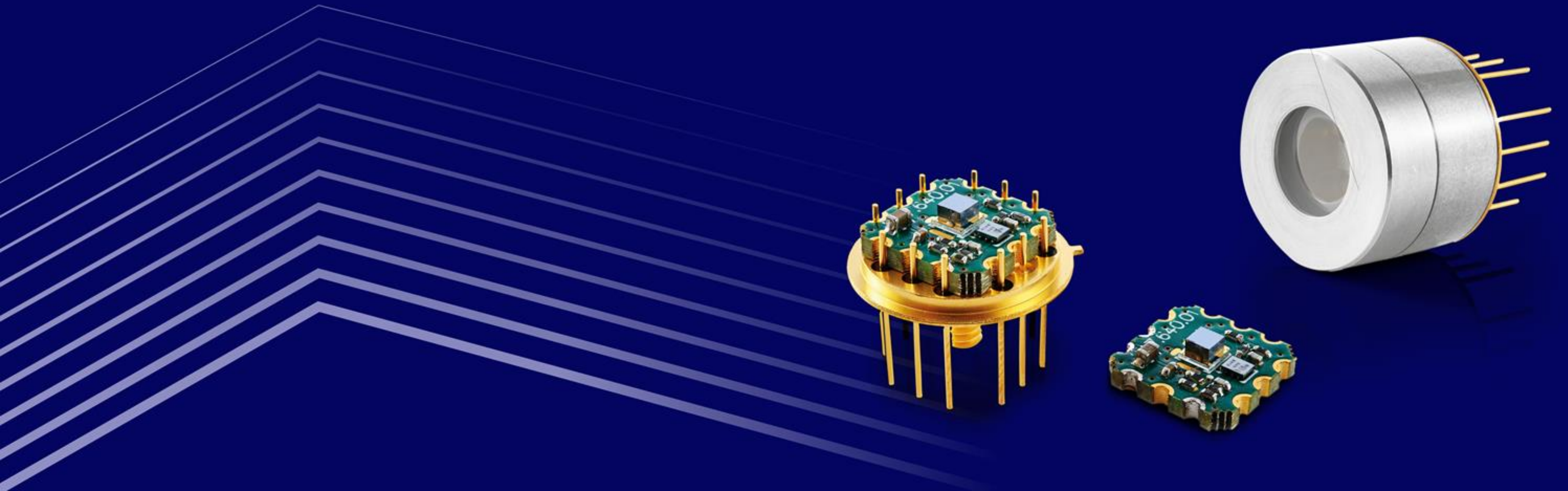


EPIC Technology Meeting on Photonics in Defense 2023



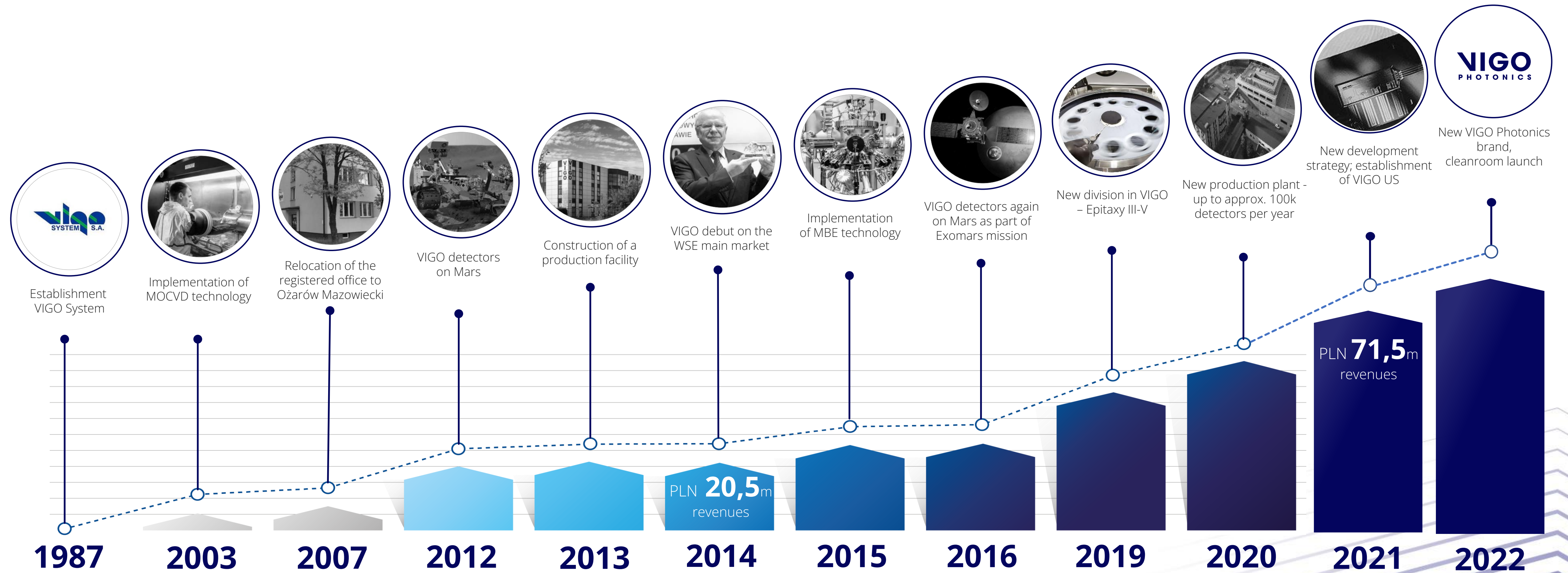
IR FPA development program



MILESTONES OF THE VIGO'S DEVELOPMENT



OVER 35 YEARS OF CONTINUOUS DEVELOPMENT AND EXPANSION ON THE MARKETS



GLOBAL RANGE



BUSINESS RELATIONS WITH GLOBAL CORPORATIONS VIGO SYSTEM HAS BECOME



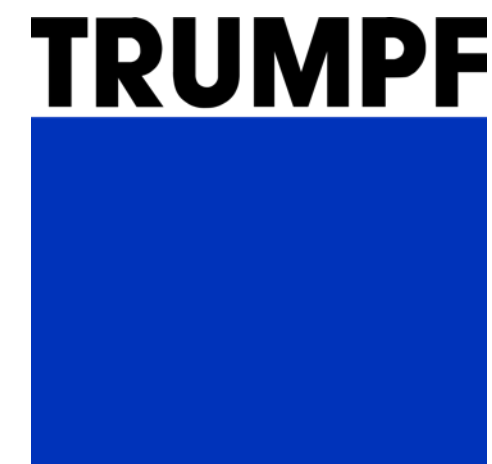
Safran Aerotechnics
(optoelectronics systems)



Emerson Electric Co.
(industrial gas analysers)



Caterpillar
(railway sensor systems)

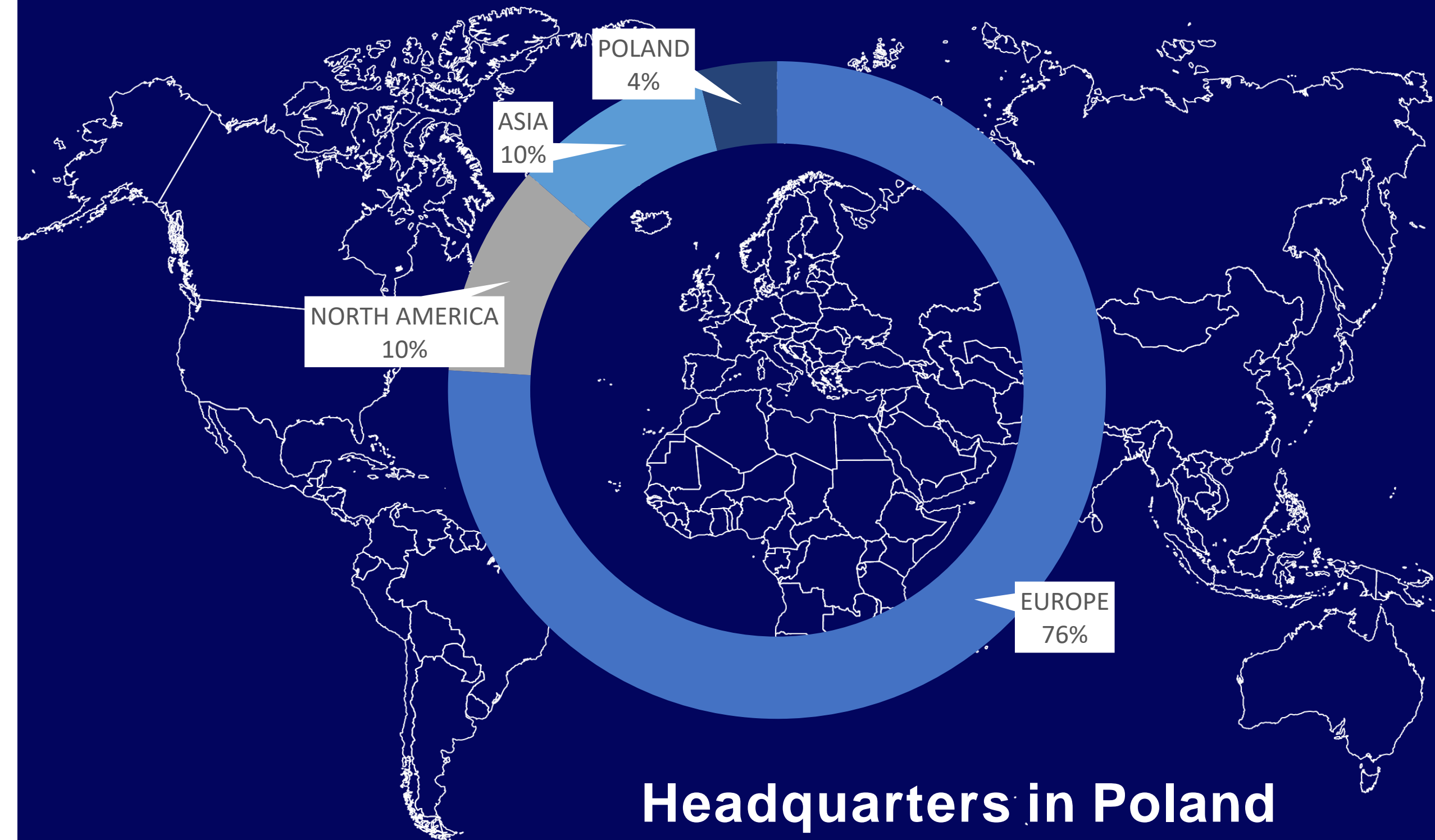


TRUMPF
(laser industry)

VIGO System has become a supplier of the high-tech components for the most demanding customers.



MARKET SPLIT 2021



Headquarters in Poland
and branch offices in USA and Taiwan

25 distributors in **18** countries supporting commercialization of VIGO products and solutions

TECHNOLOGY AND PRODUCTION OF PHOTONIC INFRARED PRODUCTS



PHOTONIC PRODUCTS AND INFRARED (IR) MATERIALS

Semiconductor materials

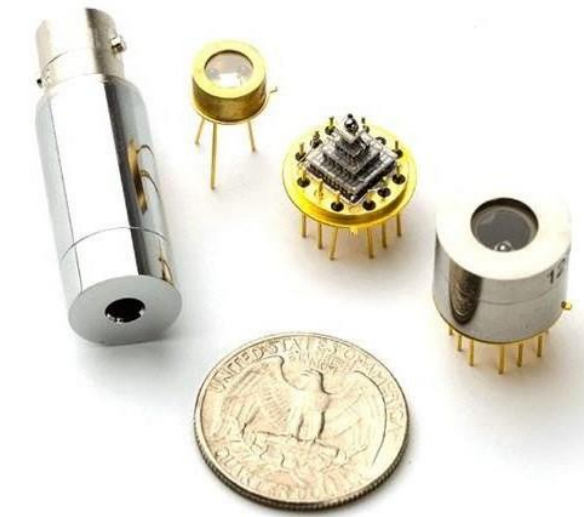


Materials of crystalline structure whose electrical conductivity is between conductors (usually metals) and insulators (most ceramic materials).

Elements for semiconductors: silicon (Si), germanium (Ge), gallium arsenide (GaAs), gallium antimony (GaSb), indium antimony (InSb).

Infrared detector

An electronic component made up of semiconductors that allows the conversion of infrared radiation energy into electrical energy.



Infrared module

An integrated system containing an infrared photodetector, signal processing electronics, optics, heat dissipation systems and other components.



VALUE CHAIN IN THE SEMICONDUCTOR INDUSTRY - VIGO'S COMPLETE LINE FOR SEMICONDUCTORS AND PHOTONIC DEVICES

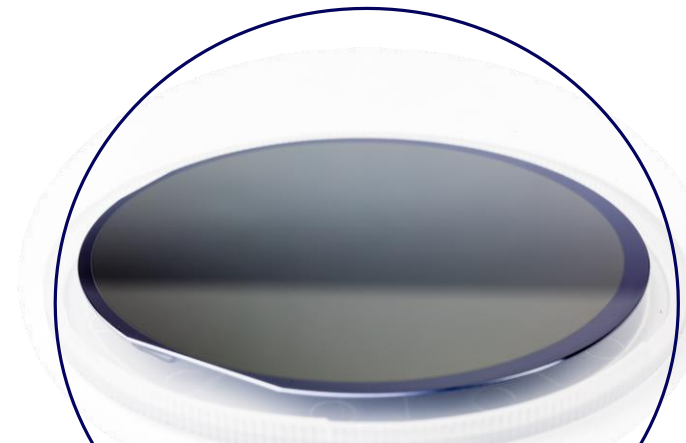
Semiconductor layers as one of the key intermediates in the value chain of VIGO's semiconductor-based products (e.g. wireless communication systems or optoelectronic systems)



1

Culture of GaAs, InP substrates

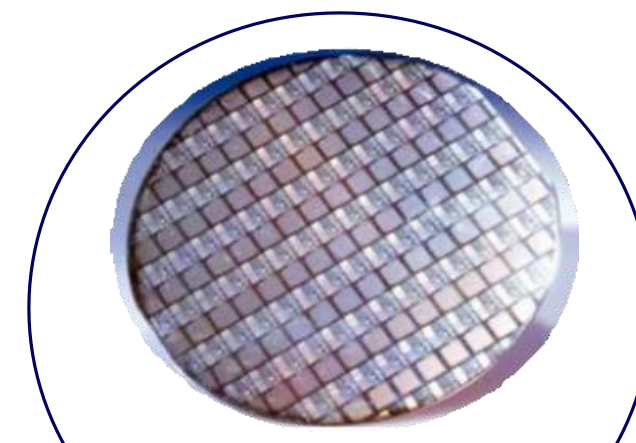
A suitable crystalline structure on which the proper layers are then grown. III-V compound semiconductors are grown on monocrystalline substrates of gallium arsenide (GaAs) or indium phosphide (InP).



2

Epitaxy

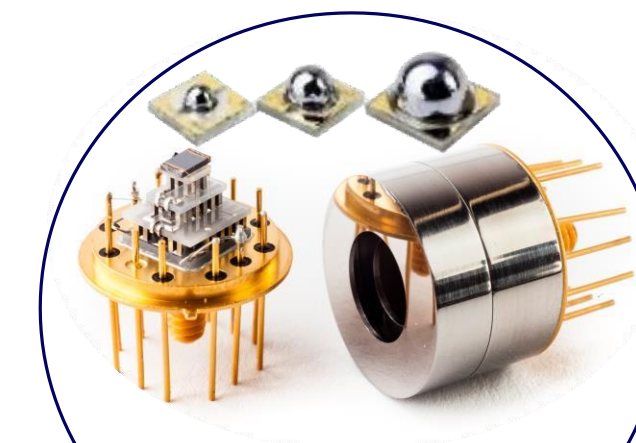
Deposition of the required semiconductor layers with the target parameters. The number of layers can be up to several hundred.



3

Processing

of epitaxial layers and fabrication of detector and laser chips through a range of physical and chemical processes.



4

Packaging

Automated assembly of chips on suitable substrates and in housings. Components (detector, laser) capable of processing an optical/electrical signal are created at the end of this stage.



5

Integration with electronics

Complete detection modules - Electronics integrated in the infrared detector. Production by specialised companies assembling electronic or optoelectronic modules..

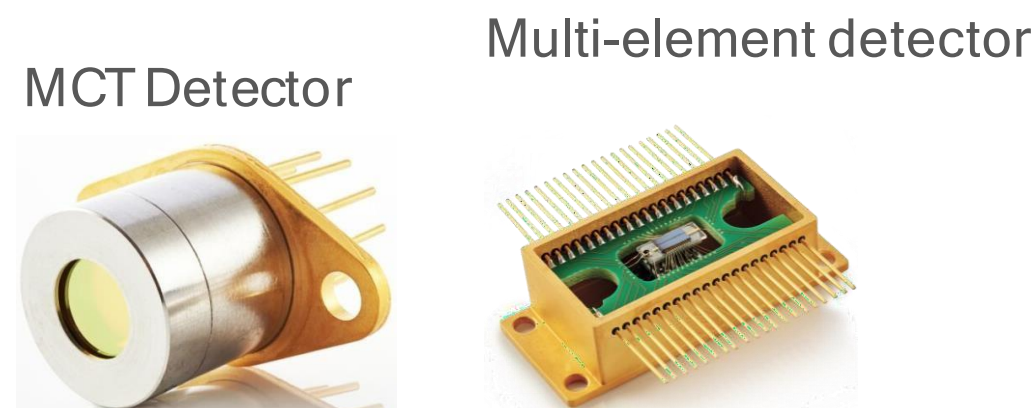
VIGO PRODUCTS TAILORED TO THE NEEDS OF INTERNATIONAL CLIENTS



SIGNIFICANT DIVERSIFICATION OF VIGO'S OFFER THANKS TO INVESTMENTS IN INFRASTRUCTURE BETWEEN 2014 AND 2020 (MBE LAB, EFFICIENT MOCVD IN THE III-V EPITAXY DEPARTMENT)

- Manufacture of MCT, InAs, InAsSb and InGaAs detectors, dedicated electronics, detection modules, accessories and semiconductor materials.
- Devices with high sensitivity over a wide spectral range from 1 to 16 μm and high speed in frequency bands up to 1 GHz.
- 90% Customised* sales - approx. 10% are sales of standard products.

MCT



Detectors and detection modules with the semiconductor layer made of MCT/HgCdTe (mercury cadmium telluride) materials

- A range of photoconductive (PC) and photovoltaic (PV) detectors used in many market sectors
- Radiation spectrum: MWIR
- Reactor: MOCVD (MCT)

III-V InAsSb



Detectors and detector modules with the semiconductor layer made of InAs (indium arsenide) or InAsSb (indium arsenide antimonide) materials.

- A range of photoconductive (PC) and photovoltaic (PV) MWIR and LWIR type II super lattice (T2SL) detectors, operating at room temperature or thermoelectrically cooled
- Radiation spectrum: MWIR and LWIR
- Reactor: MBE (InAs, InAsSb)

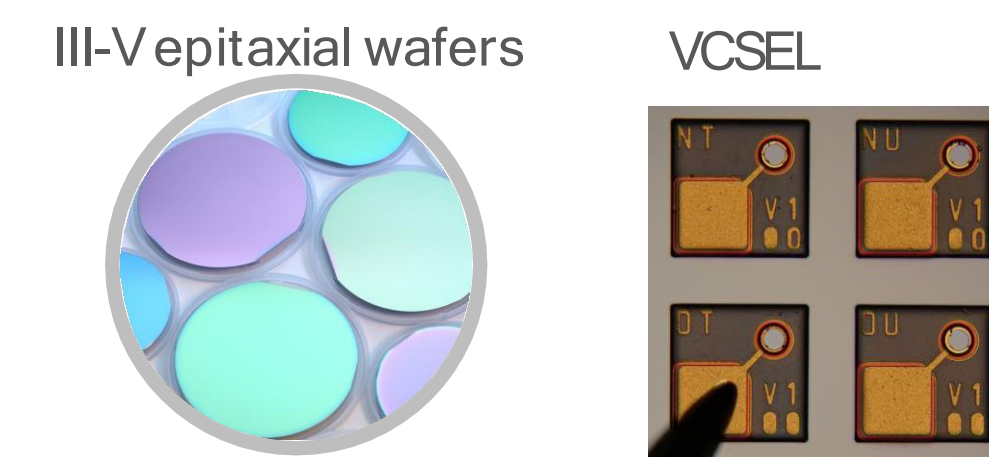
III-V InGaAs



Detectors and detector modules with the semiconductor layer made of InGaAs (indium gallium arsenide) materials.

- A variety of detectors for the SWIR range designed for mass applications
- Radiation range: SWIR (new MOCVD)
- Reactor: MOCVD (III-V)

III-V* EPITAXY



High-quality epitaxial structures of III-V semiconductor materials (InGaAs, InAsSb) offered directly to clients for in-house production of detectors/chips and VCSEL lasers as well as production of SWIR (VCSEL), including VCSEL VIGO lasers.

- A wide range of top quality products: laser layers, detectors, quantum dots, Bragg reflectors. Poland's first VCSEL laser chips.
- Radiation range: MWIR, SWIR
- Reactor: MOCVD (III-V)

SWIR / MWIR / LWIR

*realisation of product projects with the client - projects tailored to users' needs

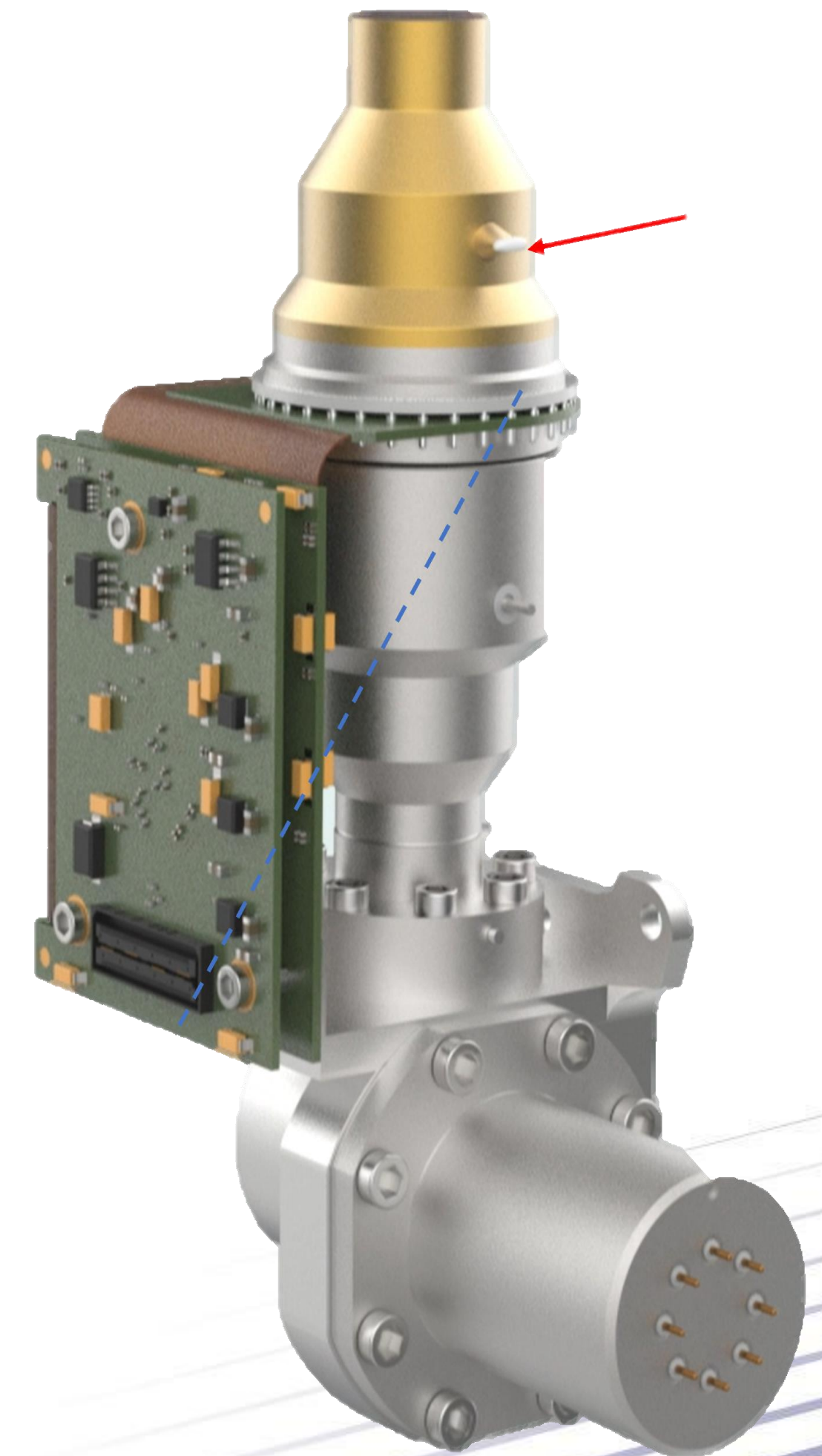
PLIR ARRAY

POLISH THERMAL IMAGING FOR THE POLISH ARMY

TECHNOLOGY DEVELOPMENT

Objective of the initiative

- Becoming a major supplier of detectors for the Polish army/armament industry
- Development of the technology for manufacturing cooled arrays



FOCAL PLANE ARRAY PROGRAM

Global situation

Pandemic

- Lockdown
- Demands rise up



- Border Crisis

- Need for the night vision



- Russian aggression



PLIR ARRAY

POLISH THERMAL IMAGING FOR THE POLISH ARMY

TECHNOLOGY DEVELOPMENT

Objective of the initiative

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NEW BUSINESS LINE

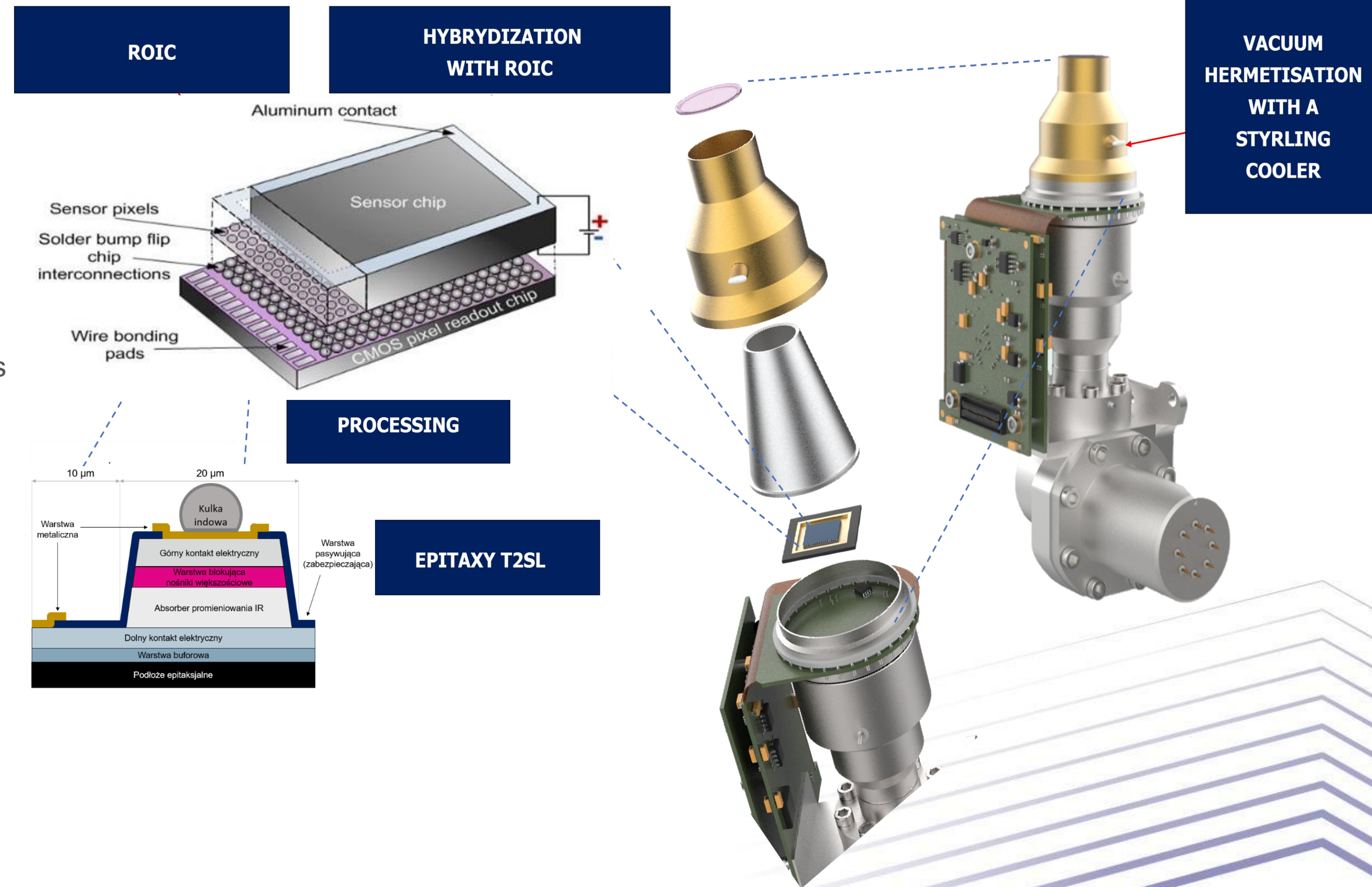
Thermal imaging sensors for the MWIR and LWIR range

- Cryogenically cooled
- Based on **T2SL** technology and III-V materials
- A wide range of resolutions from 320x256 to 1280x1024
- Long working time and stable response
- Resistance to external conditions

Short-infrared (SWIR)

- Based on InGaAs technology
- Temperature stabilized (thermoelectrically)

As a result of hybridization, each bump applied to the ROIC connects directly to the pixel of the EPI layer, which for the 640x512 matrix is over 350,000

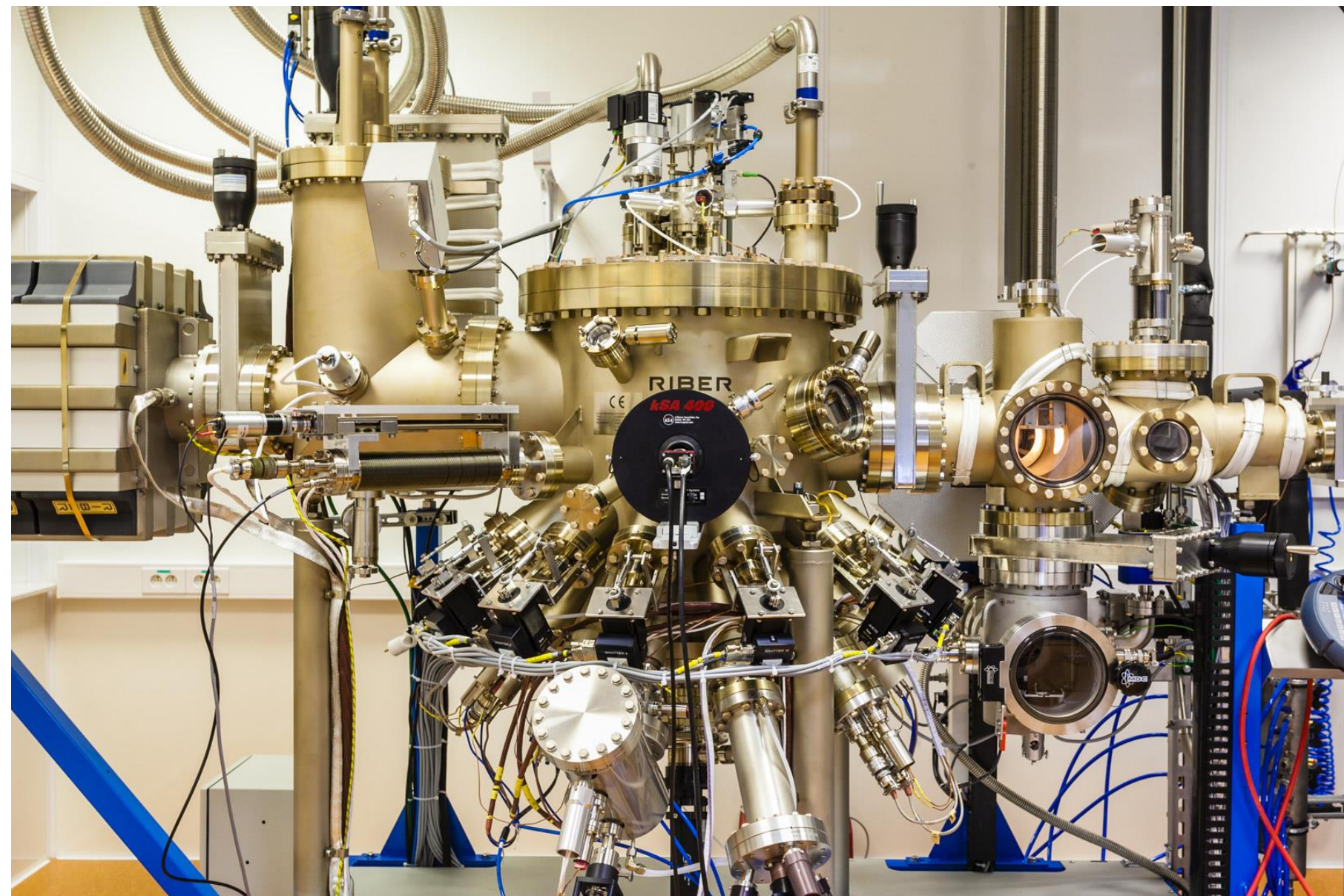


FOCAL PLANE ARRAY PROGRAM

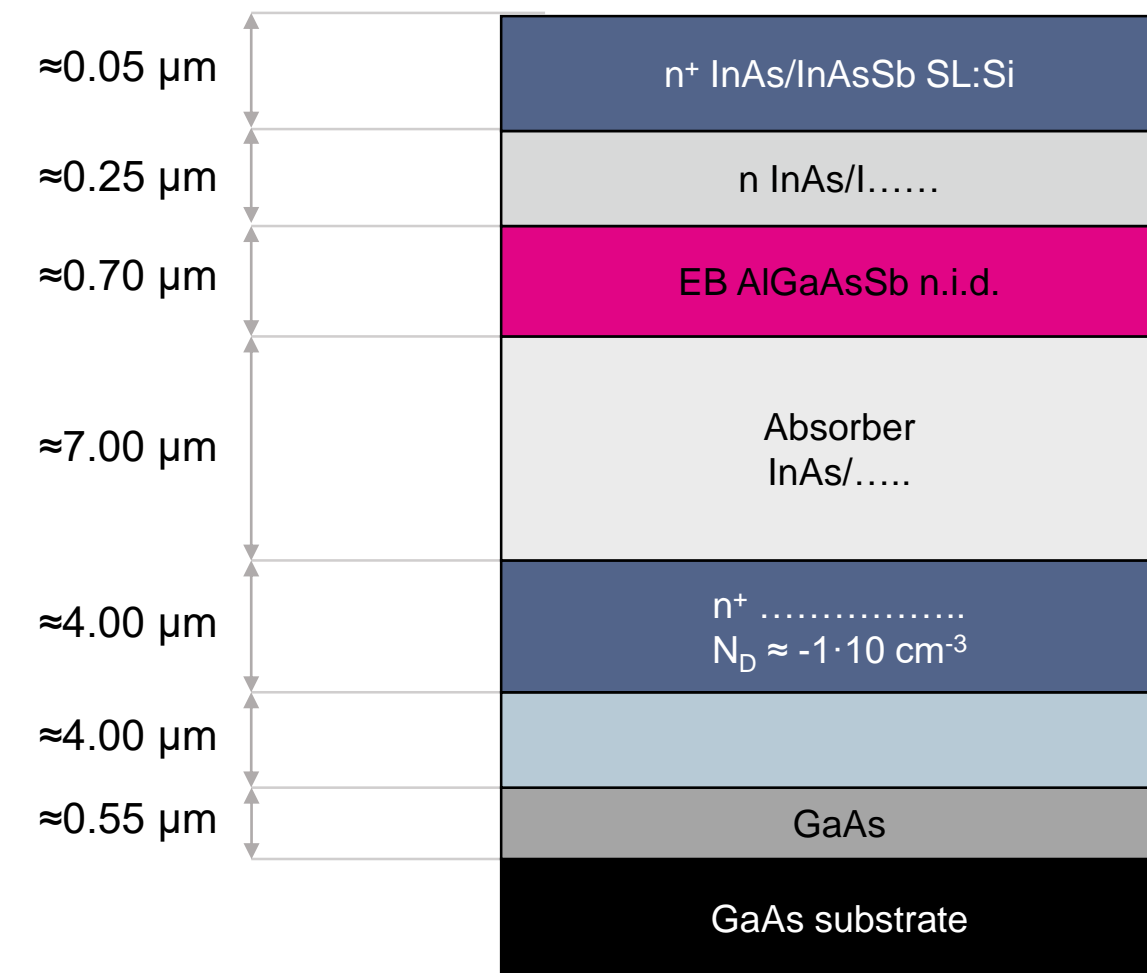
Epitaxy



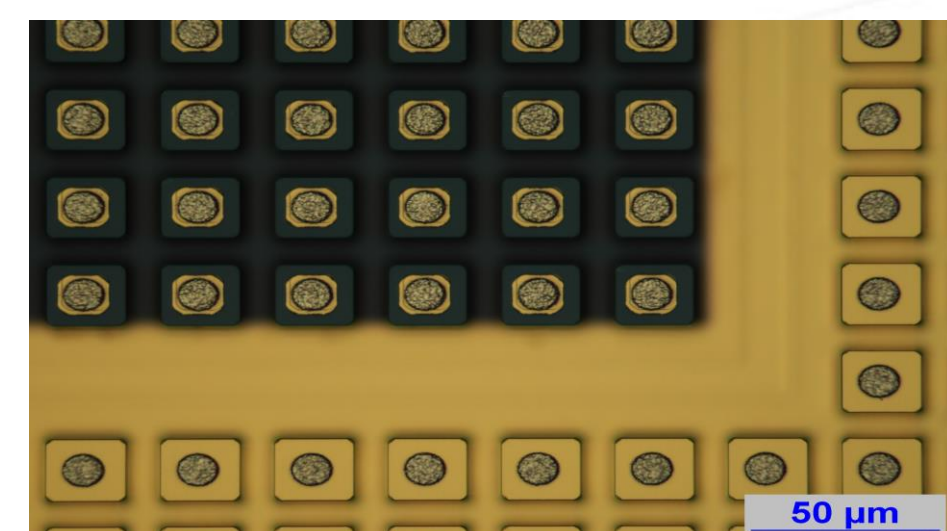
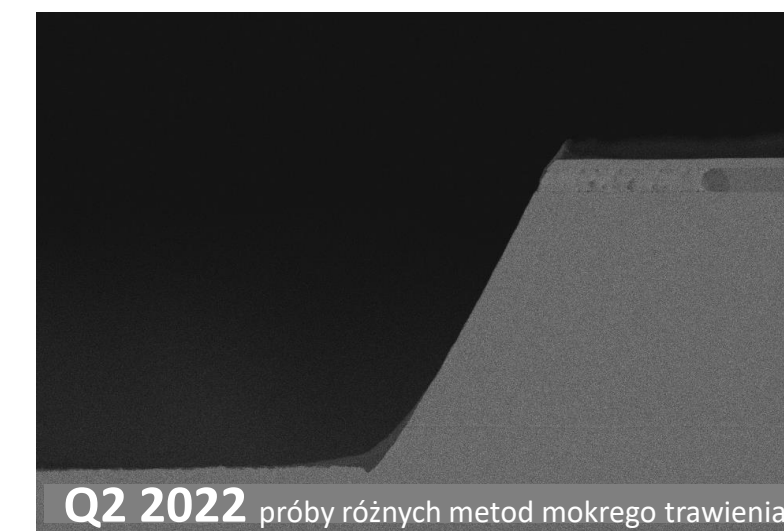
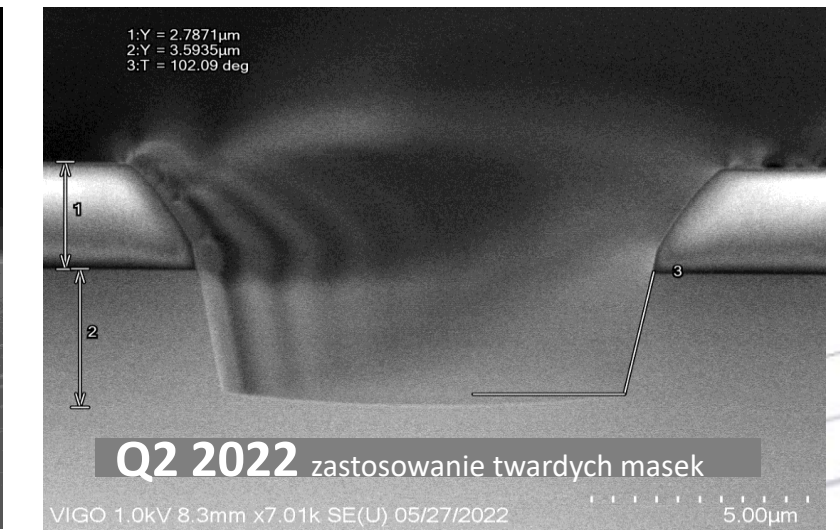
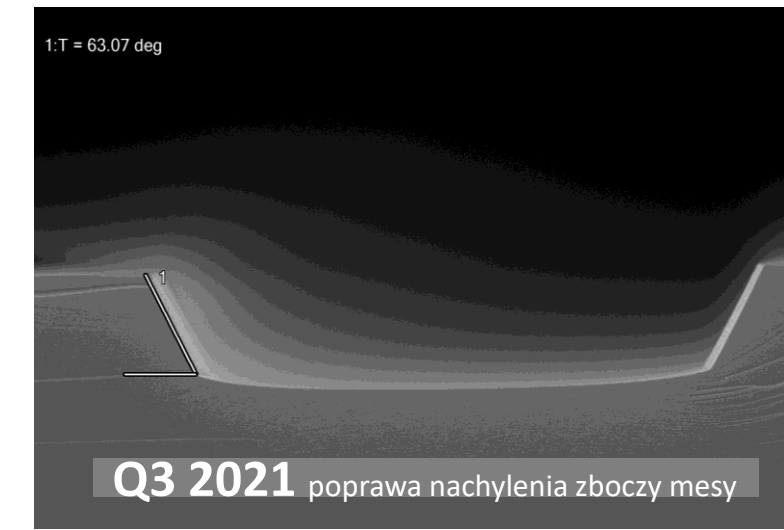
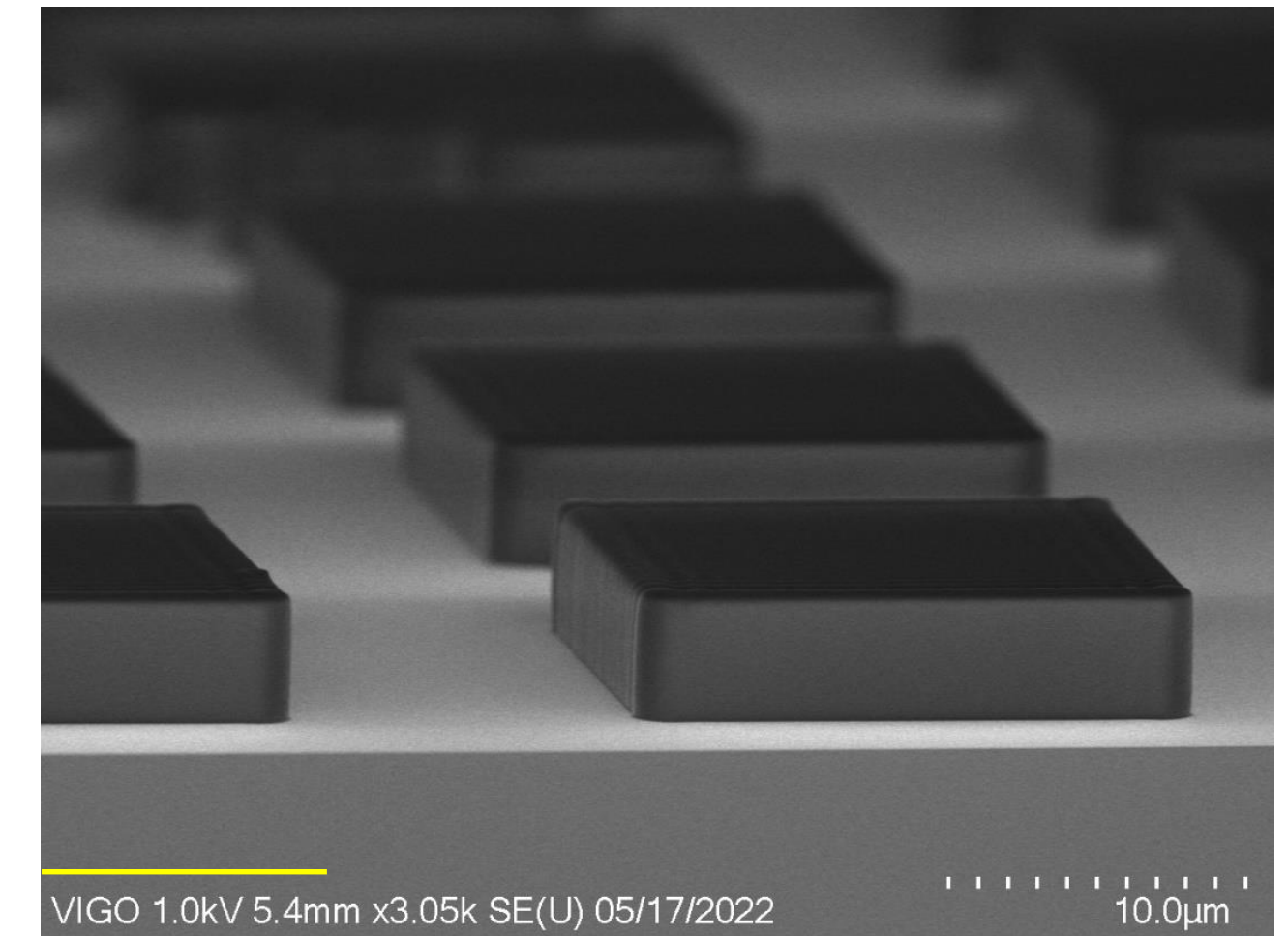
MBE reactor



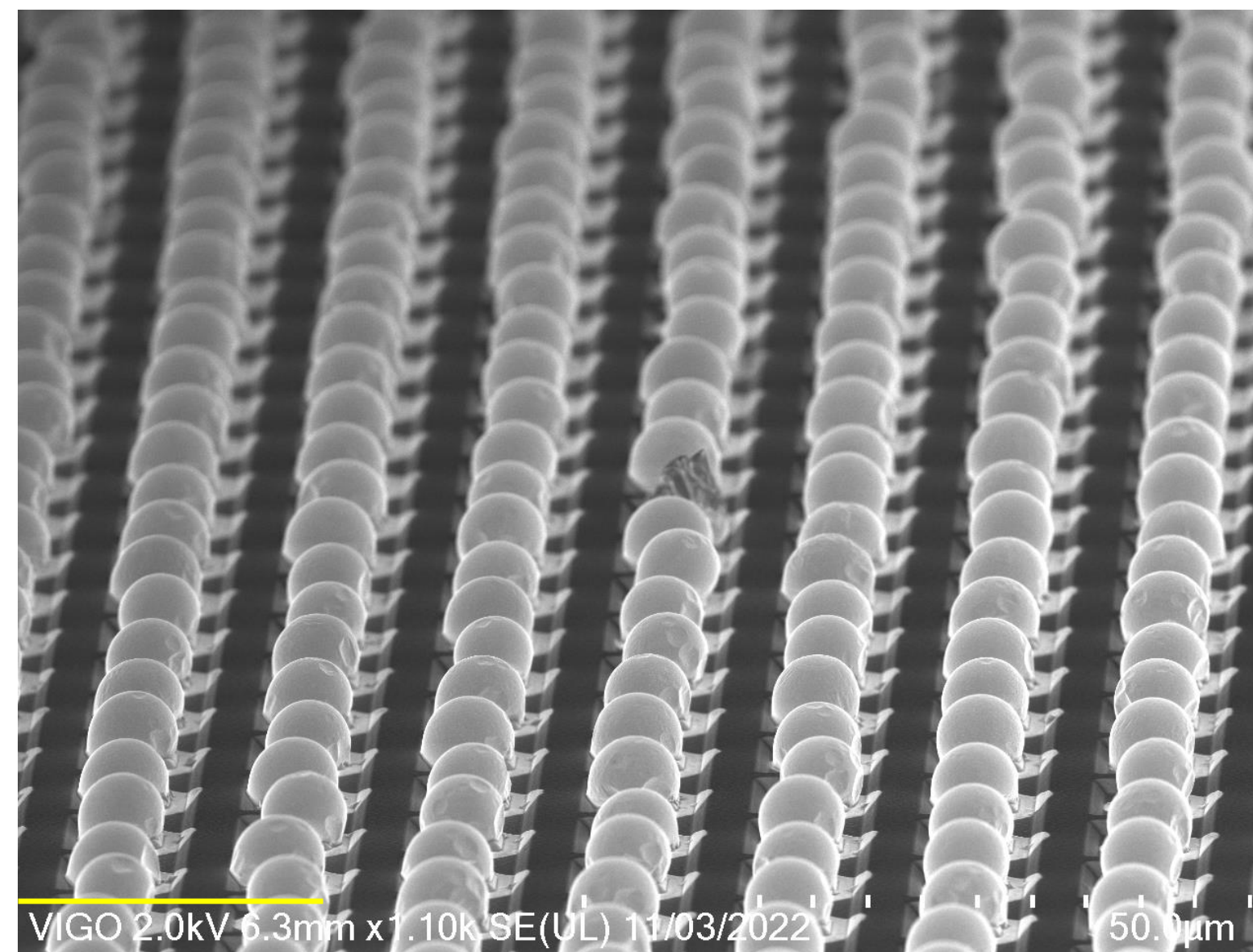
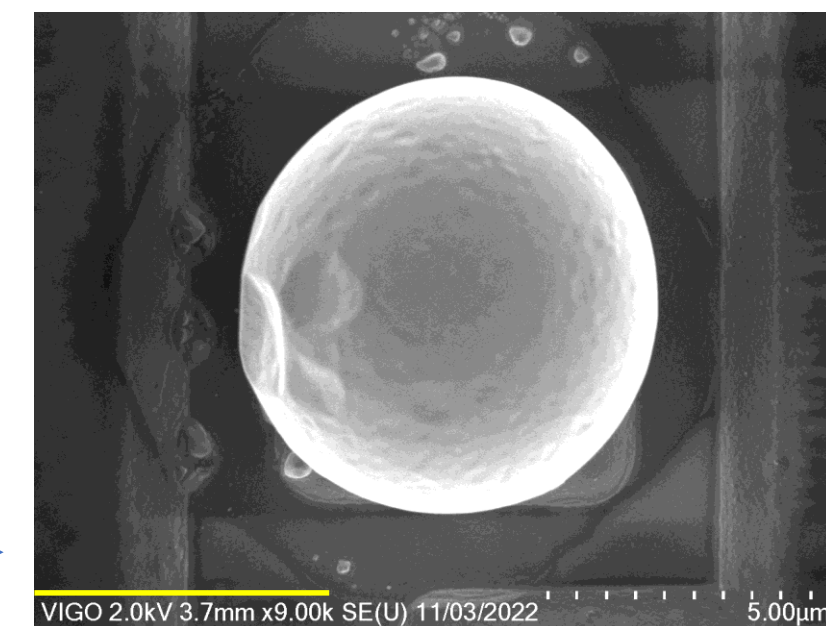
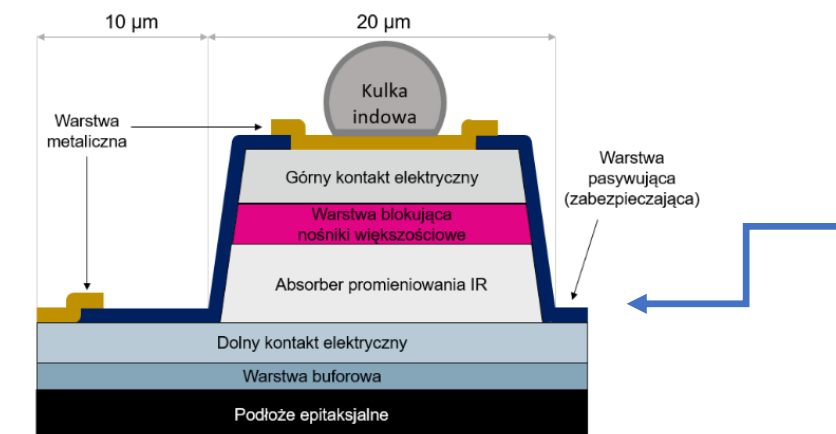
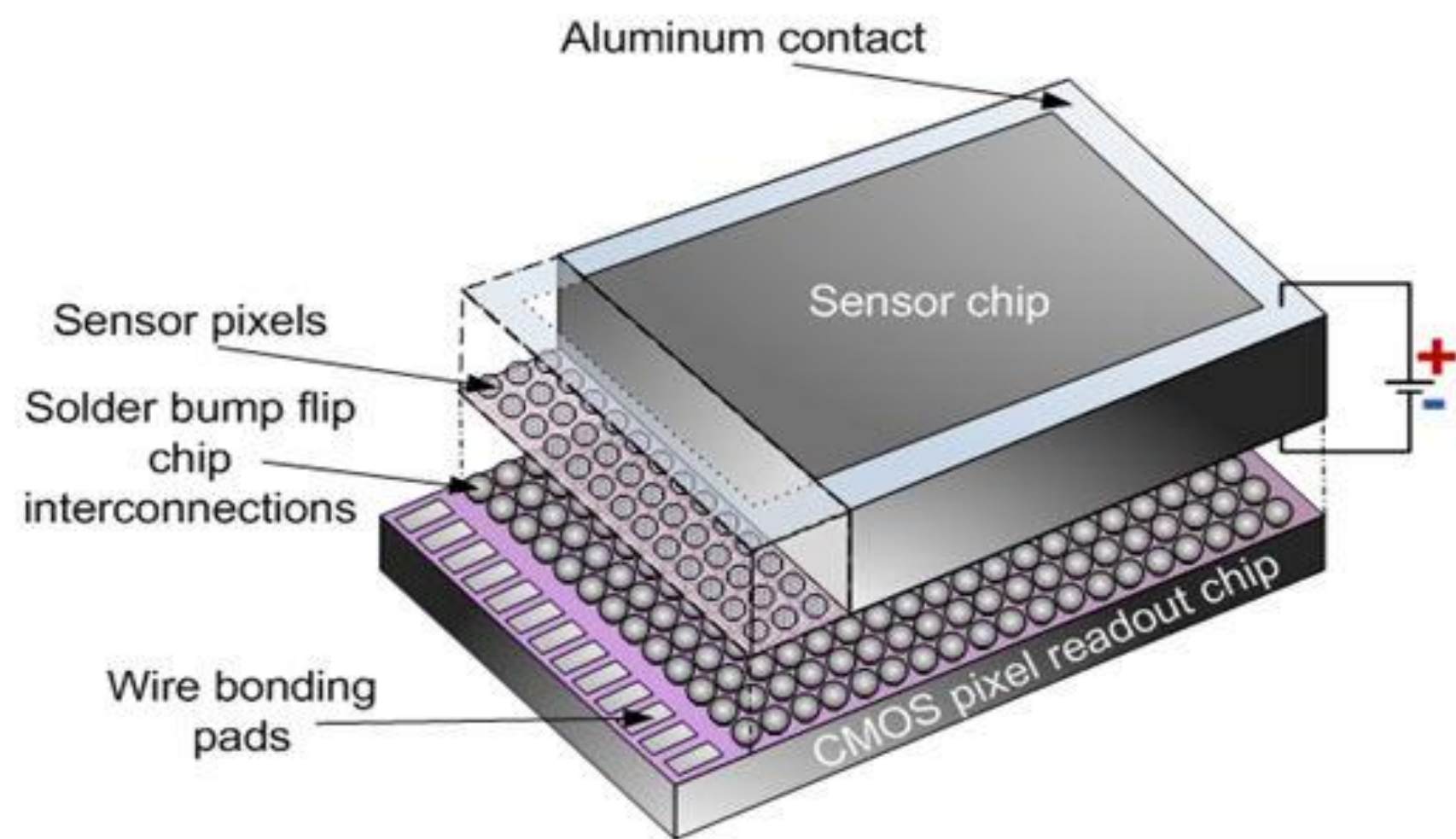
T2SL composition



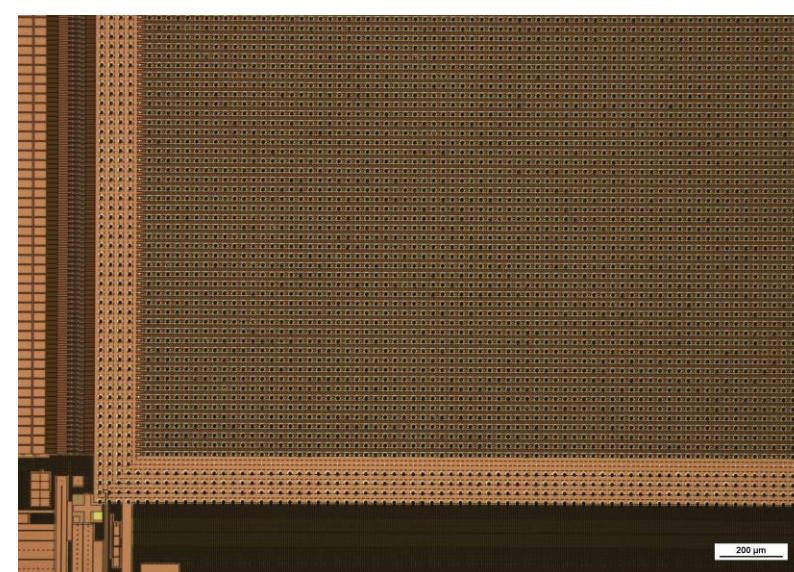
Photolithography



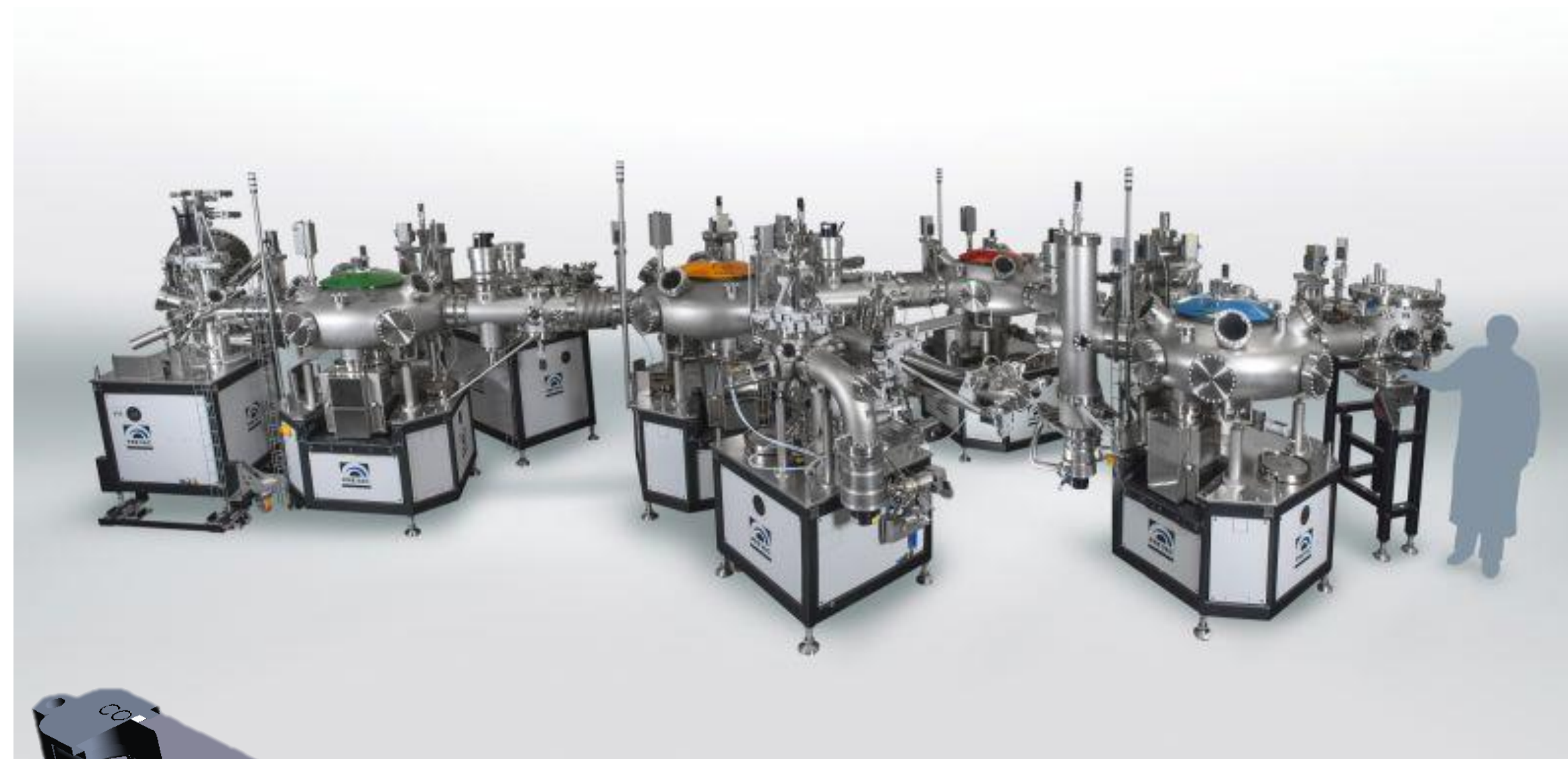
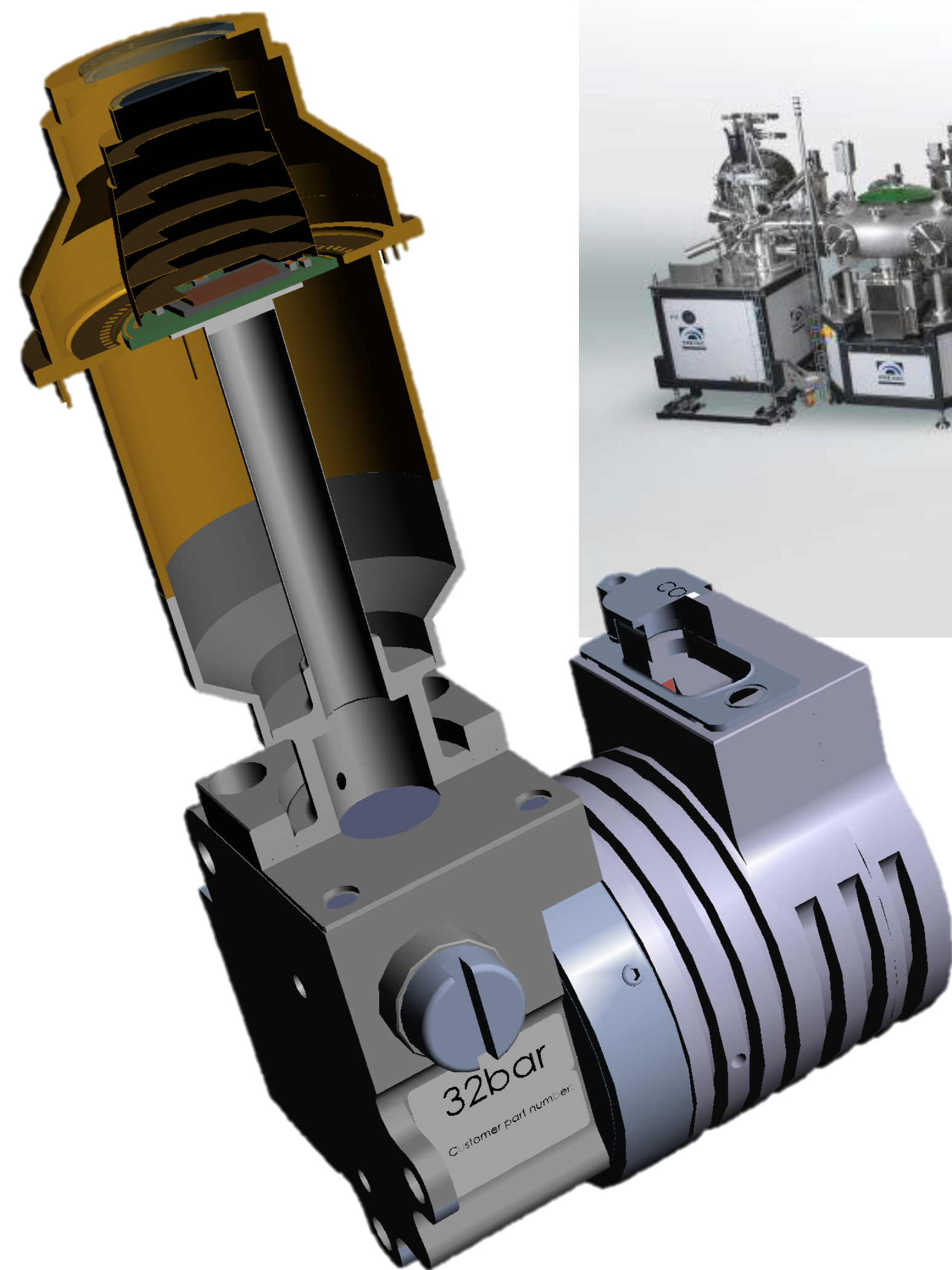
FPA + ROIC integration



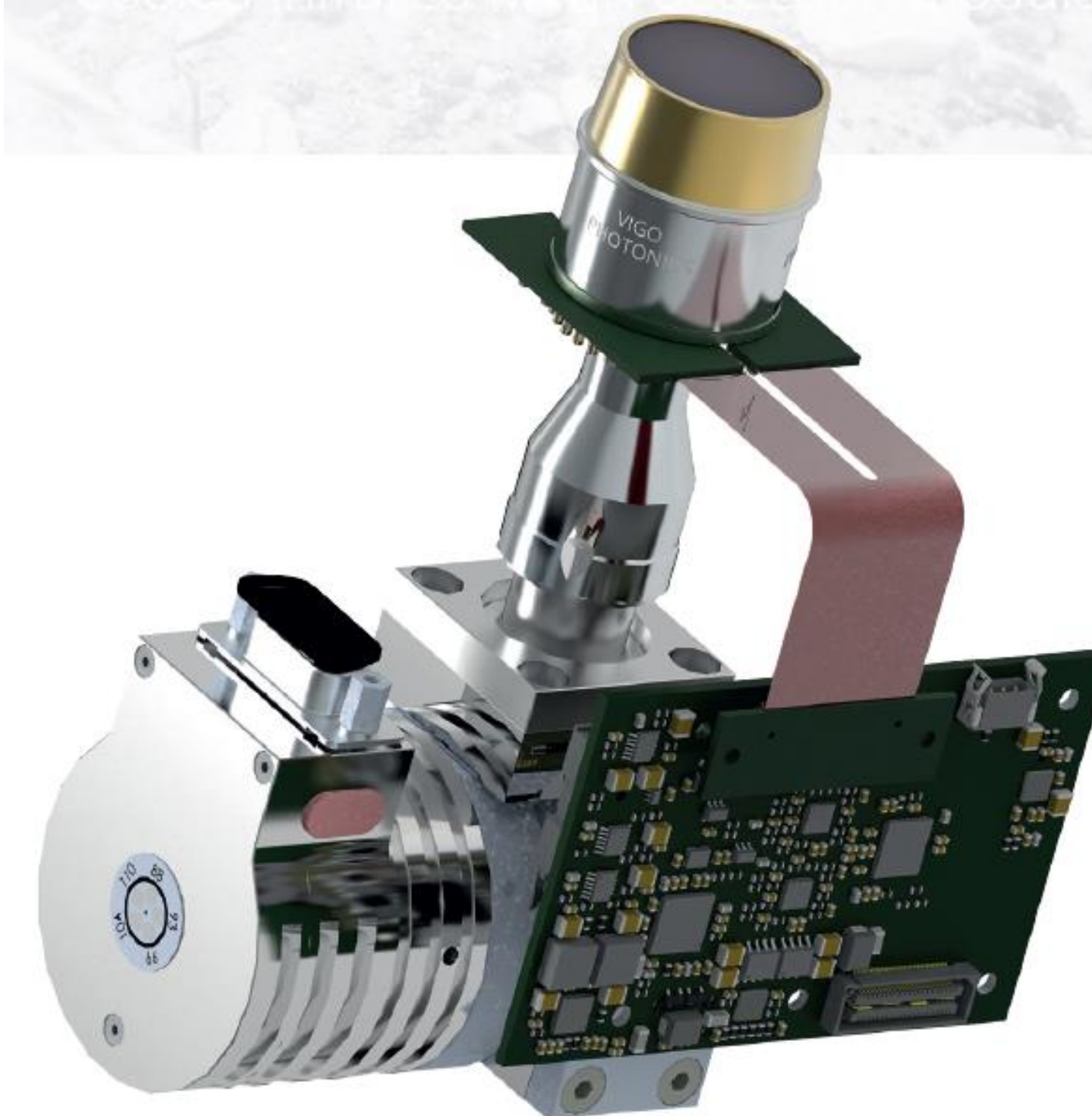
ROIC



Dewar assembly, hermetisation and electronics



- **Dewar design**
- **High vacuum technology development**
- **Welding and gluing techniques**
- **Electronics and A/D conversion**



FOCAL PLANE ARRAY PROGRAM



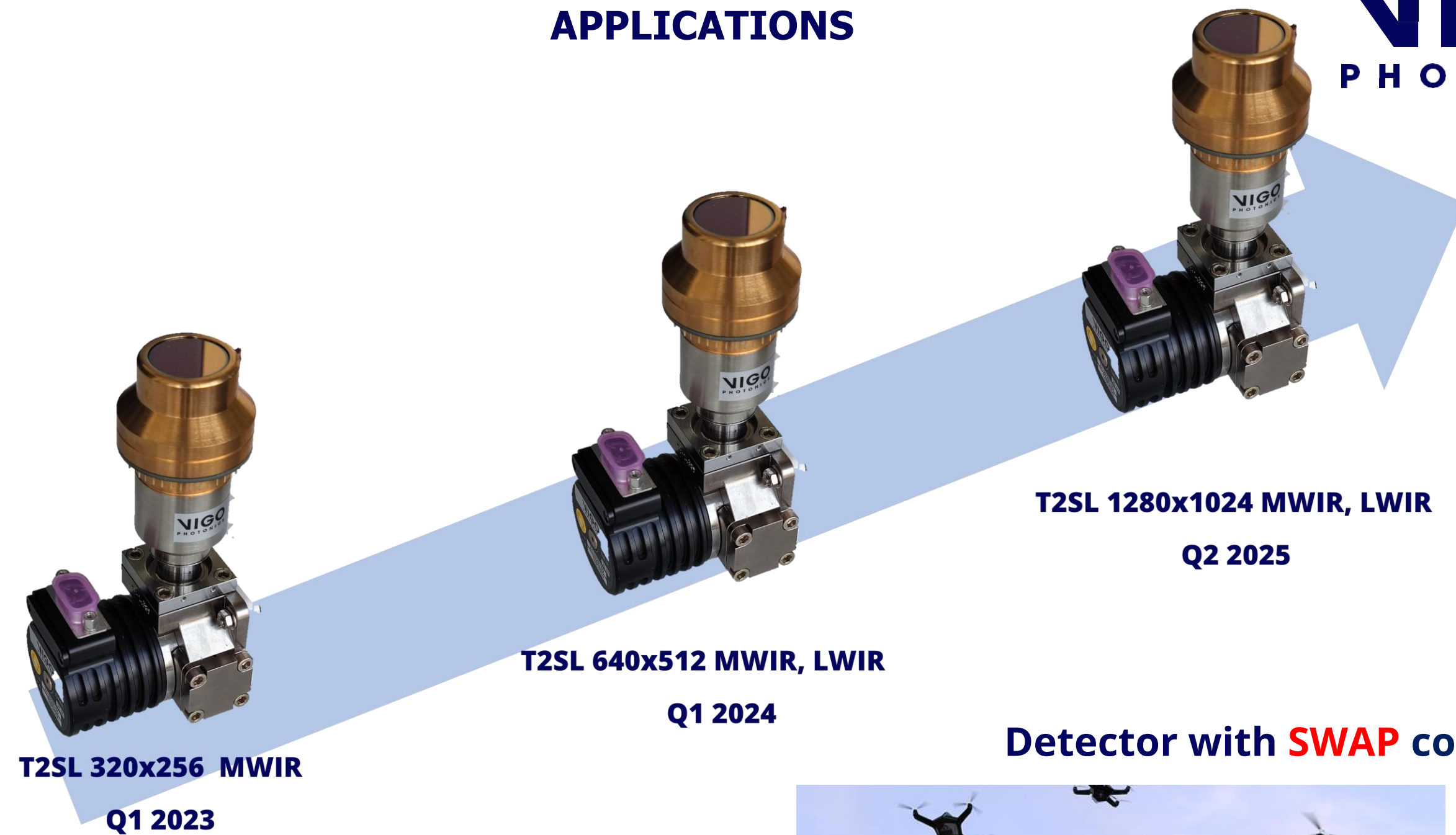
NEW BUSINESS LINE

Thermal imaging sensors for the MWIR and LWIR range

- Cryogenically cooled
- Based on T2SL technology and III-V materials
- A wide range of resolutions from 320x256 to 1280x1024
- Long working time and stable response
- Resistance to external conditions.



POTENTIAL MILITARY APPLICATIONS



Detector with **SWAP** cooler



Detector with **Stirling** cooler



Detector with **JouleThomson** cooler

FOCAL PLANE ARRAY PROGRAM

FPA

VIGO
PHOTONICS

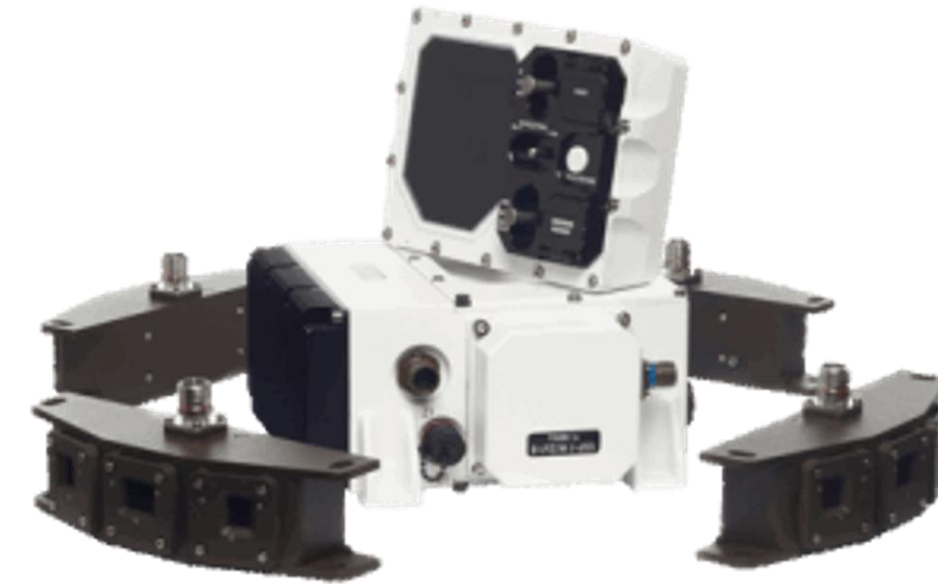
NEW BUSINESS LINE

Short-infrared (SWIR)

- Based on InGaAs technology
- Temperature stabilized (thermoelectrically)

Main advantages (SWIR)

- SWIR shows reflected light well
- SWIR reacts to high temperatures
- SWIR "sees" through the glass



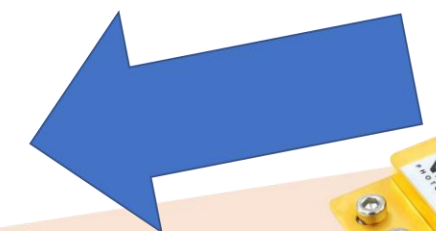
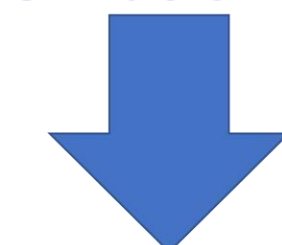
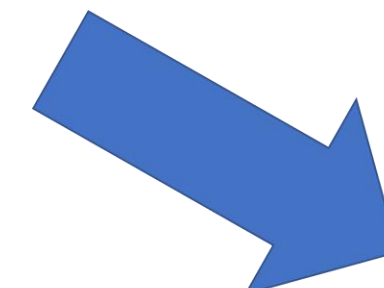
Laser Warning System



360 Vehicle observation system



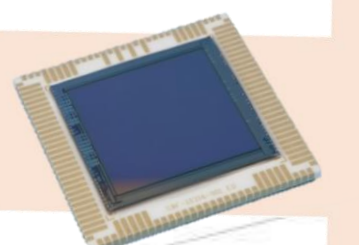
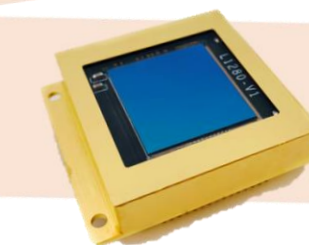
Muzzle Flash Detection



InGaAs 640x512 0.9 - 1.7 um
Q1 2023



Extended InGaAs
640x512 0.9 - 2.7 um
Q2 2024



custom ordered resolution can be prepared on call much earlier



0.75 μm 1 μm 2.7 μm 3 μm 5 μm 8 μm 14 μm

FOCAL PLANE ARRAY – TECHNOLOGY DEVELOPMENT

Dojście do etapu produkcji małoseryjnej

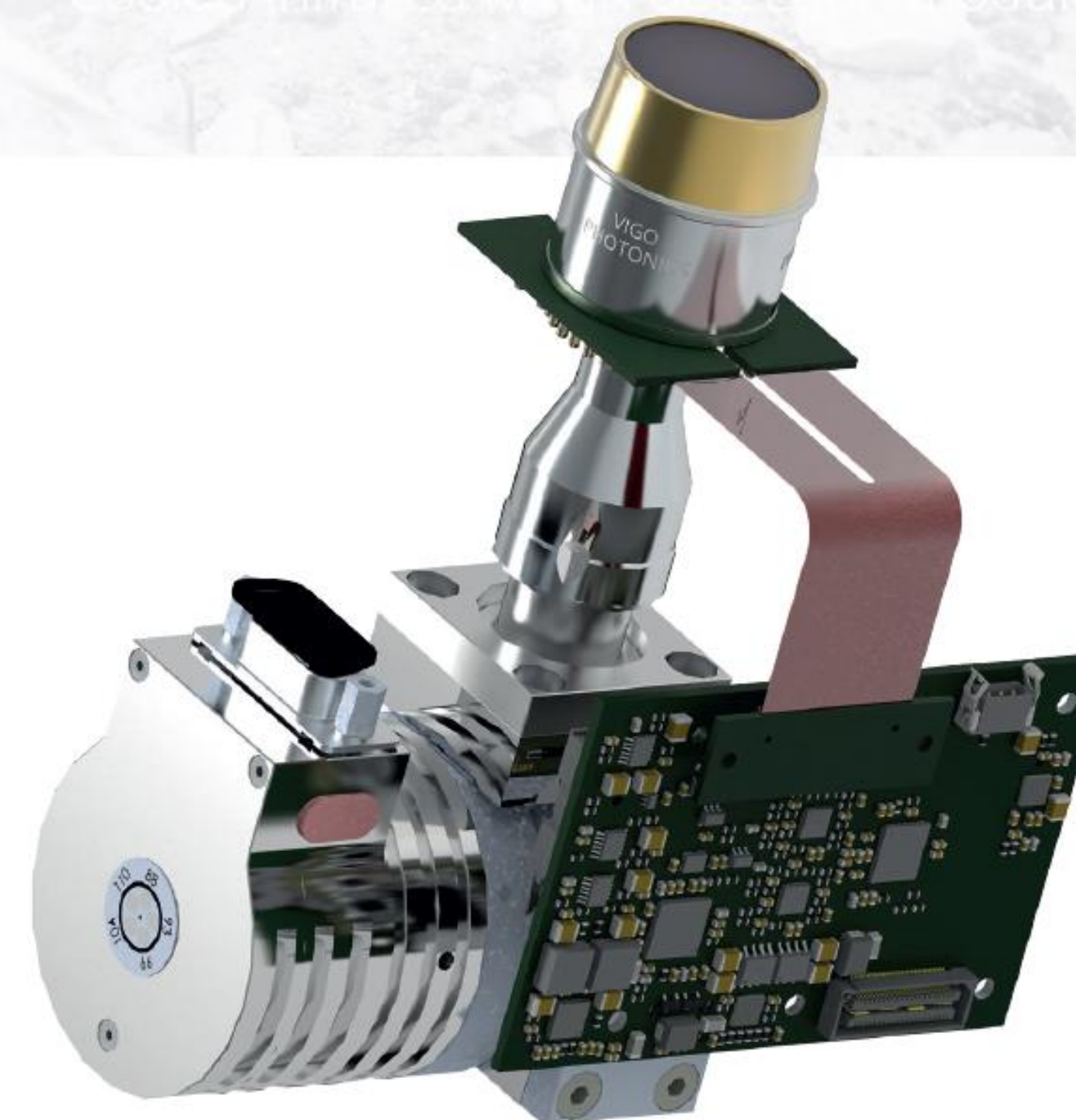
Lp	Rozdzielczość	Pixel pitch	Zakres fali	M1	M2	M3	M4	M5
1A	320x256	30µm	MWIR	3Q2023	4Q2023	4Q2023	1Q2024	x
1B	320x256	30µm	LWIR	4Q2023	2Q2024	4Q2023	1Q2024	x
2A	640x512	15µm	MWIR	4Q2023	1Q2024	1Q2024	1Q2024	1Q2026
2B	640x512	15µm	LWIR	1Q2024	3Q2024	1Q2024	1Q2024	1Q2026
2C	640x512	15µm	SWIR	3Q2023	1Q2024	1Q2024	1Q2024	1Q2026
3A	1280x1024	15µm	MWIR	4Q2023	1Q2025	1Q2025	4Q2025	1Q2026
3B	1280x1024	15µm	LWIR	1Q2024	3Q2025	1Q2025	4Q2025	1Q2026
3C	1280x1024	15µm	SWIR	3Q2023	1Q2025	1Q2025	4Q2025	1Q2026

Kamienie milowe: A B C D F					
	Warstwa EPI	Processing	Hybrydyzacja	Packaging + Hermetyzacja	ROIC
M1	Vigo	Out	Out	Out	Out
M2	Vigo	Vigo	Out	Out	Out
M3	Vigo	Vigo	Vigo	Out	Out
M4	Vigo	Vigo	Vigo	Vigo	Out
M5	Vigo	Vigo	Vigo	Vigo	Vigo

Vigo - krok wykonany w technologii zaimplementowanej w Vigo
 Out - krok wykonany na zlecenie u dostawcy zewnętrznego

ASSUMPTIONS

- 2024 - small-lot production of **30-40 pieces**.
- 2025 - full-scale at the level of min. **500 pcs/yr**



TECHNOLOGICAL PROGRESS FOR:

M1 i M2 - product 1A (technology and its repeatability)

- Epitaxy (90%)
- Processing (85%)
- Hybridization (40%)
- Packaging + Encapsulation (10%)
- ROIC (0%): Works based on ROICs from the market

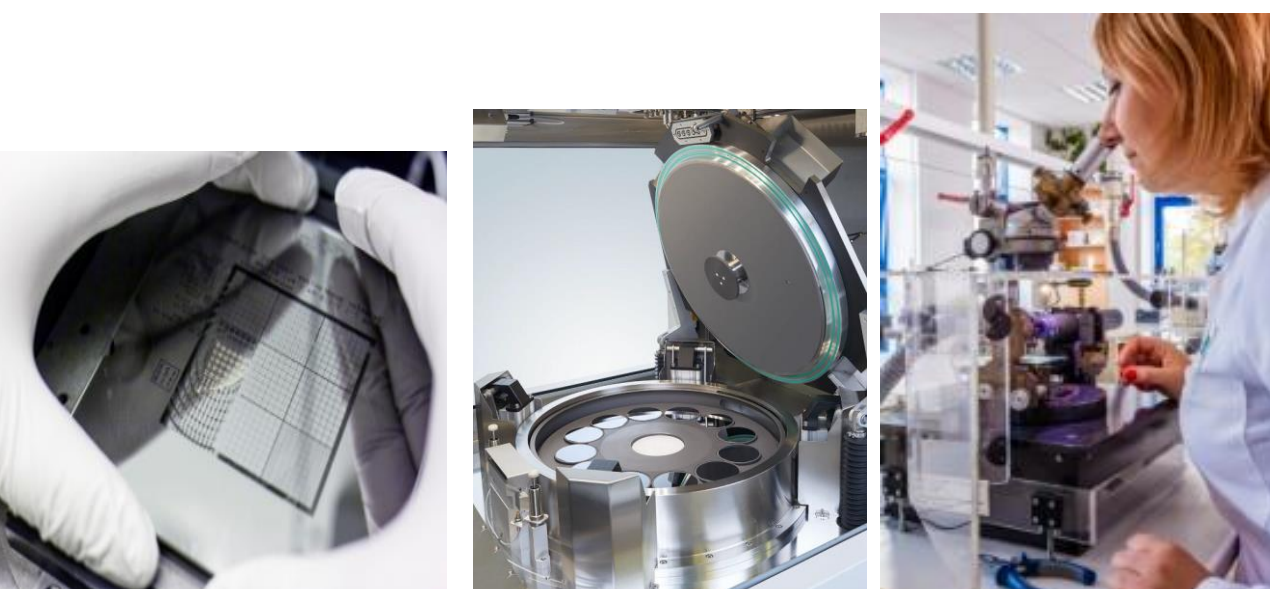
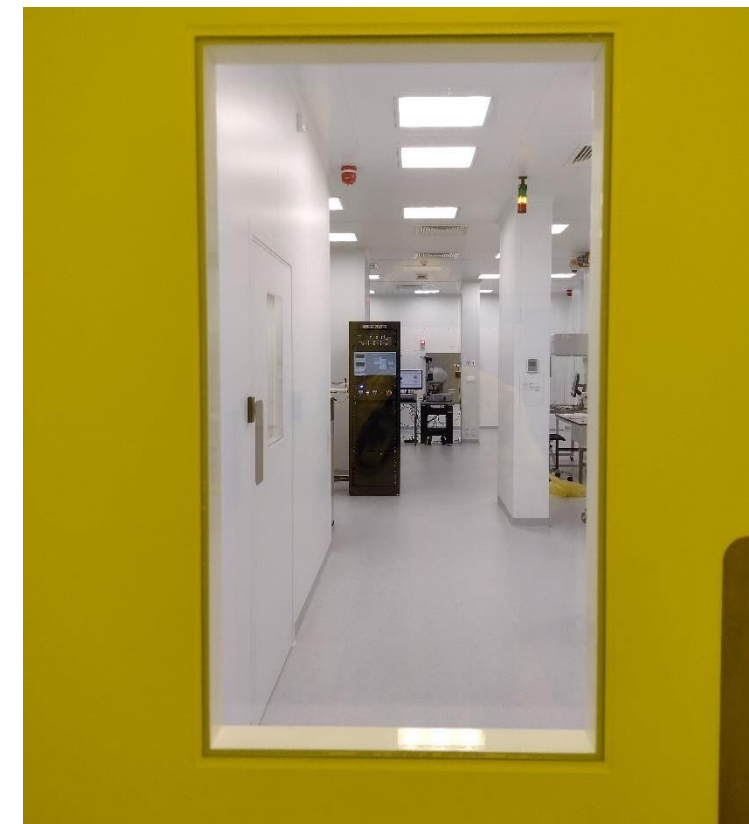
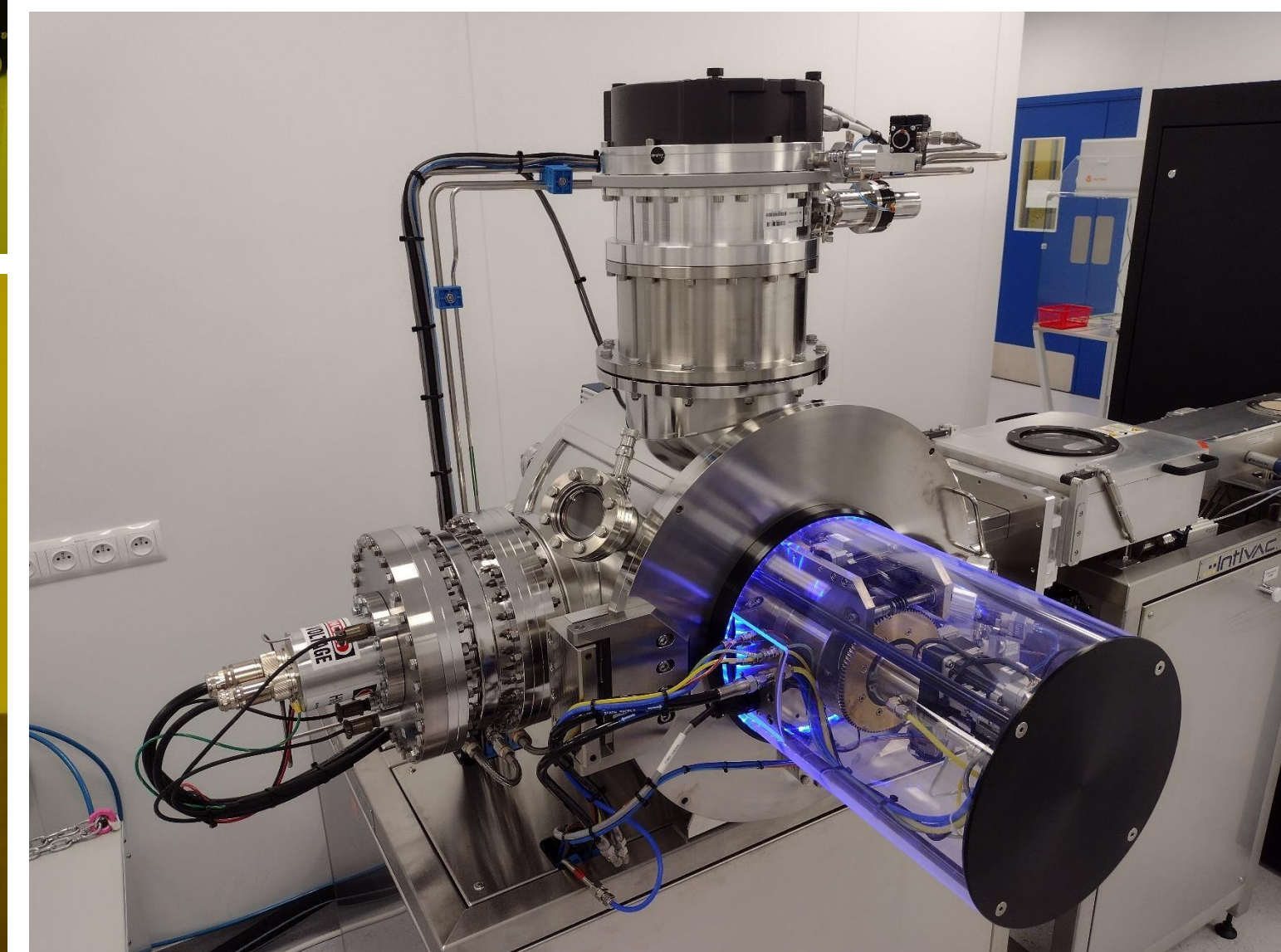
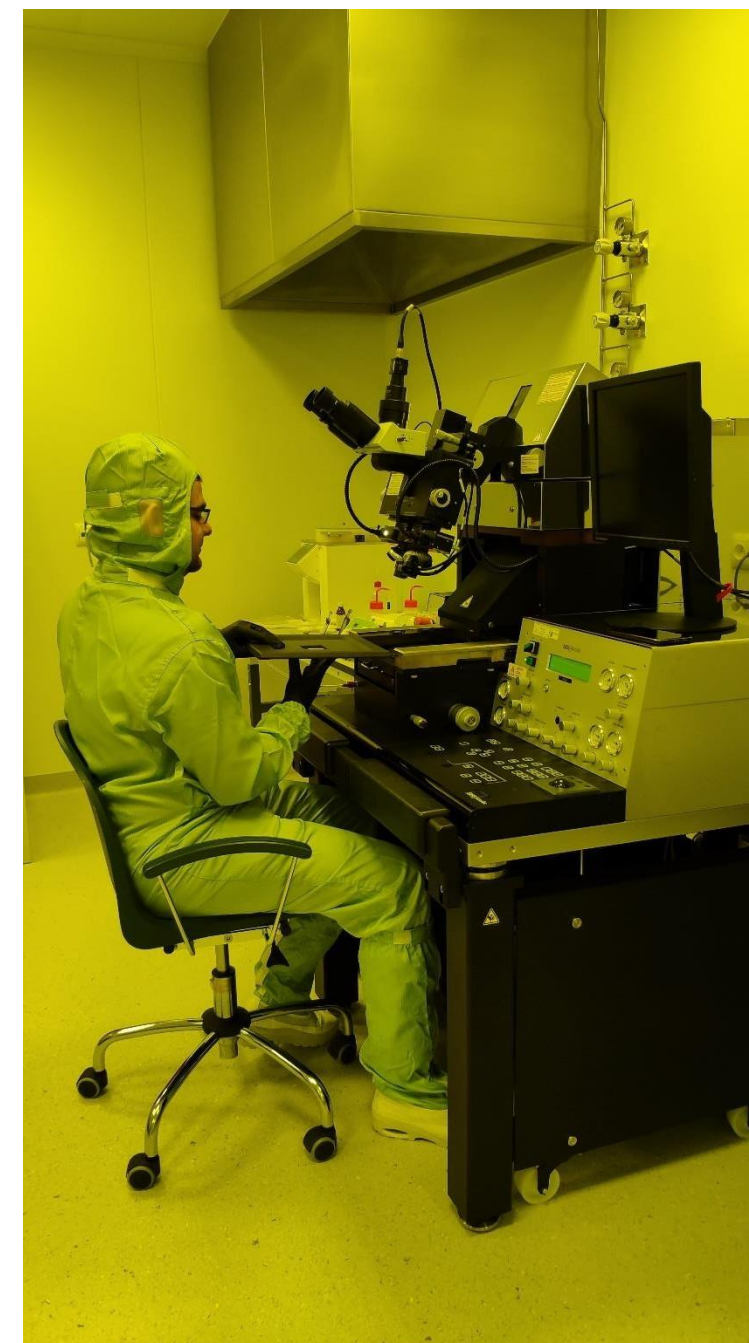
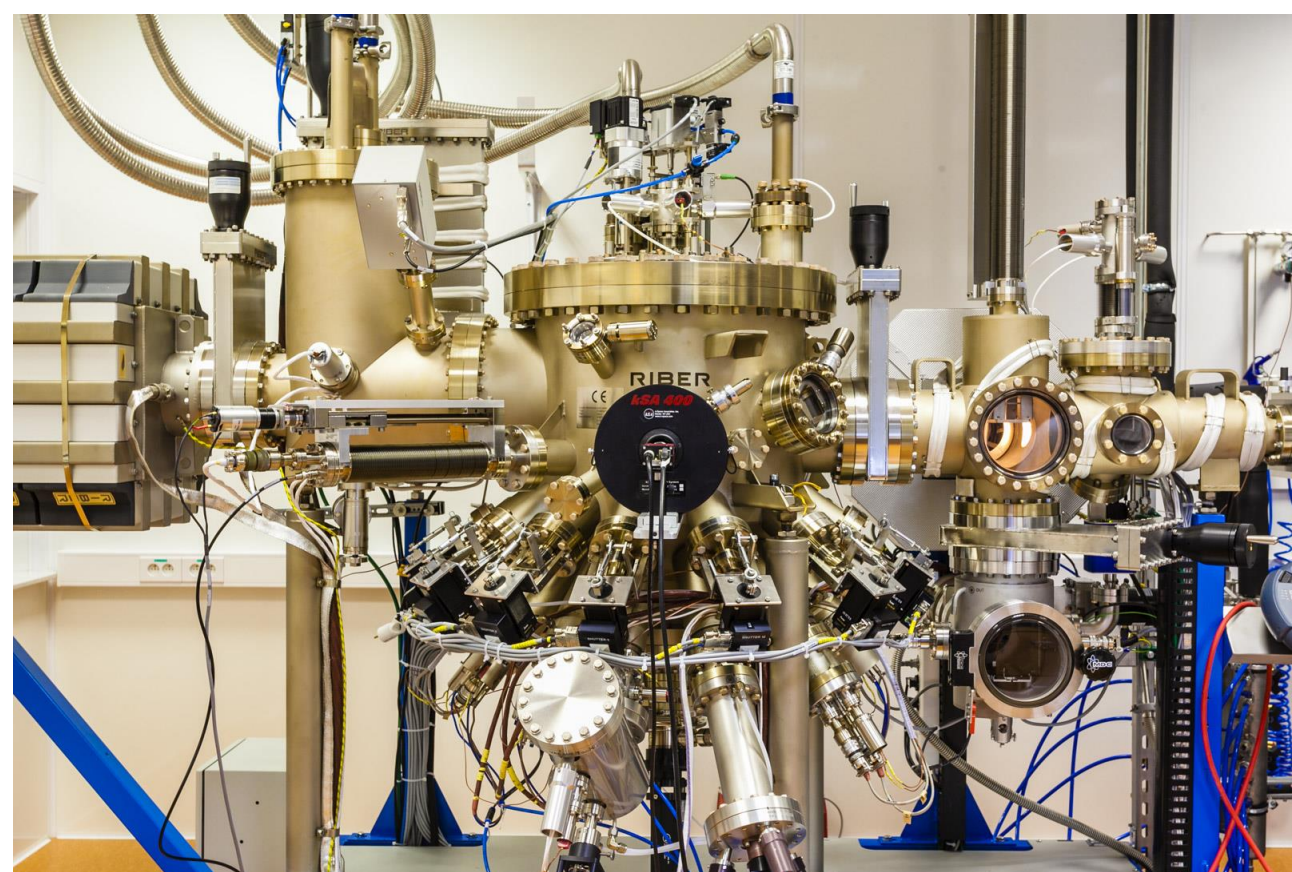
TECHNOLOGY AREA

250 sqm OF CLEANROOMS AND 6500 sqm OF TECHNOLOGY DEVELOPMENT SPACE IN TOTAL



FURTHER INVESTMENT OBJECTIVES

1. Increase in production repeatability
2. Detector chip manufacturing technology
3. Reduction of production costs
4. Meeting the highest quality requirements (military, space, semiconductor industries)



VIGO

PHOTONICS

LET'S CREATE THE FUTURE TOGETHER!



Contact us:
VIGO Photonics S.A.
email: defence@vigophotonics.com
vigophotonics.com/