

Centre for Advanced
Materials and Technologies
CEZAMAT

WARSAW UNIVERSITY OF TECHNOLOGY



**RESEARCH
UNIVERSITY**
EXCELLENCE INITIATIVE



CEZAMAT

Unique High-Tech Institution in R&D
Landscape in Poland

**Warsaw University
of Technology**



Brief analysis of the landscape

2

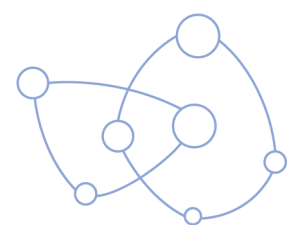
FACTS:

- Broken ICs supply chain affects enormously economics/industries
- Politically driven threat of supplies (also materials)
- Talent crisis (worldwide lack of experts)

CONSEQUENCES:

- Immediate problems' solution not possible!!!
- It will last for at least a few years (will it??)
- It will significantly change the strategy (investments, production, innovation, teaching, ... etc.)

Can we capitalize on that?!?



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Situation in Poland

3

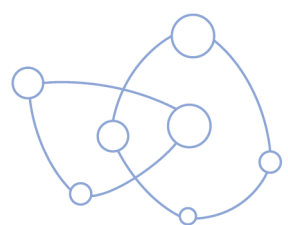
For historical and technical/economic reasons, the situation in microelectronics differs much from that in photonics:

- MICROELECTRONICS (science > innovations > ... **production missing!!!**)
- PHOTONICS (science > innovations > successful SMEs and MMEs)

MICROELECTRONICS & PHOTONICS have a significant common part in all areas:

- technology
- physics of devices (modeling and simulation)
- characterization/diagnostics methods
- design methods (ASICs and PICs)

This should be considered as an ADVANTAGE in teaching, training and gaining practical experience of new specialists!!!



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Attempts of revitalization of semiconductor industry (production) in Poland

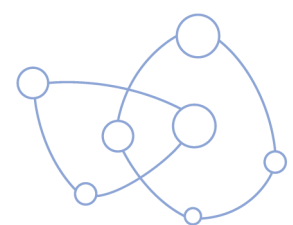
4

FACTS:

- Many attempts of finding appropriate sources of funds:
 - National Programme for Recovery (will it ever come, when??)
 - Different Ministries...
- On March 15th 2023 Minister of Education and Science – Prof. Czarnek, publicly announced significant funds (~ 1 Bln PLN) for enabling small-scale production of ICs based on CEZAMAT WUT infrastructure!!!

CONSEQUENCES:

- If this project is to take off, we need to implement in Poland „all hands on deck” approach!!
- Alliance for Revitalization of Semiconductor Industry?



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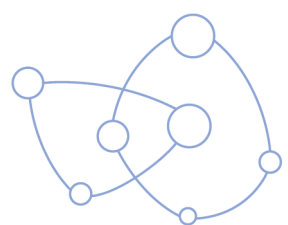
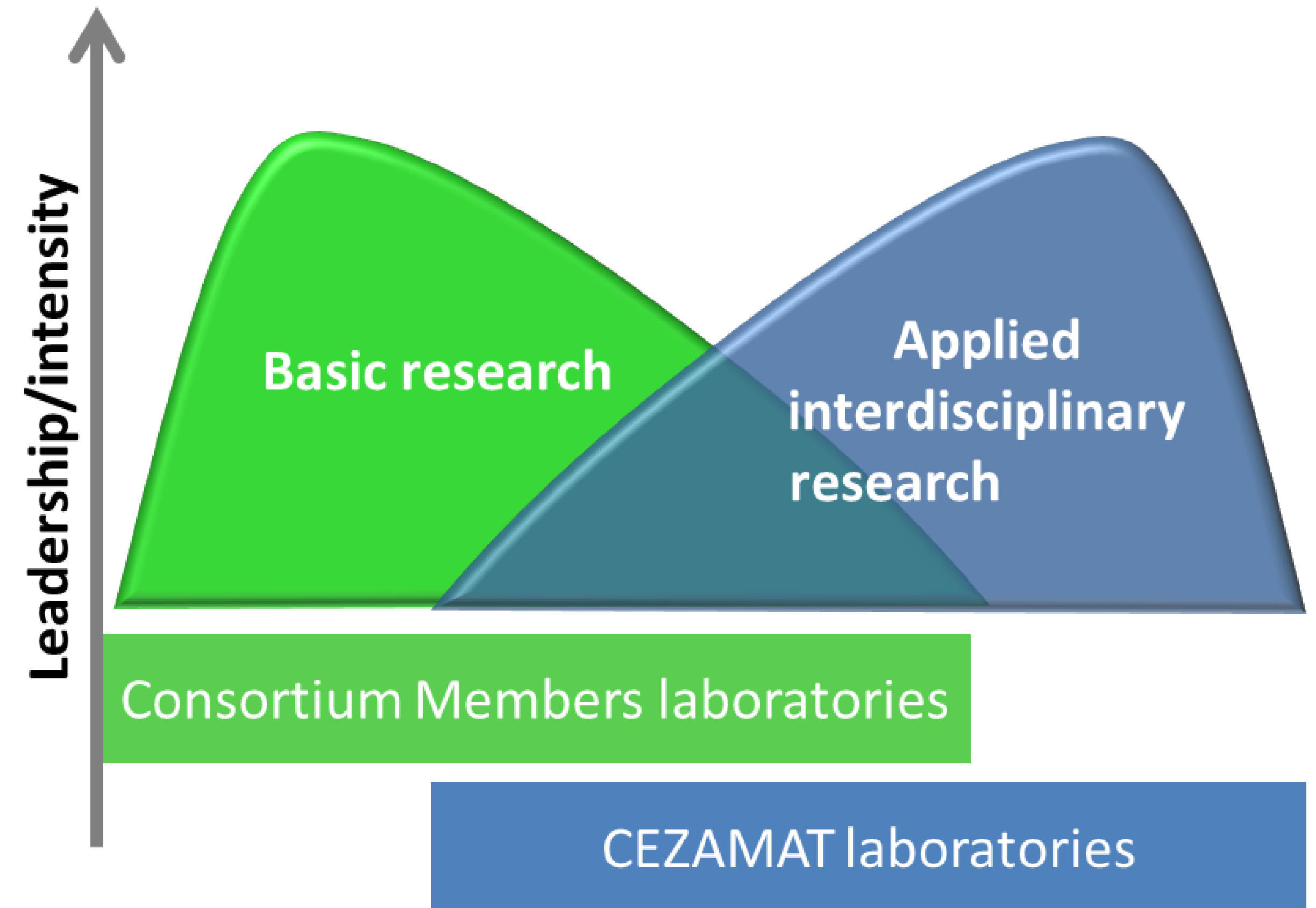
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WUT + ŁI M&P + WrUT?? + MAT?? + AGHU ??+ GUT???+...

Why not using Cluster of Microelectronics, Electronics and Photonics?

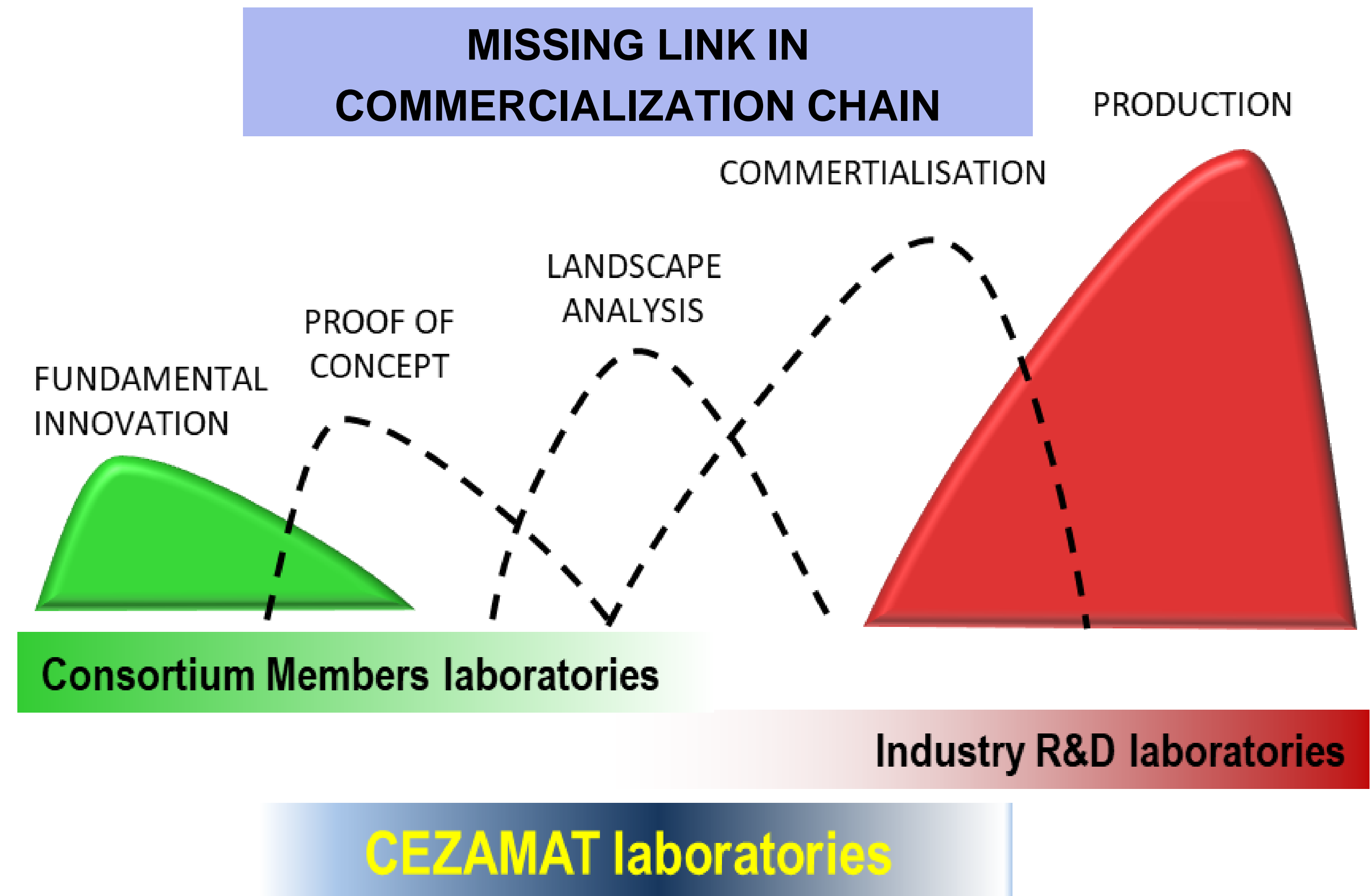
CEZAMAT main targets – interdisciplinary research and synergy

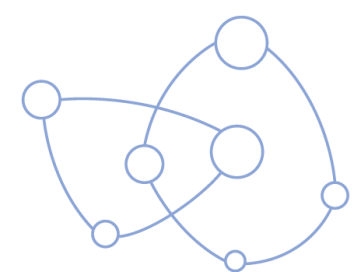
- Inspiration from existing Laboratories of Consortium Members
- **CEZAMAT supported by Consortium Members leads interdisciplinary applied research**



Position of CEZAMAT in scientific and economic ecosystems

Bridging basic research, application and commercialization:
converting fundamental science into products and technologies profitable for society!





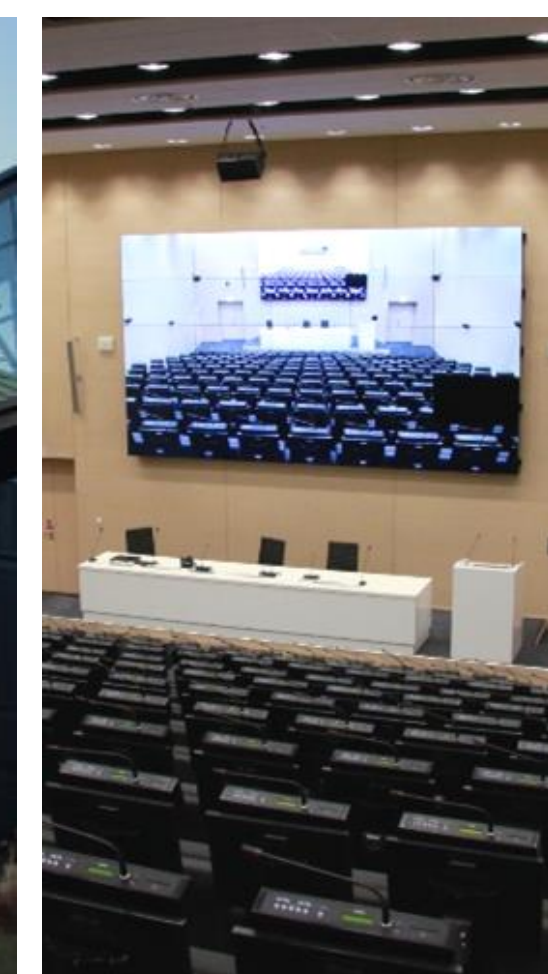
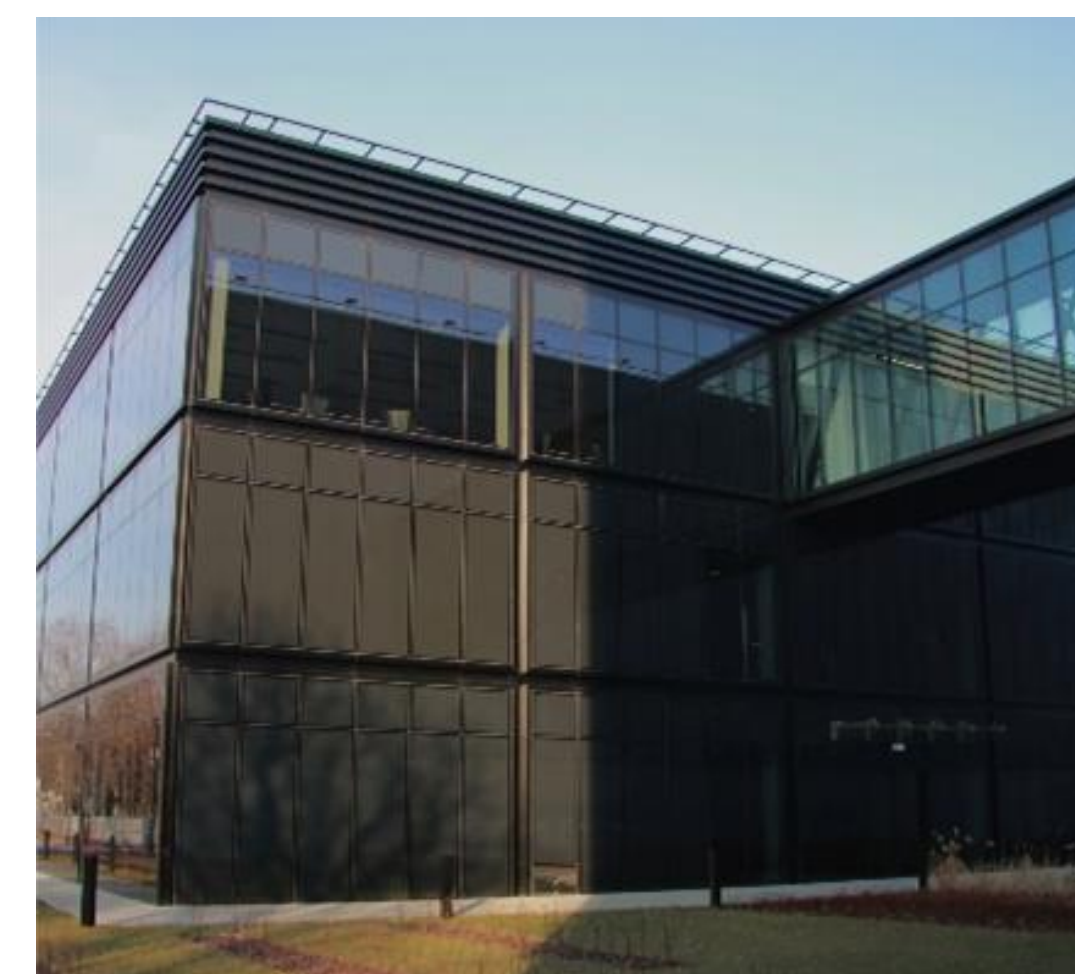
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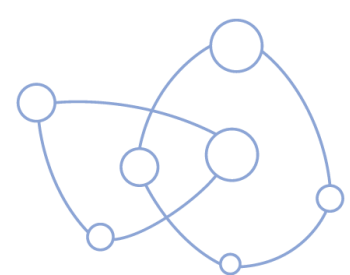
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| | |
|------------------------------------|-----------------------------------|
| Investment | > 100 mln EUR (in 2016) |
| Offices | 5.500 m² |
| Laboratories/infrastructure | 19.800 m² |
| Clean-rooms | 4.000 m² |
| Conference center | ~ 650 people |
| Personel (currently) | ~ 200 people (@hiring) |

Industry-matched fabrication lines:

- Si and alternative semiconductors (GaN/SiC) devices/ICs fabrication on up to 200mm substrates;
- stable, robust technology;
- ability to undertake tasks significant for global economics and safety.





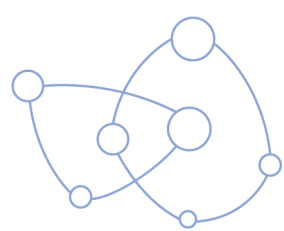
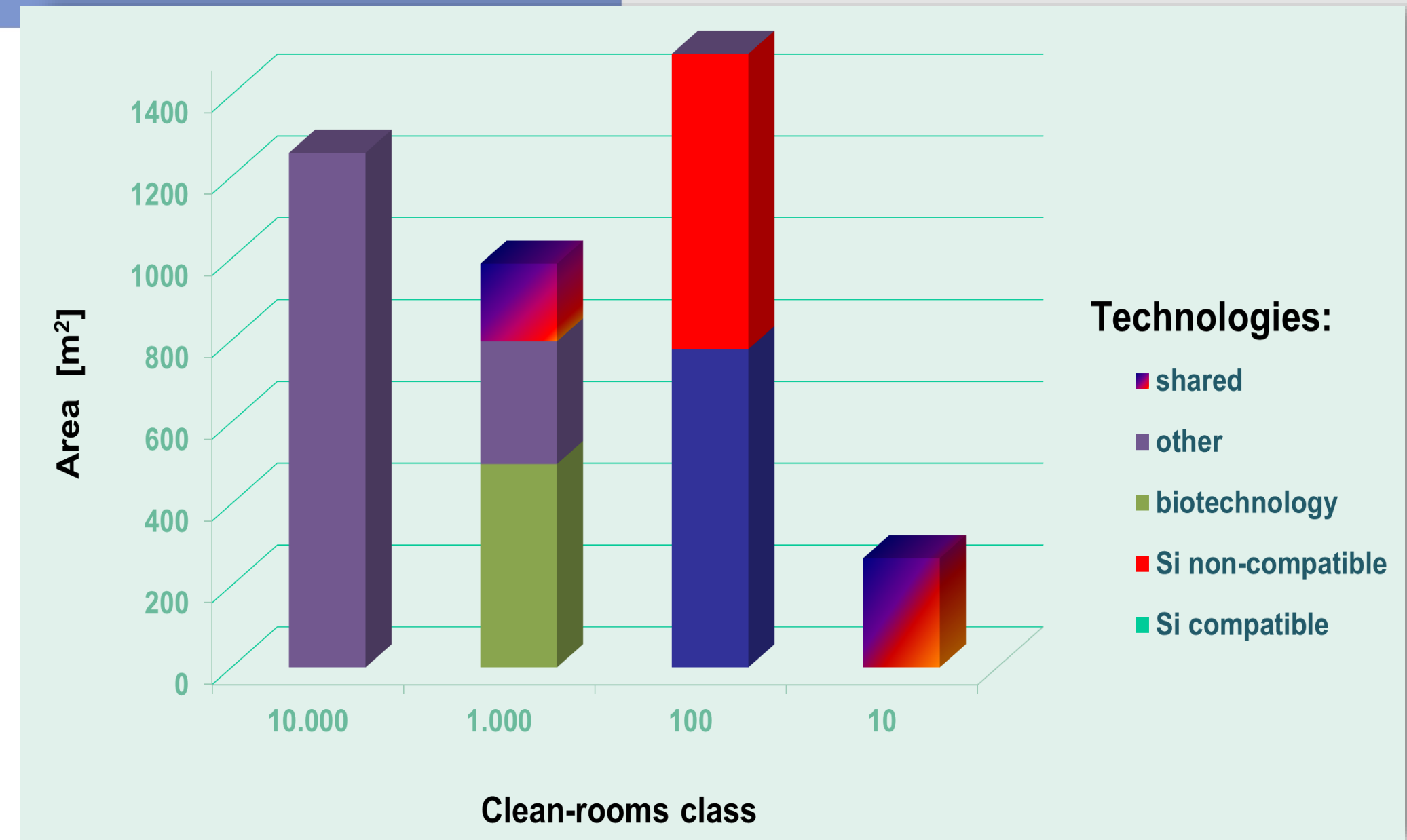
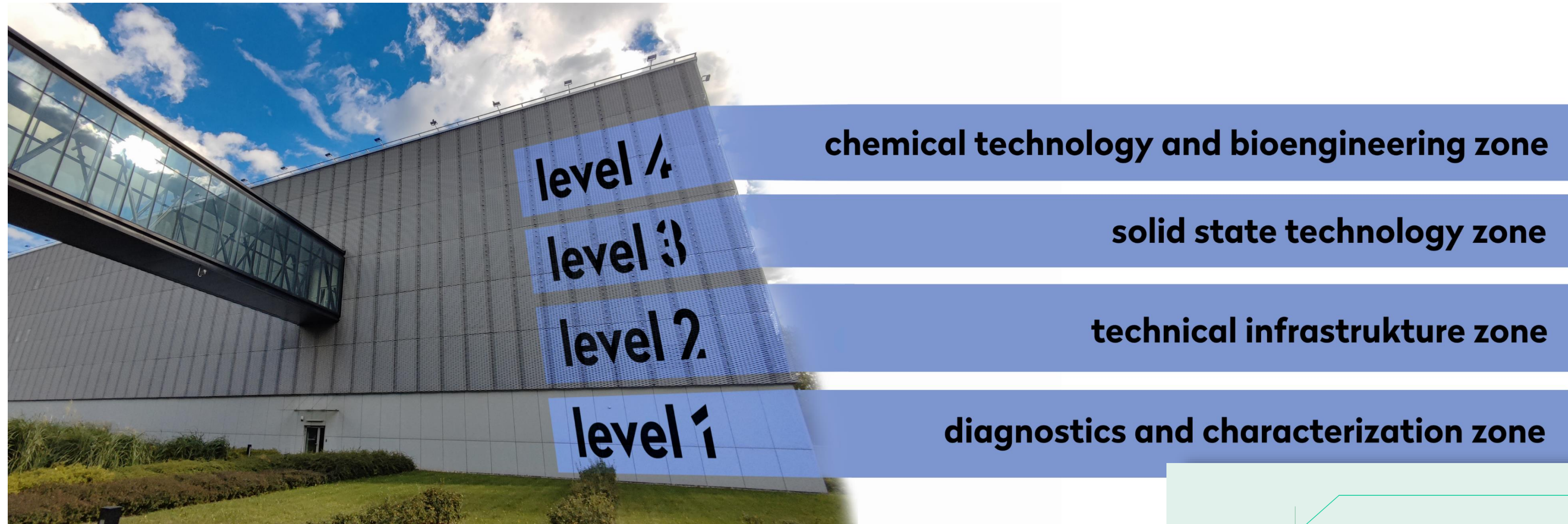
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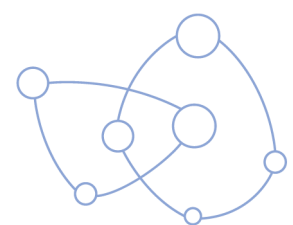
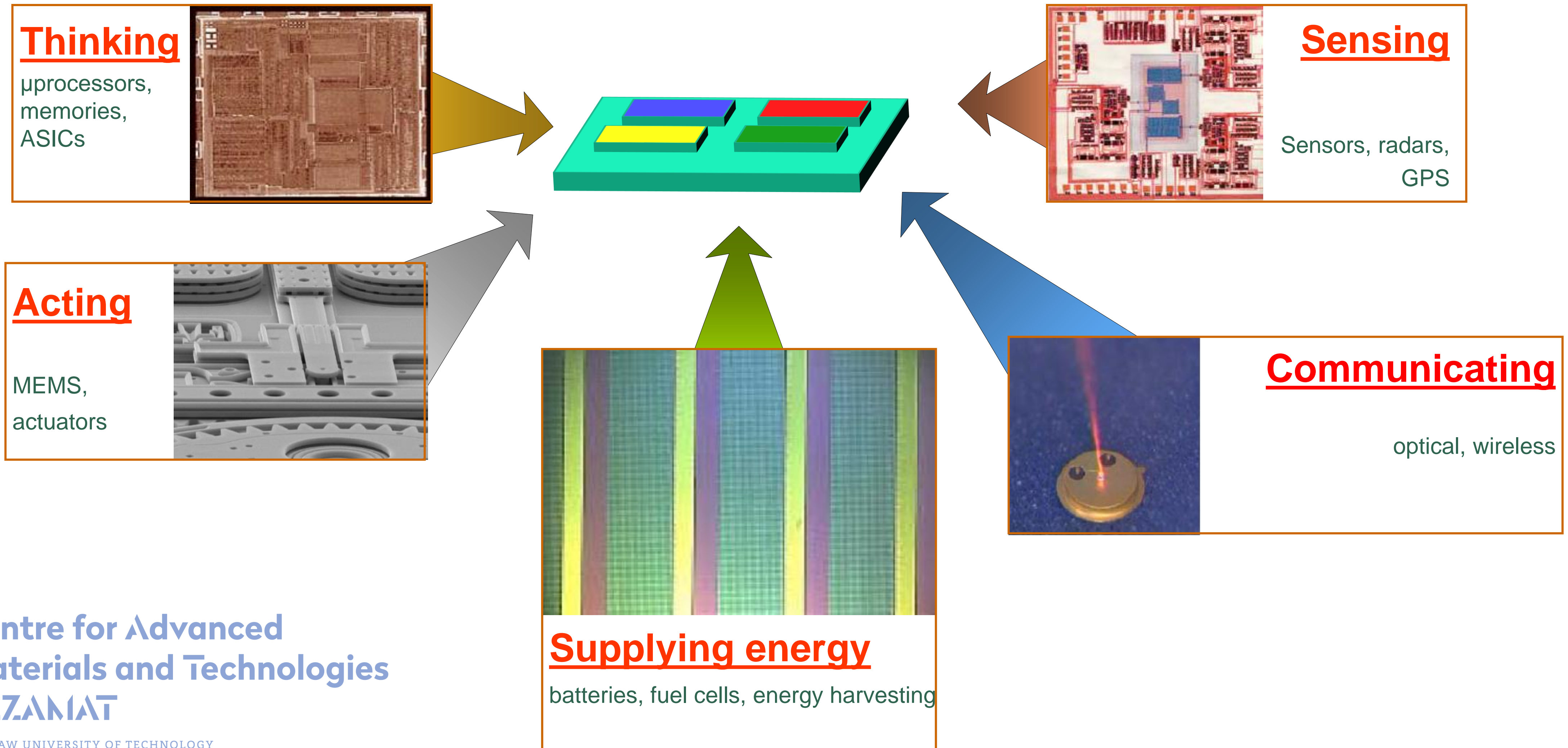
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CEZAMAT Infrastructure



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Multiple functions integrated in one MOEMS system (extreme case of „interdisciplinary product”)



Developing MOEMS (e.g. intelligent wireless monitoring network system) **requires**

11

✓ **KNOWLEDGE** e.g.: sensors, energy harvesting, ultra-low power electronics, communication, coding, big data analysis, ...:

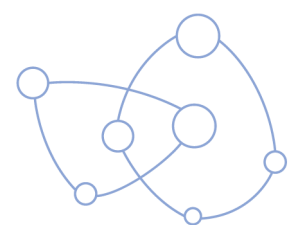
- Bio-chemistry
- Materials engineering
- Physics
- Electronics
- Photonics
- Mechatronics
- IT

↪ **We have most of this knowledge available among CEZAMAT Consortium Members!**

✓ **TECHNOLOGY**

↪ **State-of-the-art CEZAMAT Laboratories supported by laboratories of CEZAMAT Consortium**

Members fully satisfy this requirement!!



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SEMINSYS Experimental pilot line

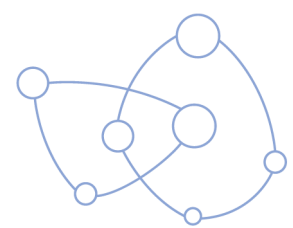
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Available equipment:

- Batch spray system for automatic cleaning of substrates and wet chemical etching of metal, dielectrics and semiconductors
- Layer deposition systems: PECVD, LPCVD, magnetron sputtering
- High-temperature furnaces (oxidation, annealing, diffusion)
- Rapid Thermal Processing (RTP) tool for ultrafast annealing, oxidation and nitridation
- Electron beam lithography tool
- Mask aligner for photolithography processes (i-line) with resist processing system
- ICP RIE plasma etching system
- Photomask cleaning device
- Ion implanter
- Characterization - optical and electron microscopes, ellipsometer

Compatibility with 2", 4", 6" and 8" wafers.

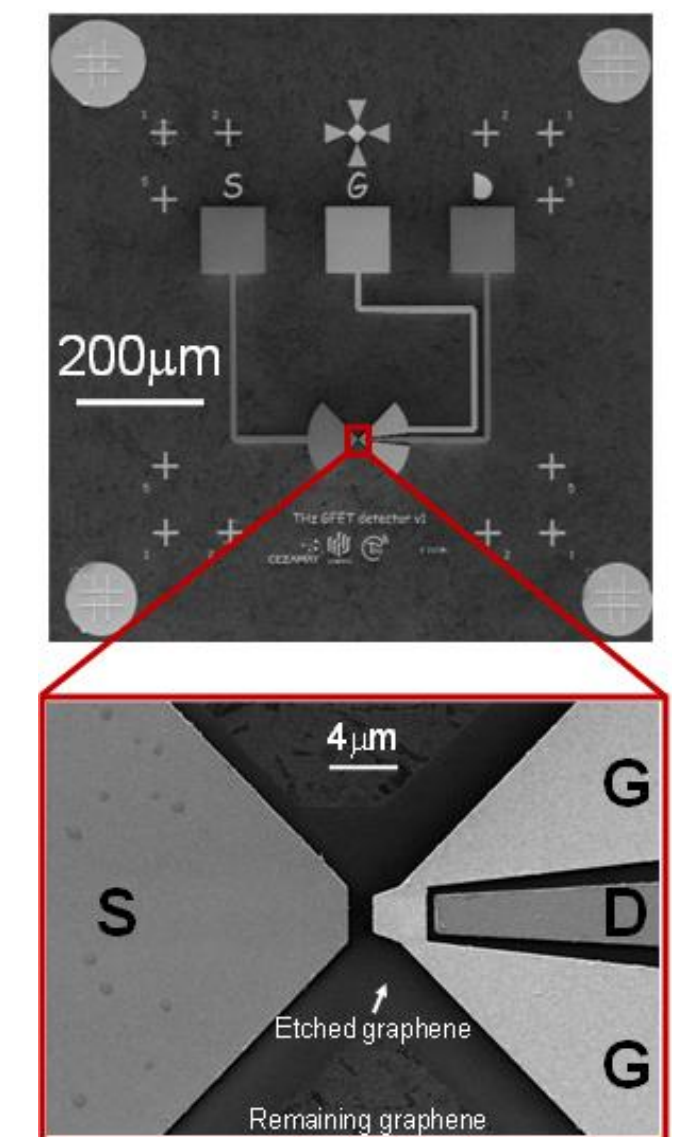
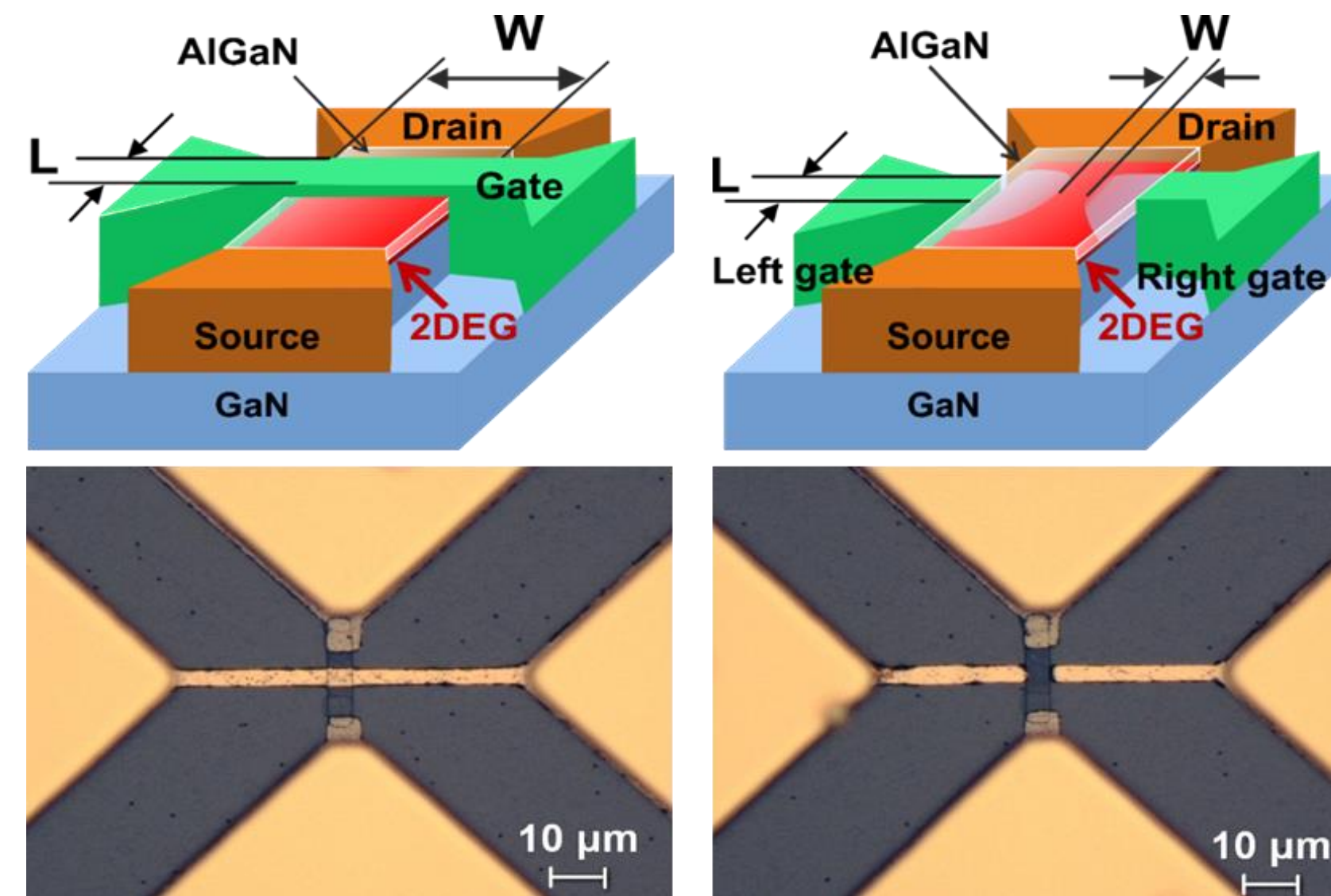
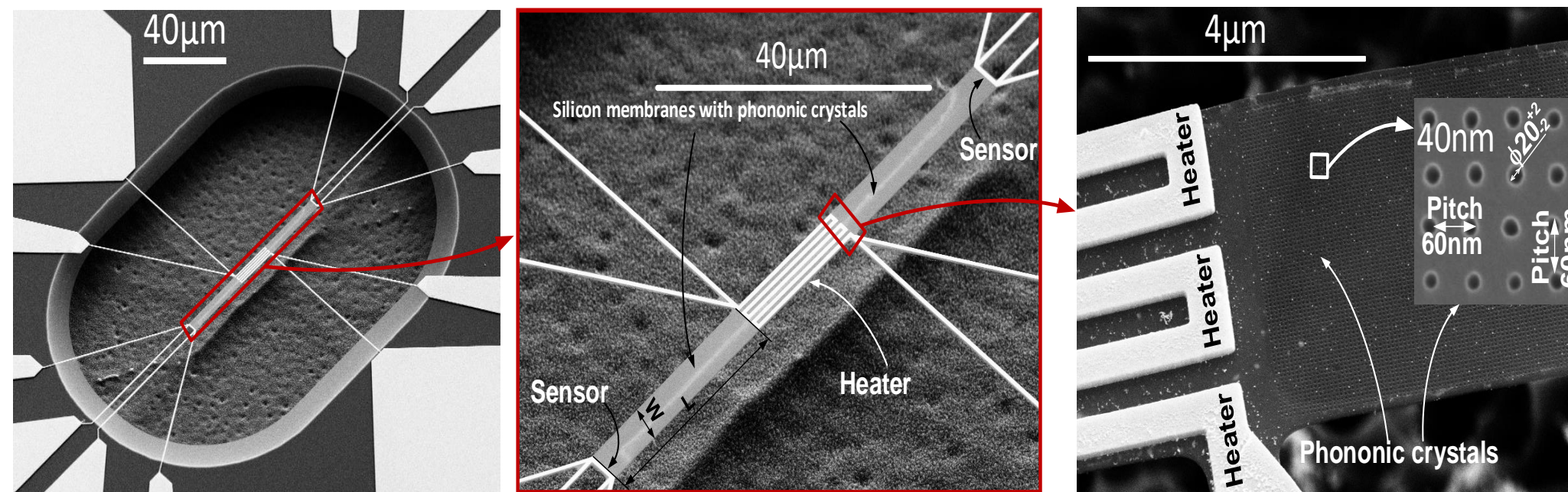
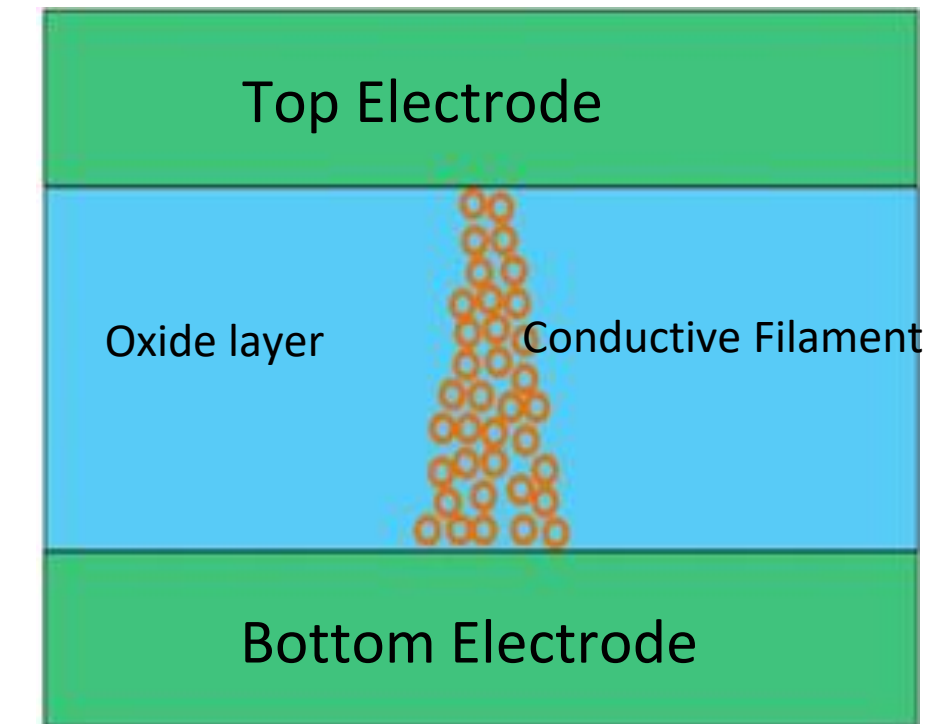
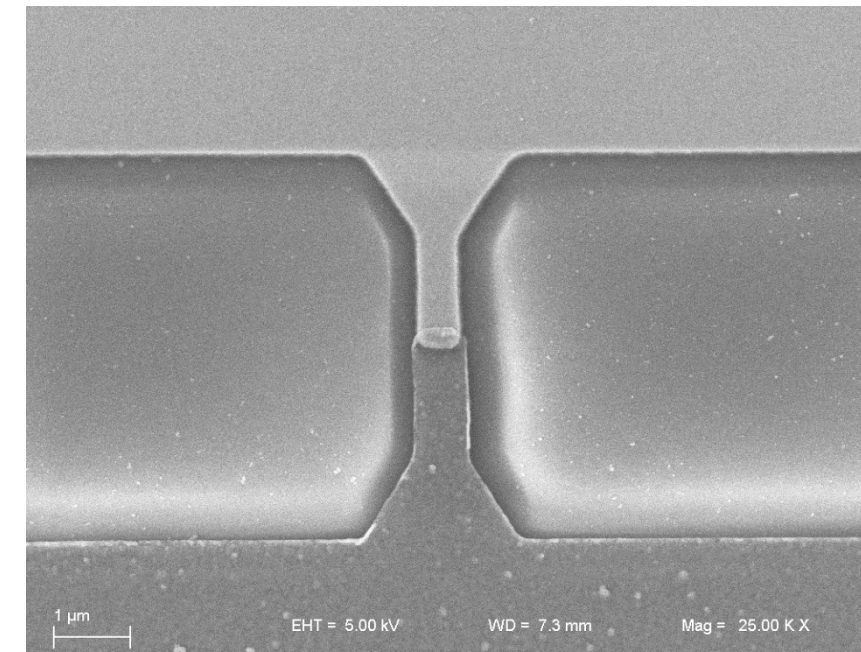


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Semiconductor devices

- Physics-based numerical & compact modeling
- Fabrication of devices based on Si, GaN, 2D materials – THz detectors, RRAM, MIM diodes
- Energy harvesting - Si-based thermoelectricity

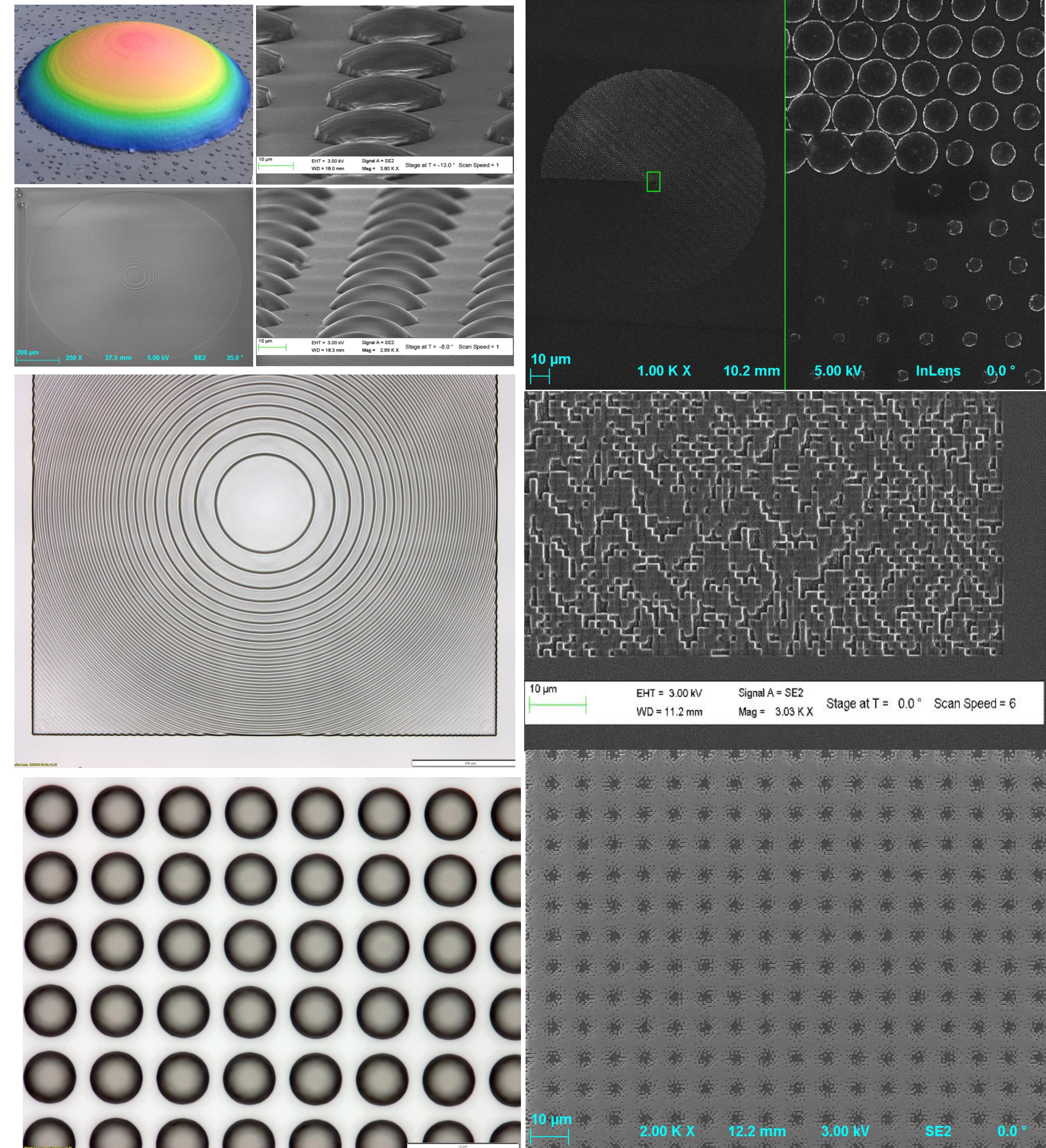
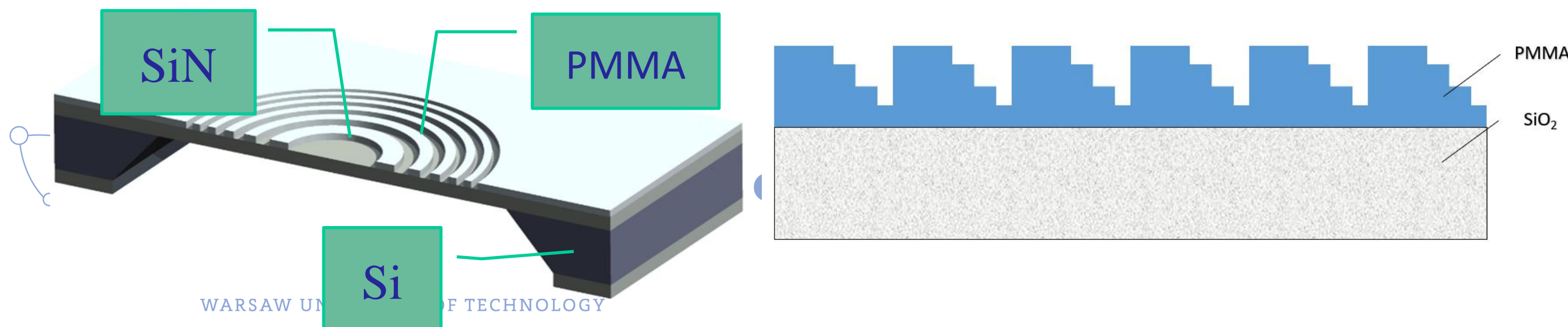
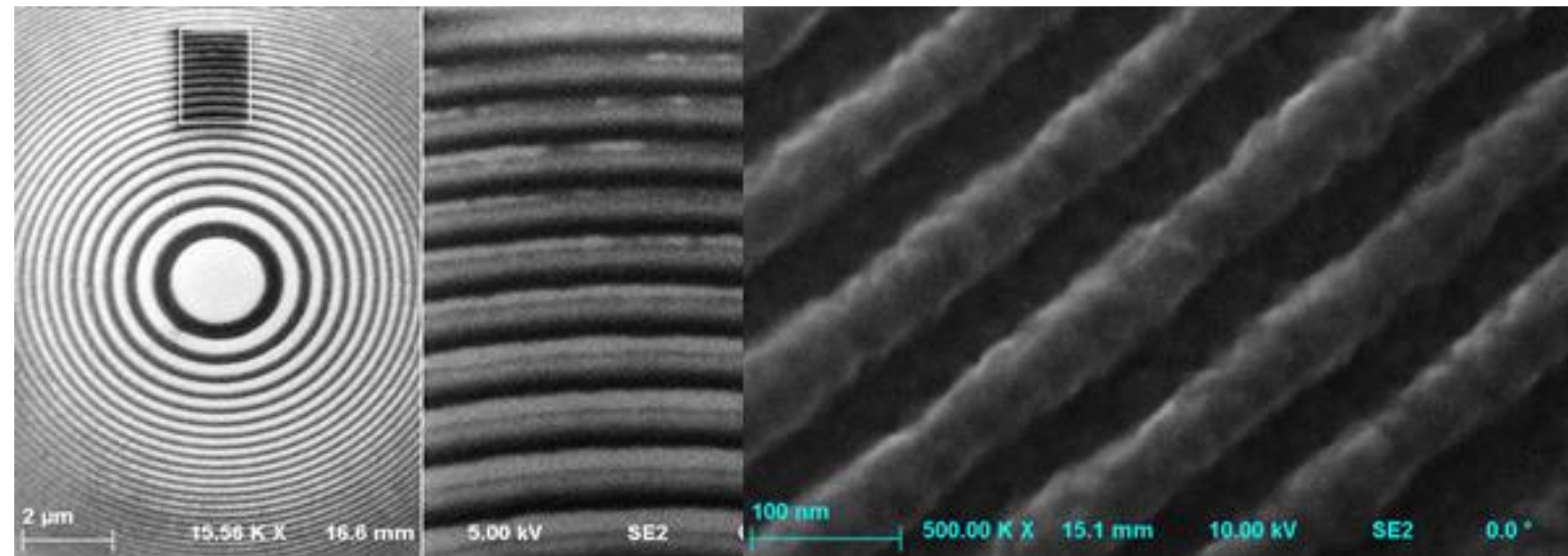


Integrated optics

Design and fabrication of optical components with ultra-high precision and resolution (e-beam litho):

- classic and Fresnel lenses,
- microlenses,
- holograms
- diffraction gratings.

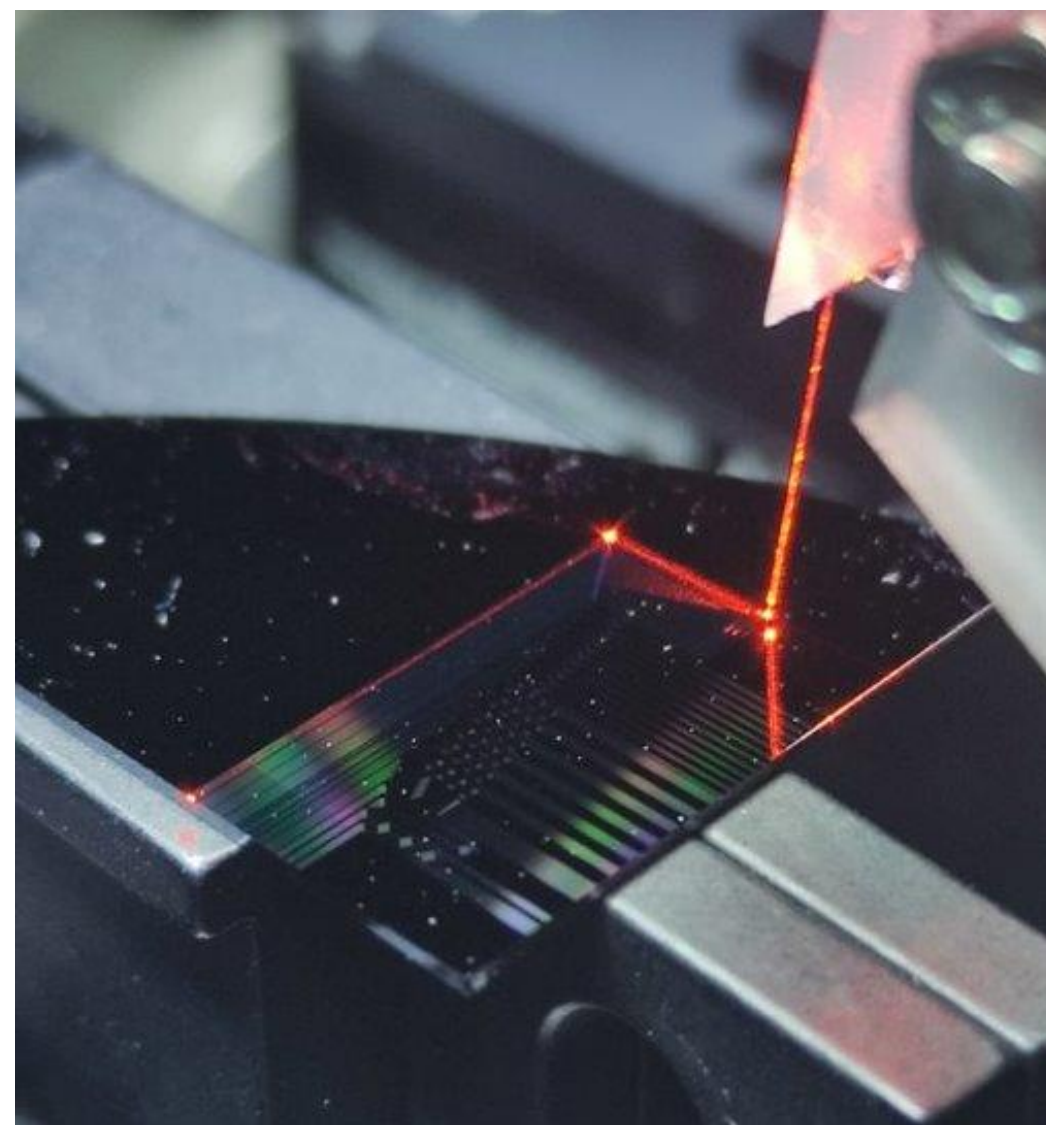
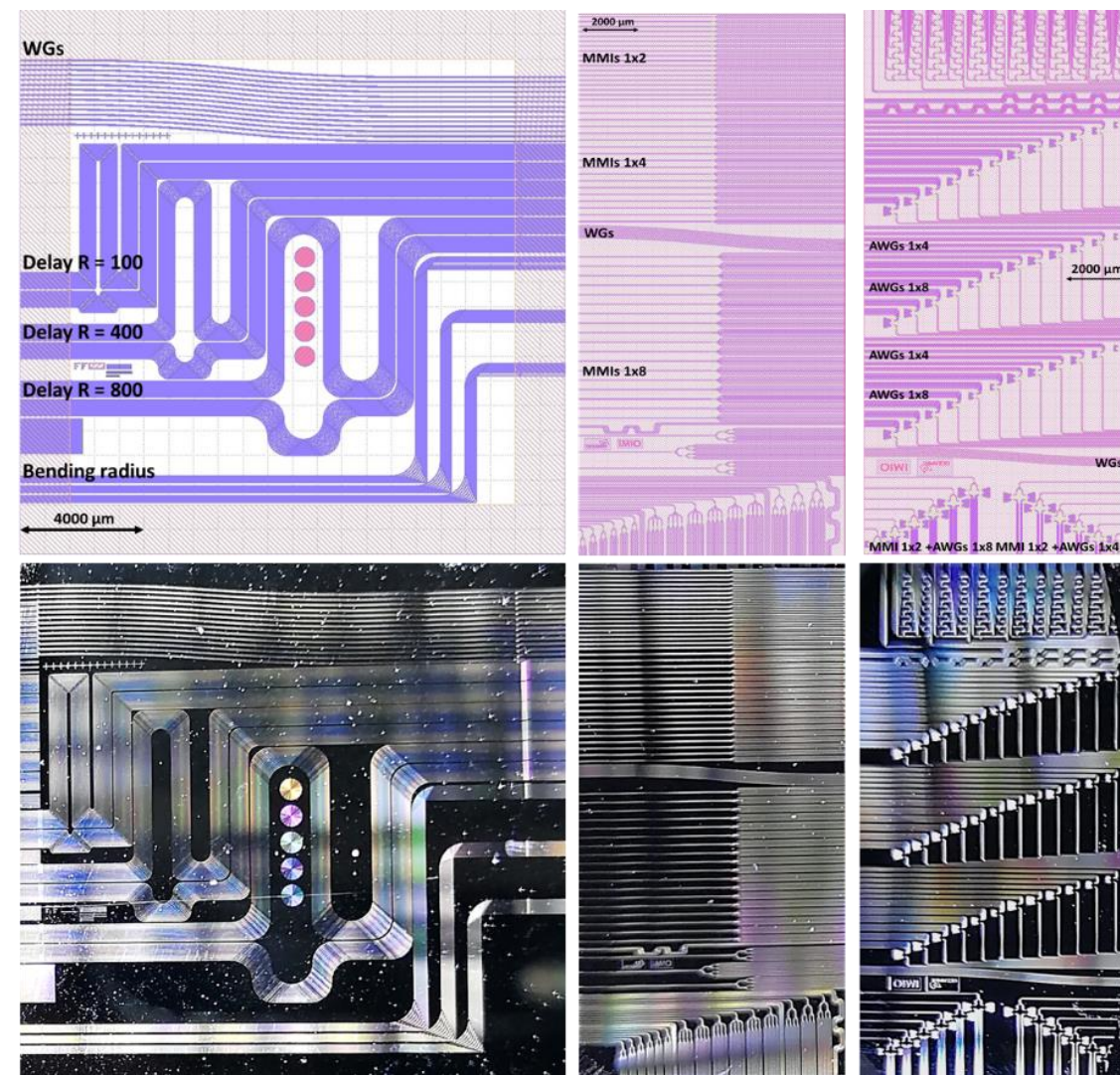
Spectral range from infrared to far ultraviolet.



Photonic Integrated Circuits (PICs)

CEZAMAT PIC platforms:

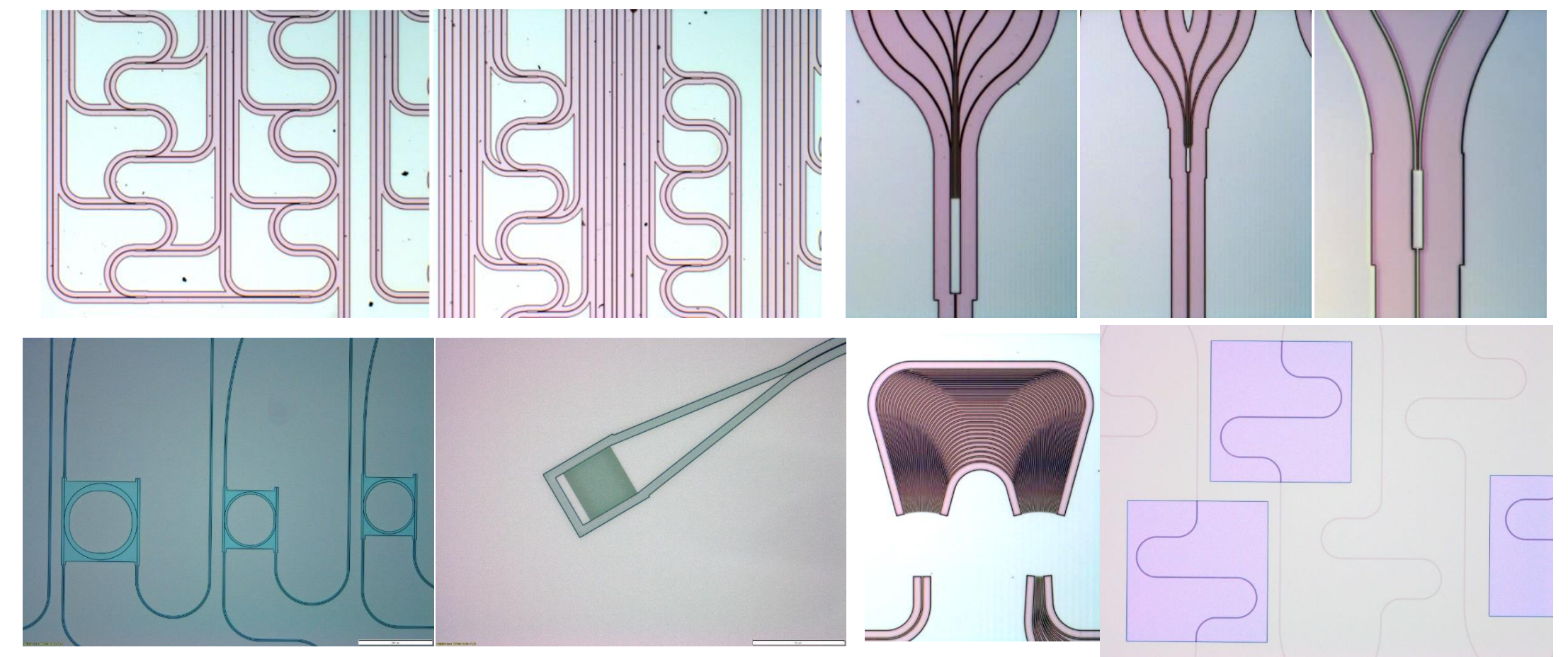
- SiN for visible wavelength range
- Si-on-Insulator, Ge-on-Si for the mid-infrared range (3-5.5 μm) - under development



Applications:

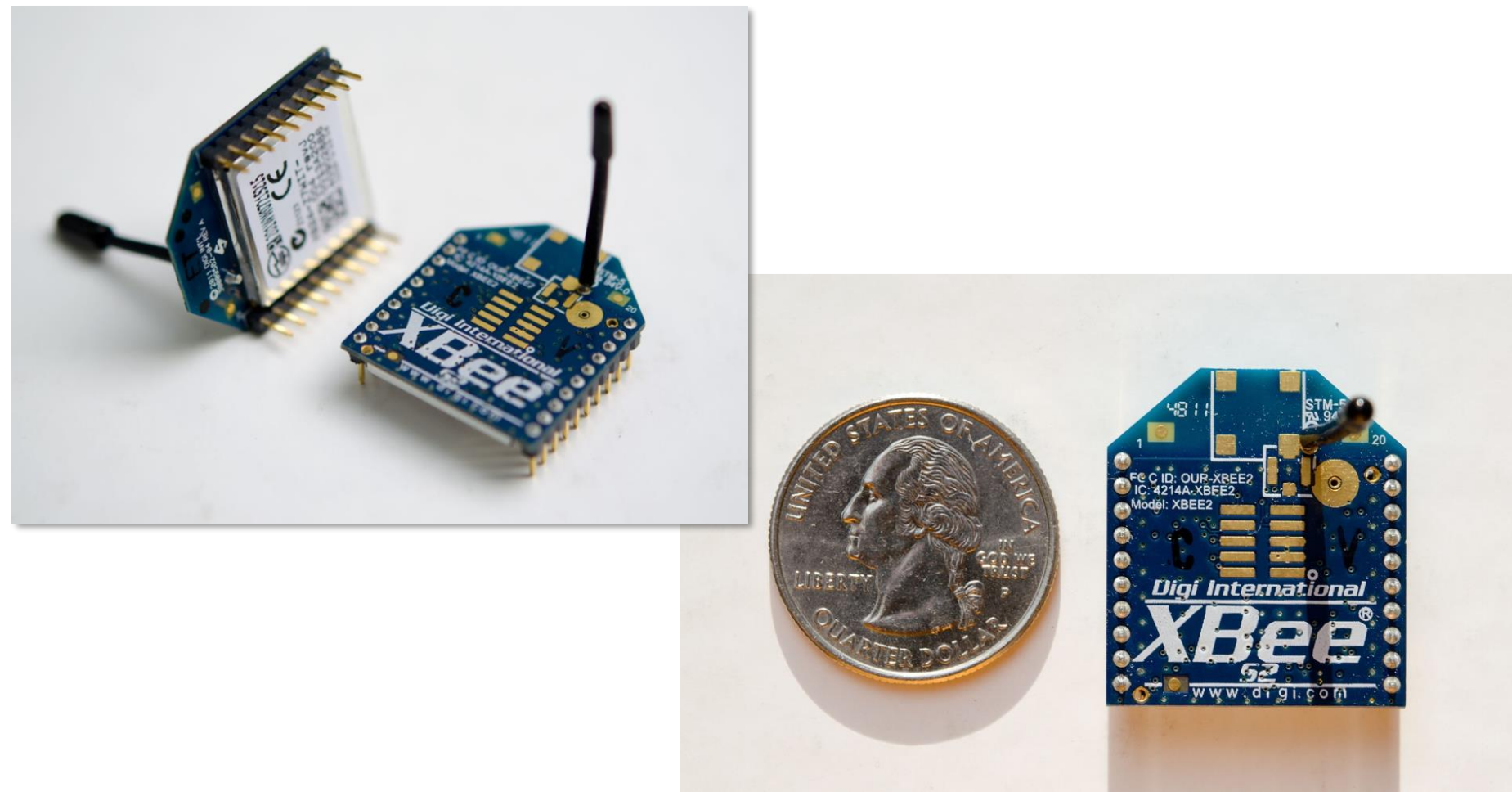
- Tele(data)com - e.g. quantum cryptography
- Biomedical (VIS) - biophotonics, biosensors
- Environmental sensors (MIR) - contamination detection
- Space and military - radiation resistance
- Computing (optical, quantum, ...)

Library of SiN PIC elements: waveguides, multi-mode interferometers, arrayed waveguide gratings, ring resonators, grating couplers, Mach-Zehnder interferometers



Internet of Things systems (IoT)

16



Wireless, selfconfiguring, selfpowering (by means of *Energy Harvesting*) network of sensors:

- Compatible with IEEE 802.15.4,
- *Energy Harvesting* allows 20 years of continuous use with no need for servicing,
- Using safe transfer layers IPv6 and TLS,
- Network nodes can be equipped with any required set of sensors, communication systems and mounted in different packages.

APPLICATIONS in control and monitoring:

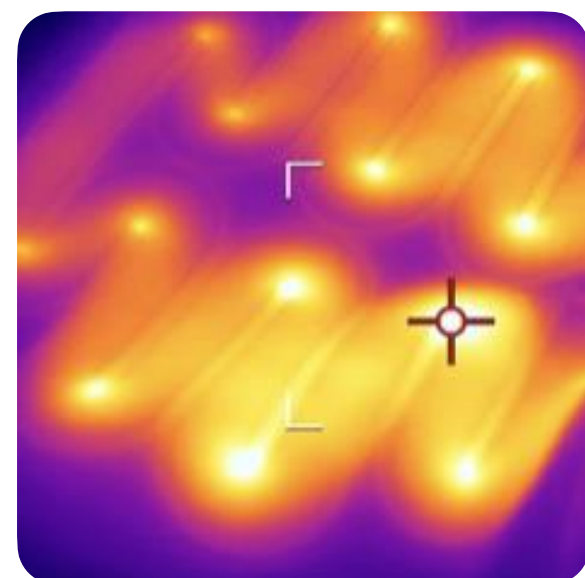
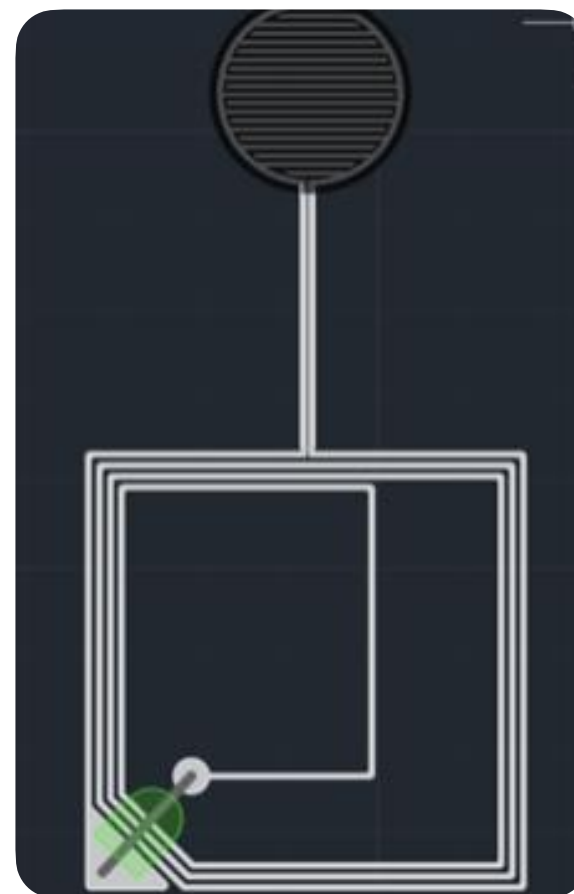
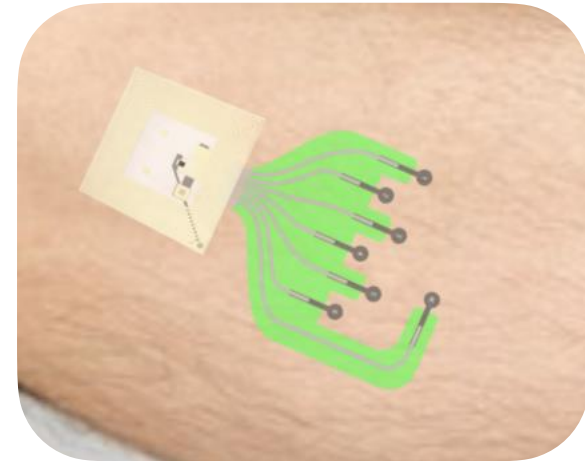
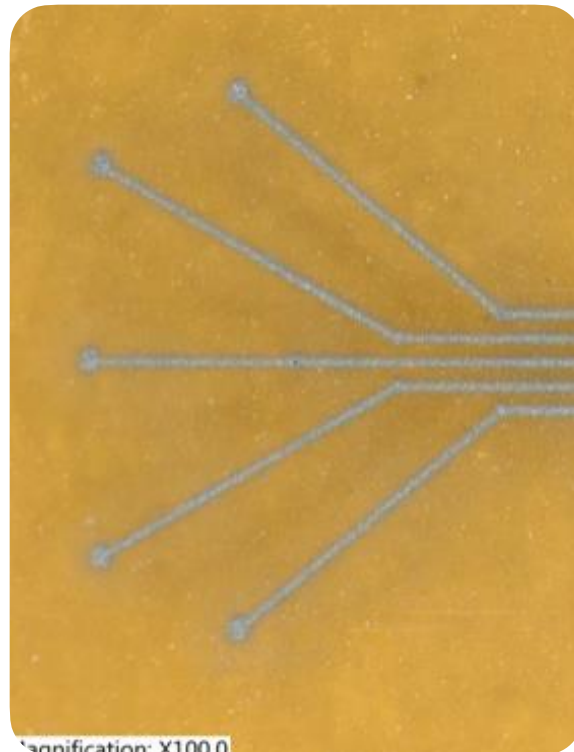
- Equipment and tools on production lines in industries
- transmission and technological lines (e.g. gas pipes, refinery infrastructures, chemical installations, ...),
- buildings (industrial and public)
- infrastructure (industrial, roads, hydroengineering),
- Food and animal farming,
- Employees working in high risk conditions.



Printed (flexible) electronics



Department of Printed Electronics
Textronics and Assembly



ECG and MRI electrodes

Telemedicine sensors

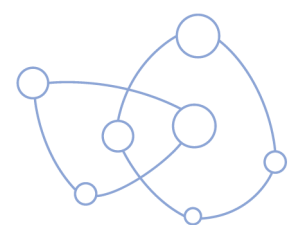
Textronic textiles

Insoles for gait monitoring

Electrochemical sensors

Pressure sensors

Electronic tattoos (patches)



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International Cooperation On Semiconductors – EC Horizon Europe

18

- **Semiconductors & Semiconductor-based photonics** are pivotal technologies for almost all existing industrial sectors, as demonstrated by the recent chips shortages.
- In particular, semiconductors are essential enablers for **digital and green transitions** and for SDGs.

ICOS is an ambitious 3 years project in the framework of the EU Chips Act, funded by the EC Horizon Europe.

Coordinator



Technical co-Coordinator



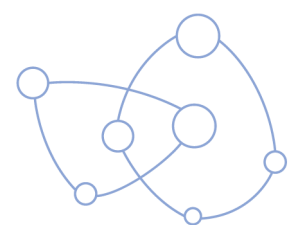
PARTNERS

| ACADEMICS | RTOS | INDUSTRIAL ADVISORY BOARD |
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| ASSOCIATIONS & CONSULTING COMPANIES | INDUSTRIALS | INTERNATIONAL ADVISORY BOARD |
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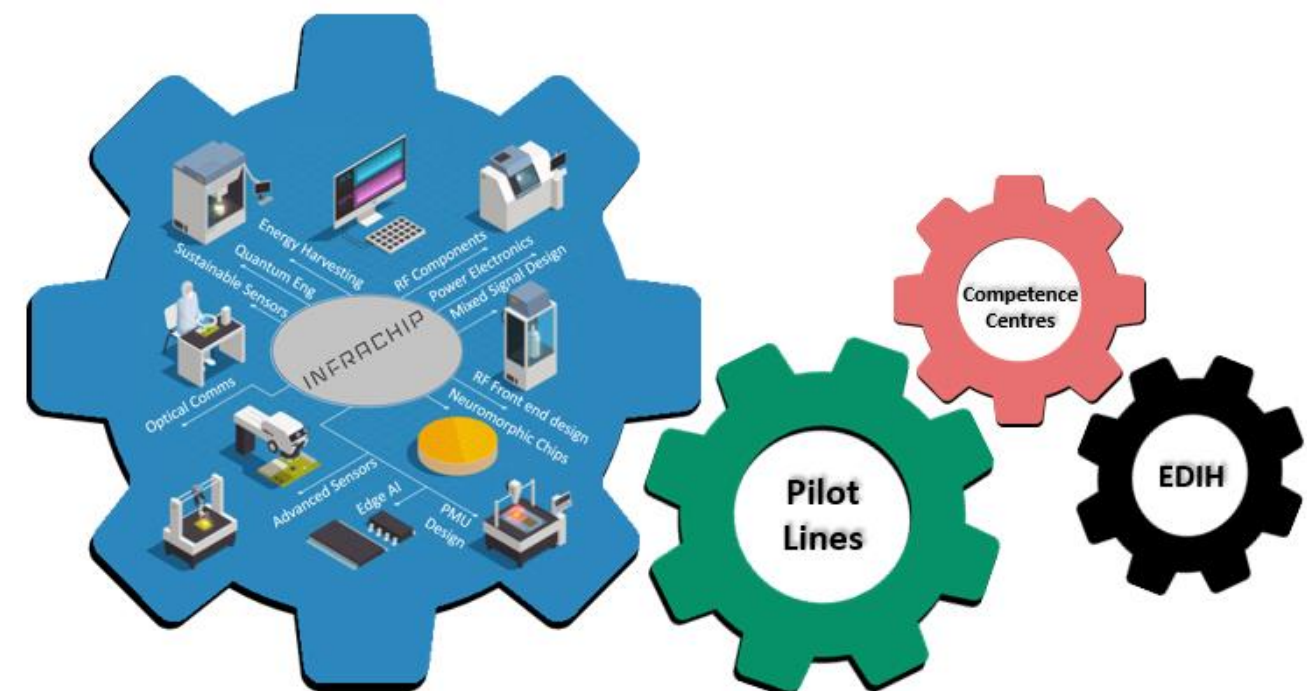
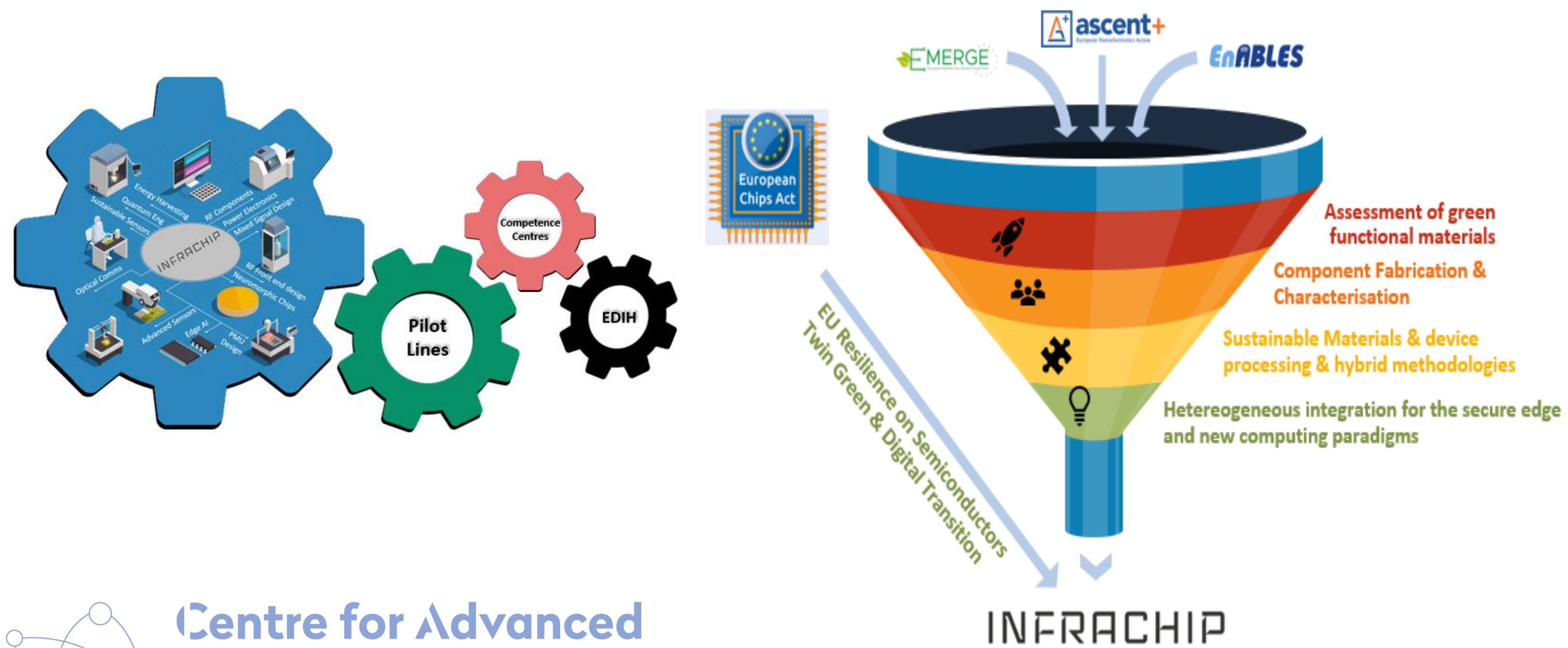
ICOS OVERVIEW

3



European Research Infrastructure on Semiconductor Chips - INFRACHIP

InfraChip will bring together an approximately €4Bn investment in infrastructure and technology blocks that is not available elsewhere as a whole. It is the InfraChip goal to shorten the translation path from the lab to the fab by enabling researchers to unlock the research and innovation capacity for next-generation and future greener semiconductor chips

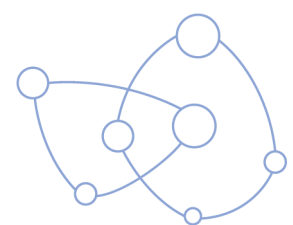


Cluster of Microelectronics, Electronics and Photonics

21

Launched on April 4th 2023.

- Polish Technological Platform on Photonics (PPTF) is the Coordinator of the Cluster.
- CEZAMAT is a Leader of its research collaboration.



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CEZAMAT – WUT in respect to semiconductor experts world crisis – MOEMS Academia

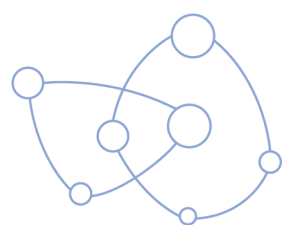
22

❖ 2 levels unique hands-on-experience courses for WUT students.

First edition –

October 2022-June 2023 (open primarily for studying at Faculties of: Electronics & Information Technologies, Physics, Material Engineering, Mechatronics, Chemistry, Electrical Engineering).

- **Level 1** – **common part of knowledge** for people intending to specialize in: technology, characterization/diagnostics, ASIC design or modeling/simulation.
- **Level 2** – **specialized courses** for:
 - advanced technology,
 - characterization-diagnostics/modeling.
 - ASIC design is very well covered at Faculty of Electronics & Information Technologies by regular courses.



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We are open for collaboration with industries and R&D institutions!!

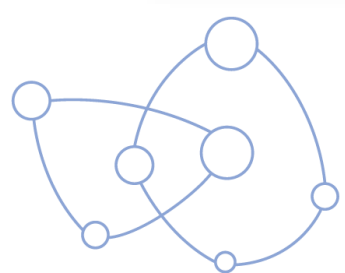


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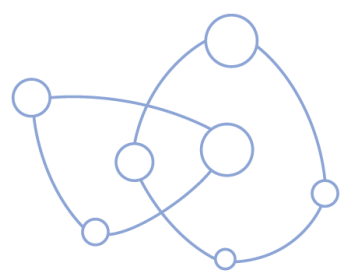


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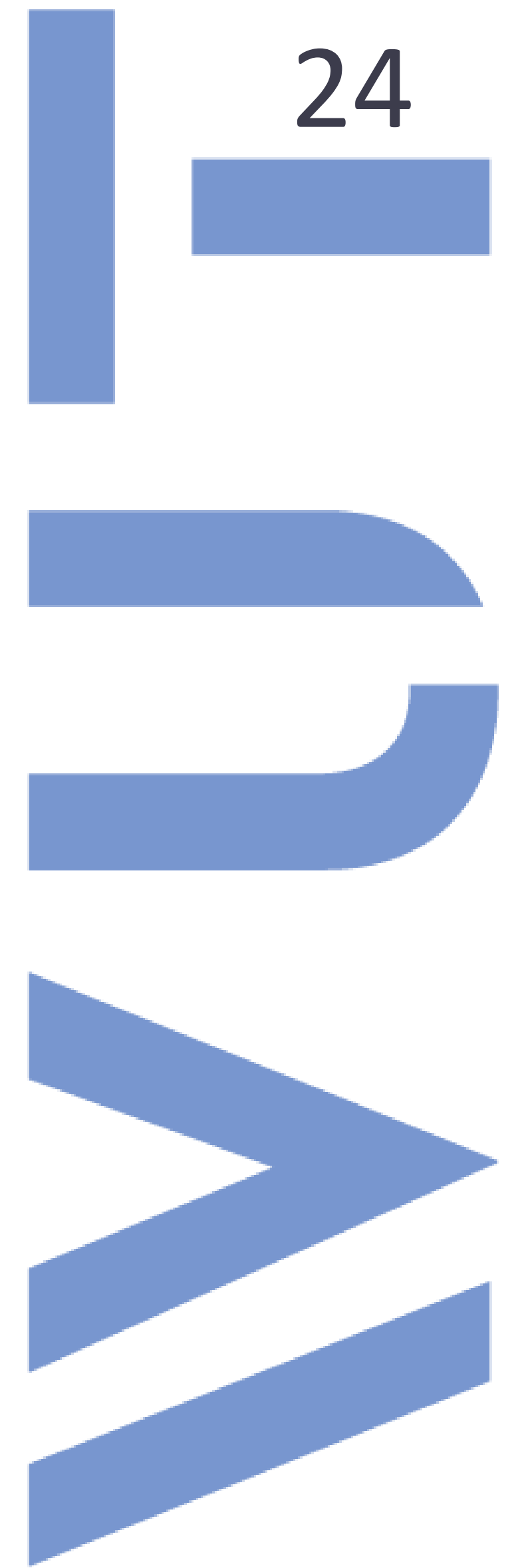
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Ultimate use of CEZAMAT potential

45

- **Bio-med-chem labs** (+4) are particularly suited for R&D providing:
 - excellent solutions and services for industry,
 - small scale production, and
 - certain parts of multi-functional systems (e.g. MOEMS) to be developed using other technologies (e.g. microelectronics or photonics) – other CEZAMAT labs.
- Semiconductor standard quality **SEMINSYS labs** (+3) allowing for pilot line production of devices, circuits and systems in fully controlled environment, including dual use applications.

