Curriculum
Condensed Matter Physics & Photonics

Master Degree in Physics

Dipartimento Interateneo di Fisica M. Merlin

Università degli Studi di Bari Aldo Moro

Why condensed matter physics

- Most of our world is in a condensed state
- Fascinating and challenging
- Really cross-disciplinary
- Truly useful

- *many interacting atoms* → *complex phenomena* due to *collective effects*
- Vast field including
  - solid state physics
  - magnetism
  - fluid dynamics
  - physics of materials
  - polymer science
  - biophysics
  - plasmas
  - global scale climate predictions …

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- Quantum mechanics playground
- Statistical mechanics
- Many body interaction
- Artificial nanostructures
  - Matter by design
  - Nanotechnologies

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- The largest branch of physics
  - About 30% of the physicists in the world can be classified as «condensed matter physicists» [AIP]
- Liveliest subfield of physics
- Cross-connections with
  - Engineering
  - Biology
  - Chemistry
  - Medical and forensic sciences ...

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- Transistor
  - 6×10^7 transistors/year/person
- Micro- and nano-electronics
- Laser
- LEDs
  - Lighting, energy saving
- Solar cell
- Medical imaging
- Environment: clean water, clean air, sustainability
- …

Why photonics

Photonics – the technology of harnessing light

Photonics comprises the

- **generation**
- **amplification**
- **transmission**
- **modulation**
- **detection**

of light

Lighting
(LEDs, displays)

Manufacturing
(high power lasers)

Telecommunication
(fibers)

Medicine
(lasers, microscopes)

Sensor technology
(optical sensors)

LED light bulb

glass fibers

Photonics bears the same relationship to light and photons as electronics does to electricity and electrons.

Teaching closely related with cutting edge research and technology transfer

- Physics of nanostructures and quantum devices
- Light-matter interaction
- Mid-IR and THz photonics
- Quantum optics

- International networks

- Laser material processing
- Photoacoustic sensors
- Electronic bio-sensors
- Non-conventional imaging

- Intellectual property (patents)

- National and international projects

- Technological clusters

Condensed matter physics & photonics

I

1.2 Mathematical methods of physics

1.2 Computational physics

1.2 Laboratory of digital devices

3. Statistical mechanics

4. Quantum field theory

5. Condensed matter physics

II

6. Critical and non equilibrium phenomena

6. Quantum Technologies

6. Spectroscopy and computer modeling of molecular systems

7. Laboratory of photonics

8. Solid state physics

9. Optoelectronics and nanotechnologies

- Free exam

III

10. Laboratory of quantum optics

11. Physics of sensors and laboratory of spectroscopy

11. Laboratory of data acquisition

- Free exam

- Laboratory of plasma physics
- Field theory for condensed matter
- Molecular dynamics
- Digital devices
- Advanced informatics
- Machine learning for physics
- Radioactivity measurements and control
- Didactic physics

Research highlights

Partnership with

THORLABS

(Spagnolo, Patimisco, …)

LASER SPECTROSCOPY

PolySenSe

"A joint-research laser spectroscopy laboratory for Optical Gas Sensing"

CORRIERE DELLA SERA

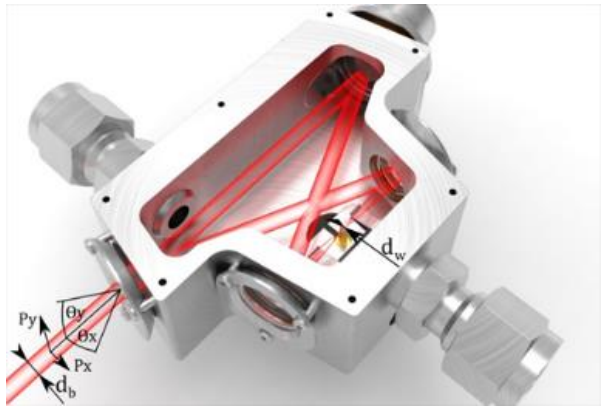
CORRIERE DEL MEZZOGIORNO / CRONACA

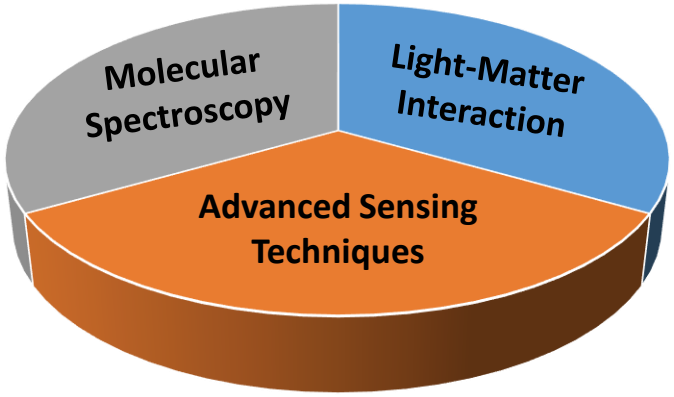
Stampa | Stampa senza immagine | Chiudi

BARI

Thorlabs investe 2,5 milioni nel Politecnico per la ricerca

L'obiettivo è realizzare a Bari, così come ha già fatto al Mit di Boston, un laboratorio che svilupperà studi sui sensori ottici ultra sensibili per la rivelazione di tracce gassose





Potential applications:

Breath analysis
Environmental monitoring
Leaks detection
Hydrocarbon gases monitoring
Monitoring of hotspot areas (explosive precursors, narcotics)

Collaborations & Career opportunities

Rice University, Houston, U.S.
Astro Project
Sensing on drone

Shanxi University, Taiyuan, China
Hundred Talents Project
Sensing for Environmental Monitoring

Technical University of Wien, Austria
Optical gas sensing with photothermal spectroscopy in high finesse optical cavity

OPTAPHI Double Doctorate Program
Optical Sensing using Advanced Photo-induced Effects

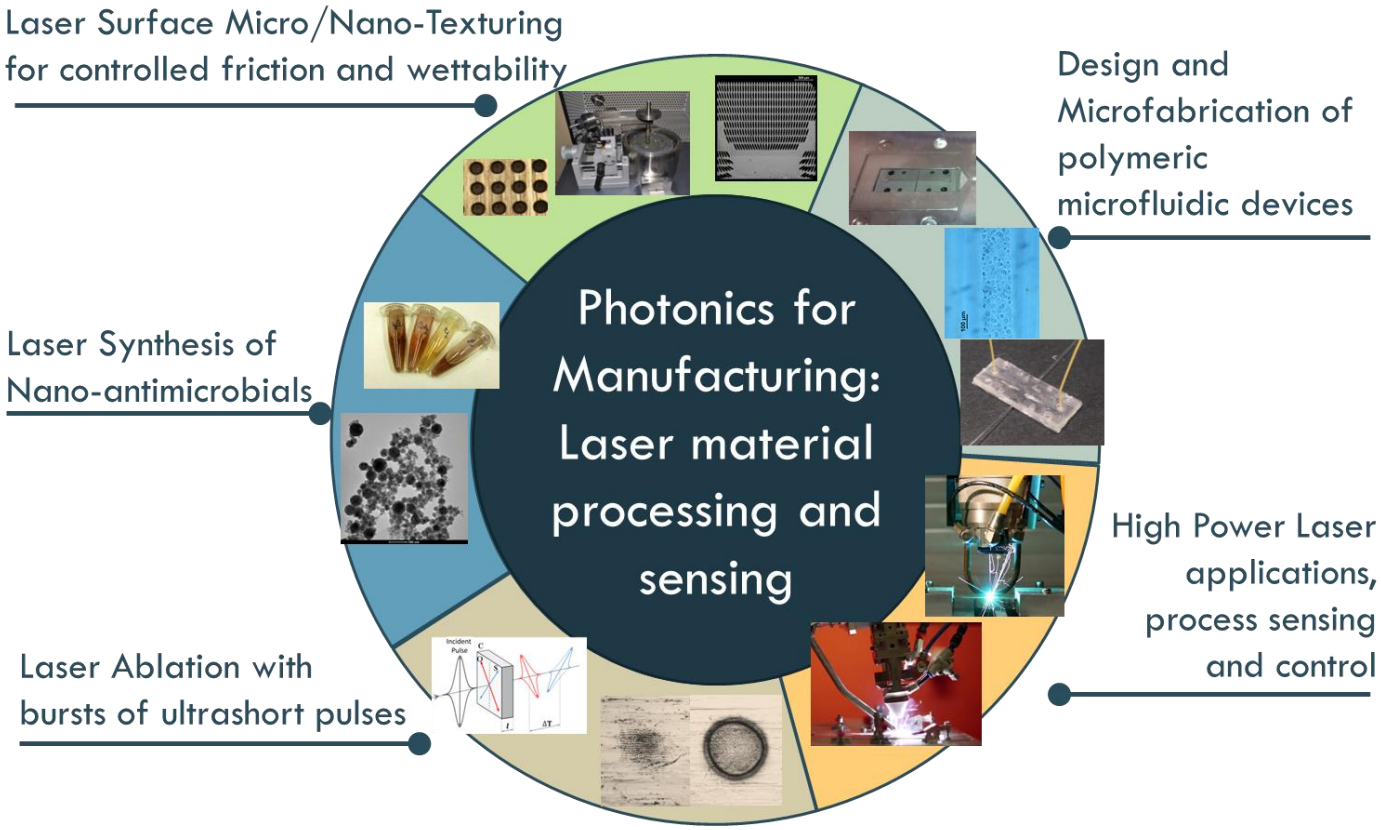
THORLABS
Development of photoacoustic sensors

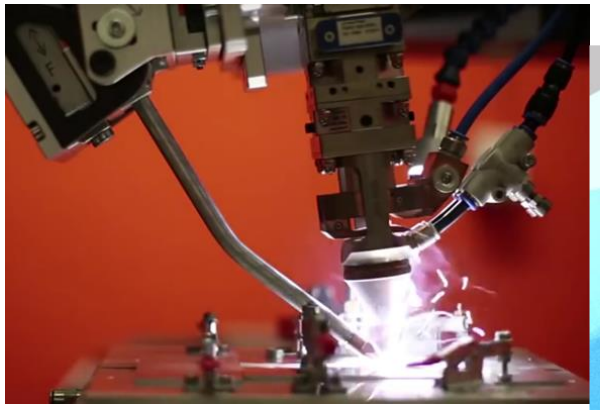
aramco
Hydrocarbon and isotopes detection

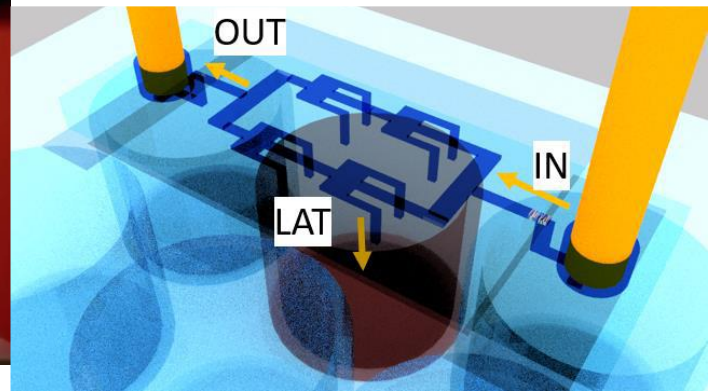
MASMEC
Leak detection in mechatronics components

LASER MICROMACHINING

(Ancona, Volpe, …)







Collaborations & Career opportunities

UNIVERSITY WEST

ALPhA NOV
Centre Technologique Optique et Lasers

IFN

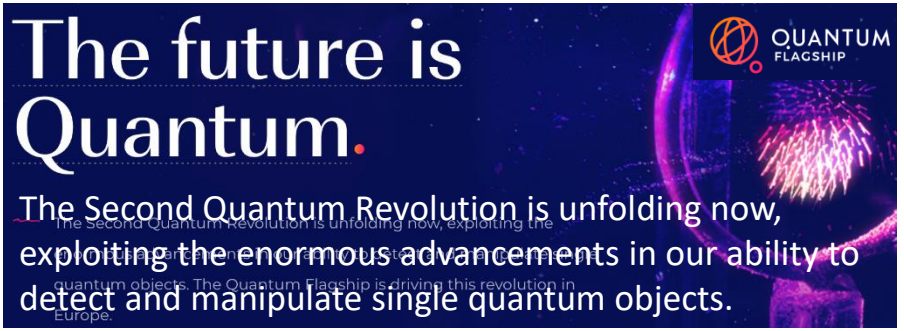
BOSCH

de remi facemmo ali
1990
POLITECNICO DI BARI

CRF
CENTRO RICERCHE FIAT

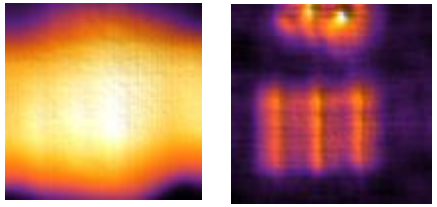
Fraunhofer

life.augmented

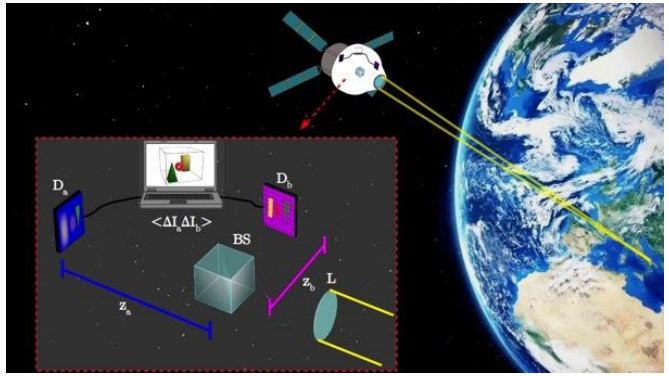


Quantum optical technologies 2.0

"Correlation plenoptic imaging": Refocusing & single-shot 3D imaging



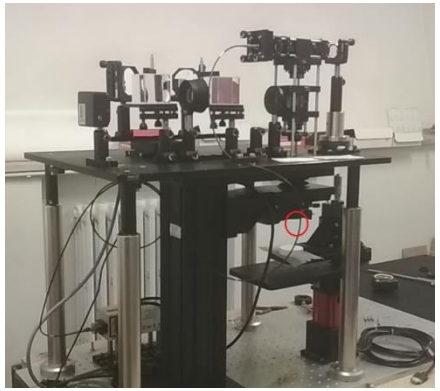
4 international patents



QUANTERA

INFN Istituto Nazionale di Fisica Nucleare

Regione Puglia



Potential applications:

- 3D microscopy
- Virtual & augmented reality
- Hyperspectral imaging
- Imaging of space
- Industrial inspection
- Earth observation
- Particle tracking
- 3D fluid dynamics

Referente:
Milena D'Angelo

Intellectual property award 2019

"The most promising italian patent in the field of life science"

Collaborations & Career opportunities

Echole Polytech. Federal de Lausanne, CH
Qu3D
Ultra-fast single-photon detectors

Planetek Hellas, GR
Qu3D
Ultra-fast electronics

University of Olomouc, CZ
Qu3D
Super-resolution & quantum tomography

Istituto Nazionale di Fisica Nucleare (TO)
PICS4ME
Biomedical quantum microscopy

Planetek Italia (BA)
PON Close
Imaging for earth observation

University of Maryland College Park, USA
Biomedical imaging

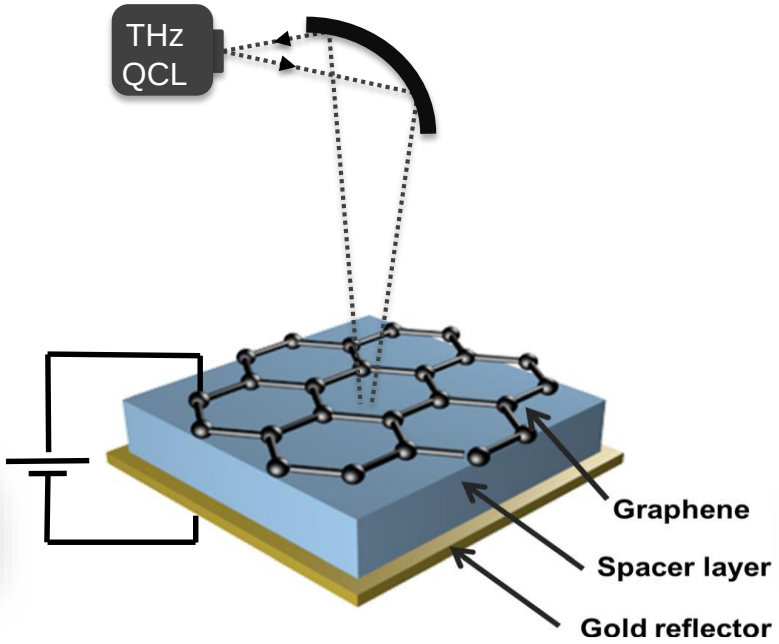
Istituto Nazionale di Ric. Metrologica (TO)
Sub-shot noise quantum imaging

University of Maryland Baltimore C., USA
Joint PhD program
Quantum imaging and interference

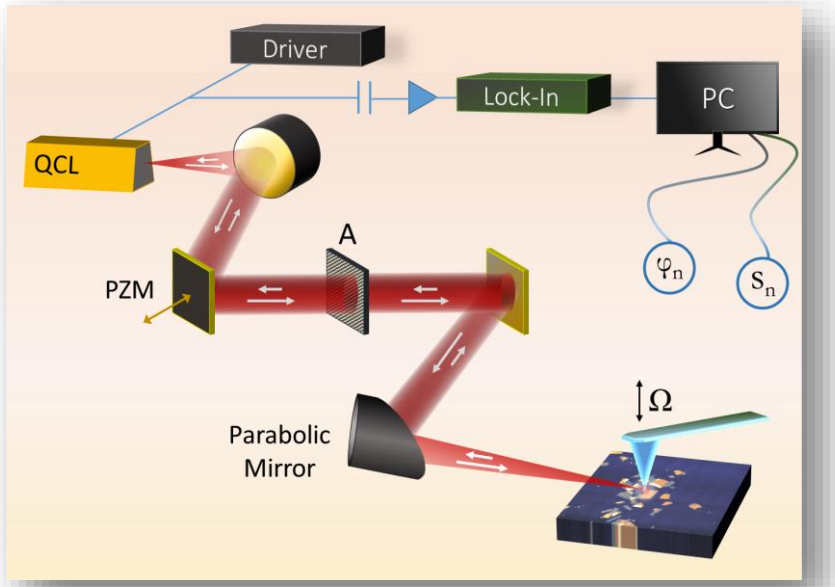
Leonardo, Sitael, German space agency, …

THz photonics

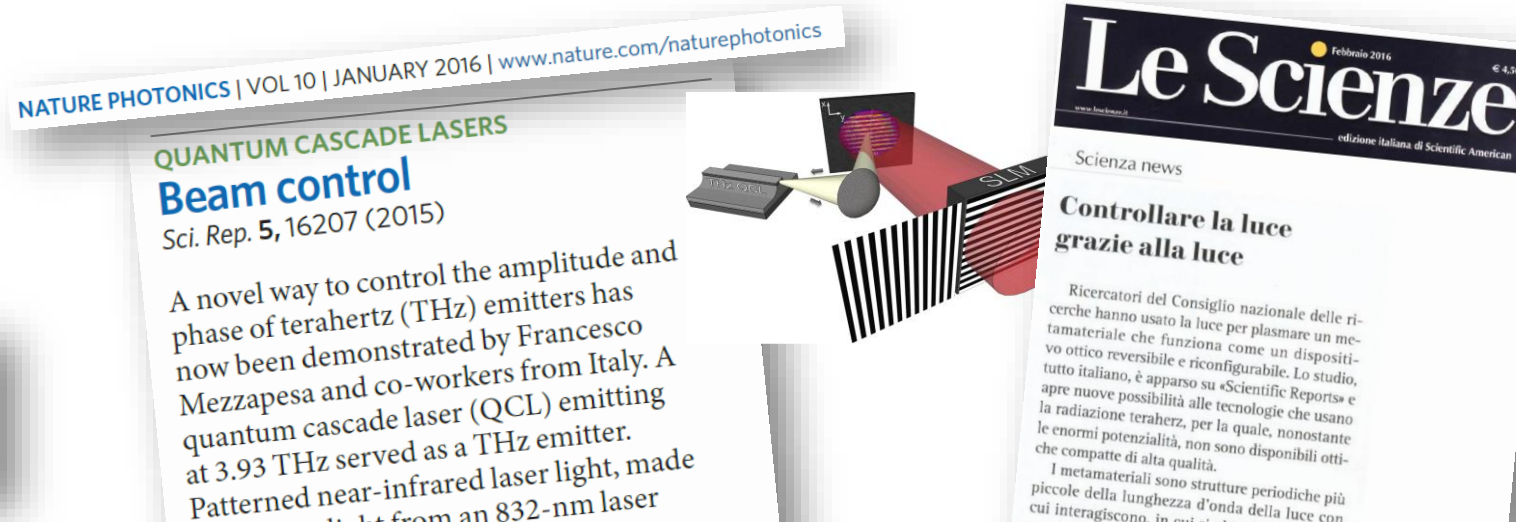
- H2020 European GRAPHENE FLAGSHIP – THz electro-optic modulators based on graphene and metamaterials (Scamarcio, …)
- THz Quantum Cascade Laser frequency combs



- Phase resolved near-field self-detected THz nano-imaging of 2D materials (Scamarcio, Brambilla, …)



- Photo-generated metamaterial modulators for CW THz QCLs (Scamarcio, Dabbicco, Brambilla, …)



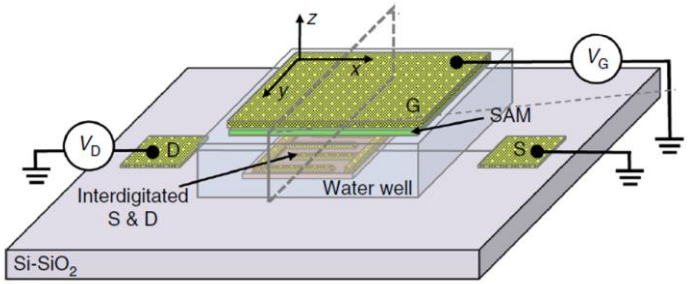
GRAPHENE FLAGSHIP

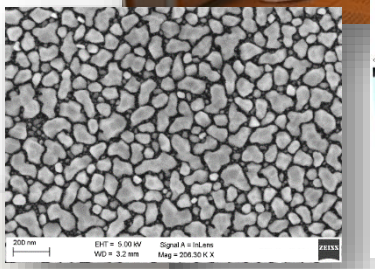
Single molecule transistor sensors

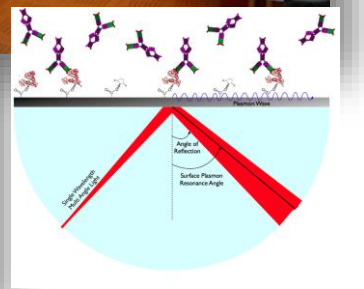
- Research and Innovation Action - H2020 - Single molecule bio-electronic smart system array for clinical testing (SiMBiT) (2018-2021, coord. UNIBA)
- PON projects (2018-2022, PI: G. Scamarcio)
- International patents (5)

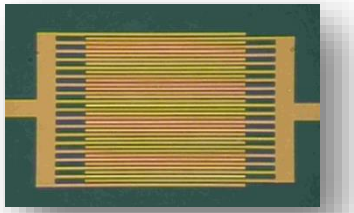
TECHNOLOGY · 16 AUGUST 2018

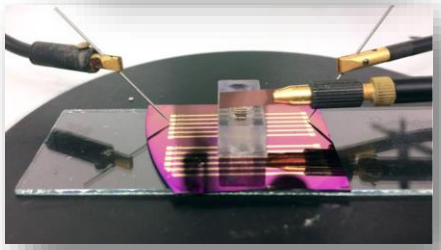
A sensor detects the light touch of a single molecule

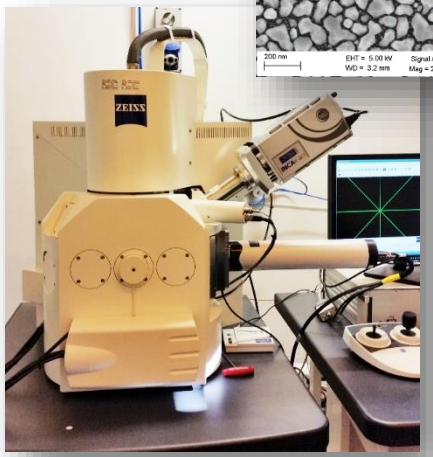












CSGI · HEINRICH HEINE UNIVERSITÄT DÜSSELDORF · Åbo Akademi · iit ISTITUTO ITALIANO DI TECHNOLOGIA · TU/e · FlexEnable Truly flexible electronics · MASMEC · efficient innovation

conclusion

- You can’t go wrong becoming a very strong scientist in condensed matter physics and photonics because you can work in many different fields
- Work hard and enjoy it!