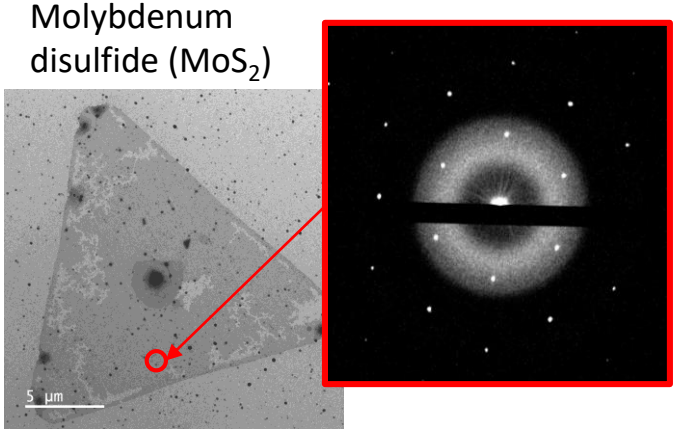
Stages

Transmission electron microscopy (Dr. Gemmi lab)

- Imaging (of both biological samples and crystals)
- Diffraction (to identify crystal structures)

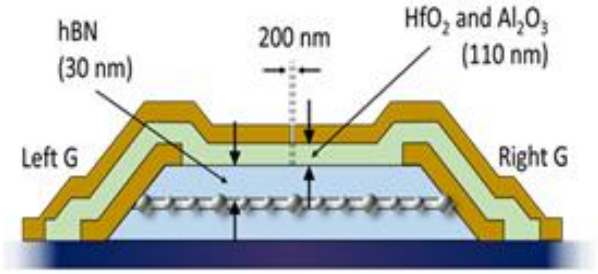


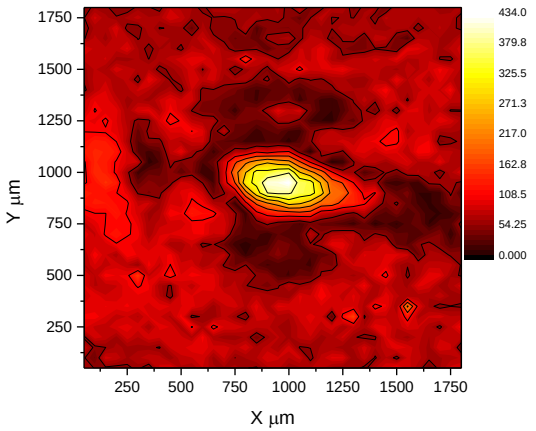
Molybdenum disulfide (MoS_2)



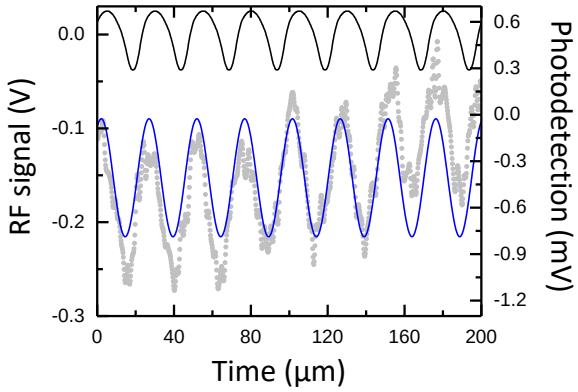
Optical test of nanodetectors operating at THz frequencies (Prof. Vitiello lab)

Graphene THz photodetector (PTE effect)





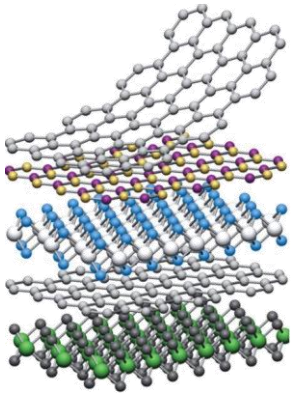
40 kHz: amplitude 381 µV

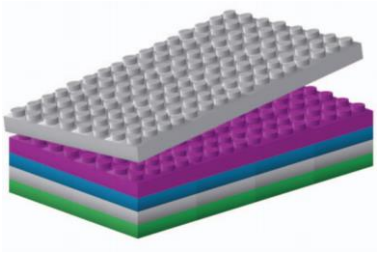


PhD project

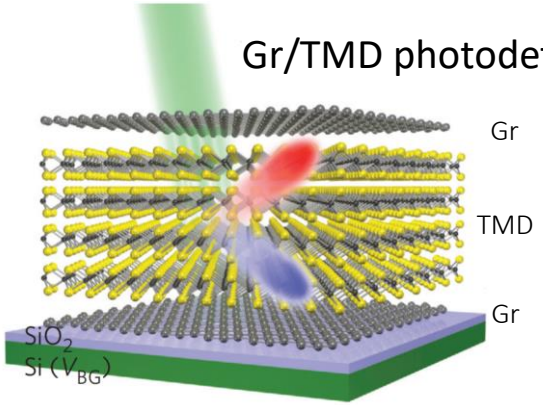
Graphene/TMDs heterostructures for optoelectronic applications

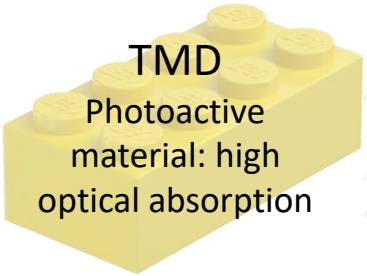
Van der Waals heterostructures (vdWH) → combine layers with different properties to engineer **new functional materials**

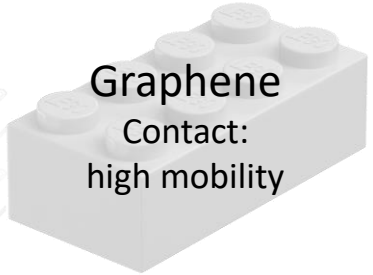




Gr/TMD photodetector

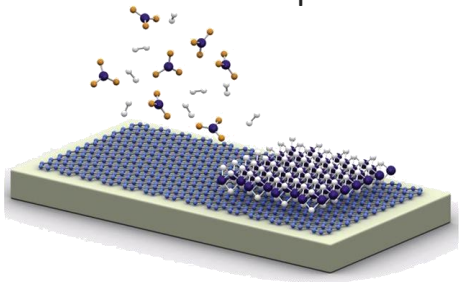






✗ **Exfoliation** → no control on size, shape, orientation, time consuming, not scalable

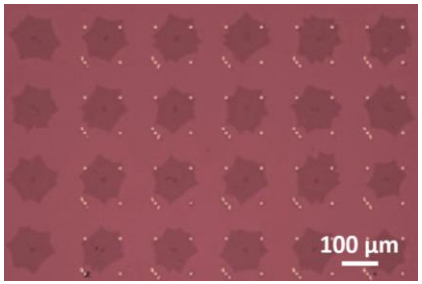
✓ **Chemical vapor deposition (CVD)** → scalable technique

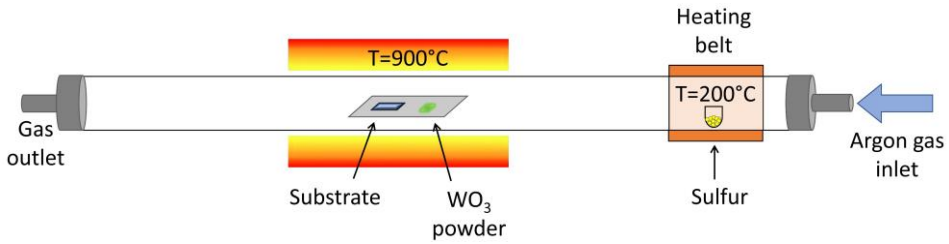


- Synthesis of **high-quality** materials on a **large scale**
- Different **stacking methods** (synthesis + transfer, direct synthesis)
- Materials **characterization**, **surface science** investigations, etc…
- Devices fabrication and measurements

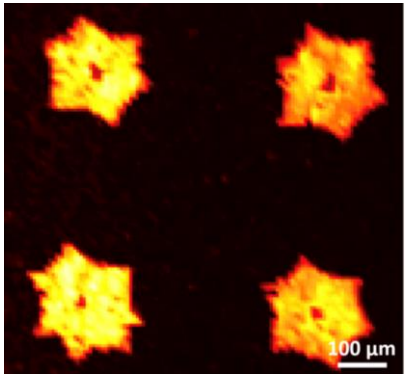
PhD project

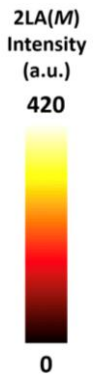
Achieved: Deterministic direct growth of WS_2 on CVD graphene arrays

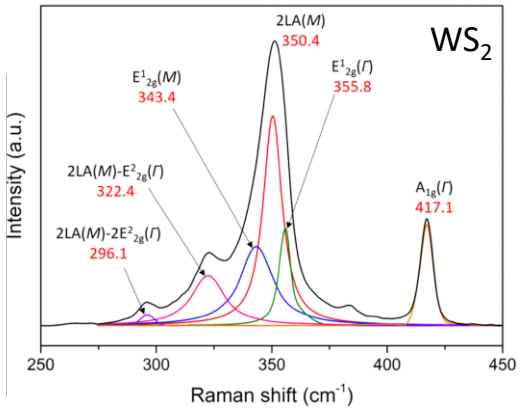




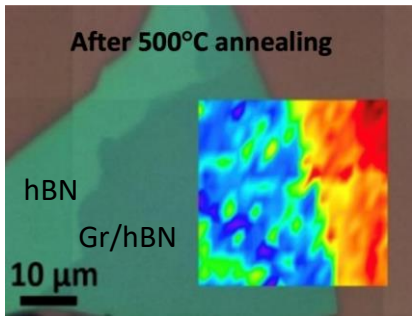
G. Piccinini *et al* *2D Mater.* (2019) https://doi.org/10.1088/2053-1583/ab49f0



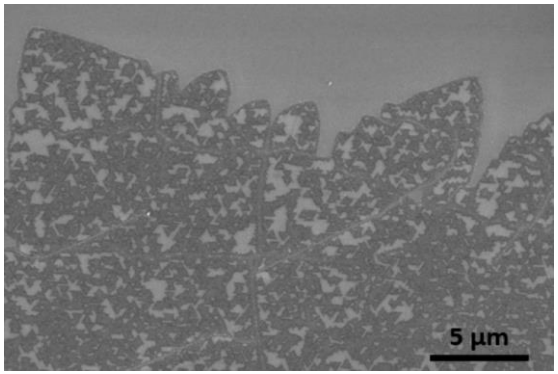




Graphene 2D peak width

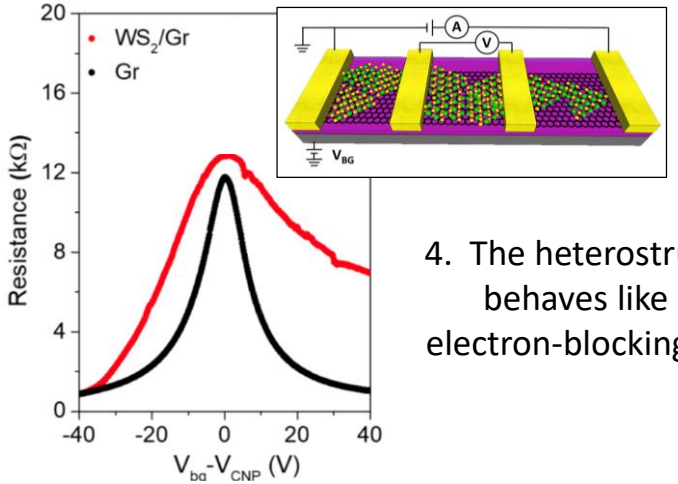


3. Graphene is doped (interaction with SiO_2)
↓
hBN: good protective substrate



1. Development of an approach for monolayer WS_2 on graphene arrays

2. Selective growth on graphene (i.e., not on SiO_2)

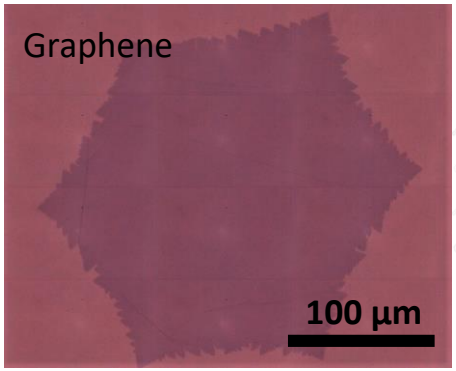


4. The heterostructure behaves like an electron-blocking layer

Next steps

Aim: high-performing optoelectronic devices (e.g., graphene/WS_2 photodetectors)

- **Mechanical stacking** of CVD monolayer materials and characterization



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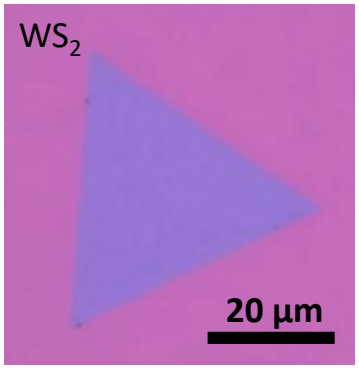

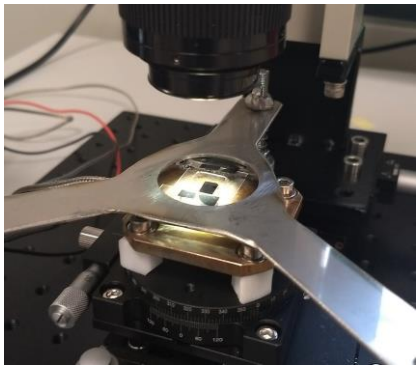

micromechanical stage

A preliminary Raman characterization revealed that the quality of graphene is preserved after the stacking process

- Devices photodetection performances → **photocurrent measurements**
- Different **rotation angles** between the materials
- **Interfaces**, **band alignments** and **charge transfer mechanisms**
  - LEED
  - Time-resolved ARPES
  - Pump-probe reflectance spectroscopy