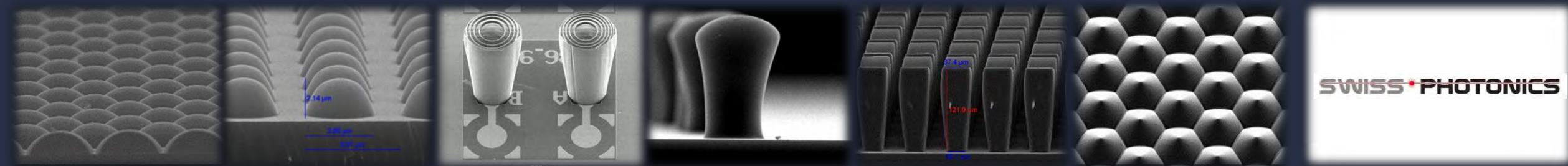


A new era for micro-optics manufacturing : the final frontier ...

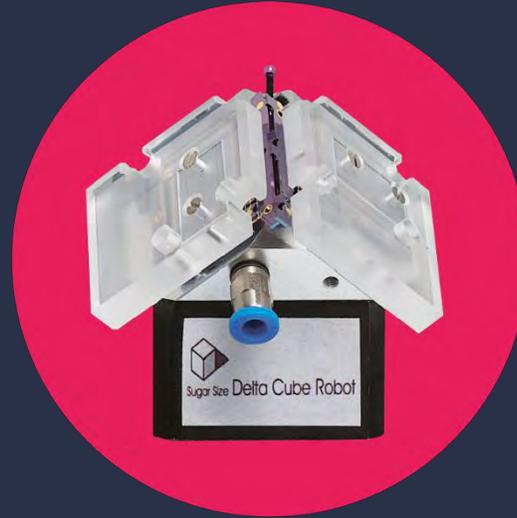
Rolando Ferrini

CSEM SA – MicroNano Optics

Swissphotonics Webinar, 03.06.2020



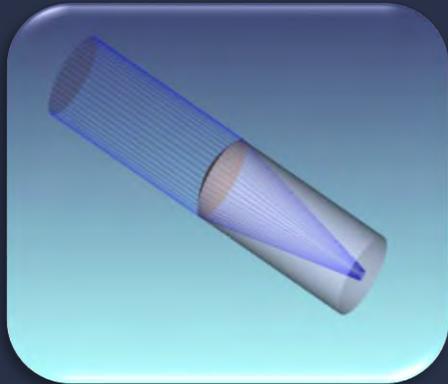
CSEM mission



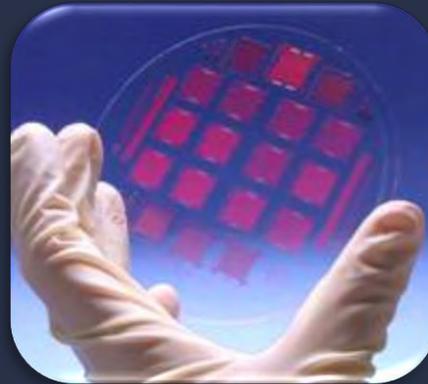
Development and transfer of world-class (micro-)technologies to the industrial sector – in Switzerland, as a priority – in order to reinforce its competitive advantage.

- Cooperation agreements with established companies
- Encouraging the creation of start-ups

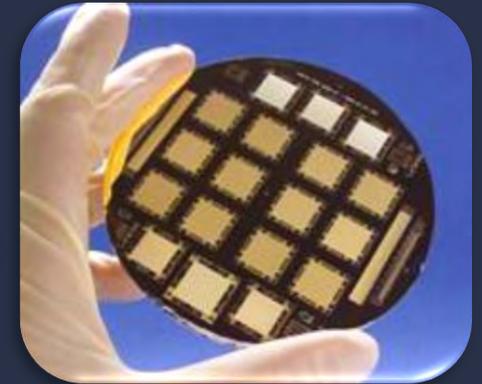
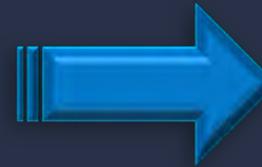
Manufacturing by imprint technologies



Design & simulation



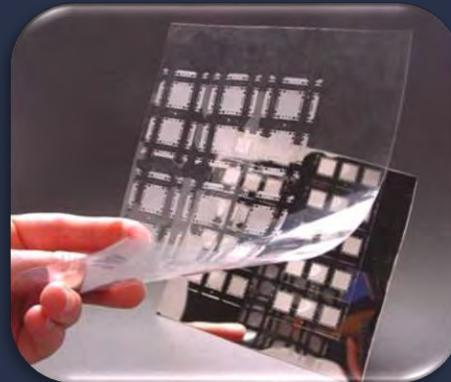
Origination



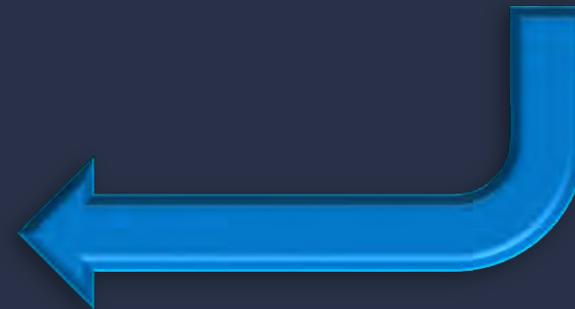
Tooling



Manufacturing upscaling



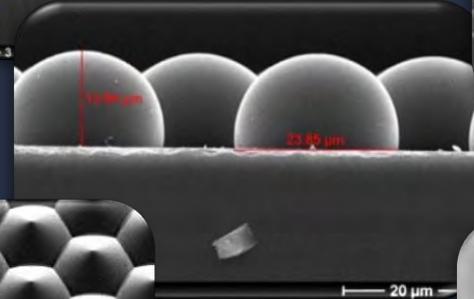
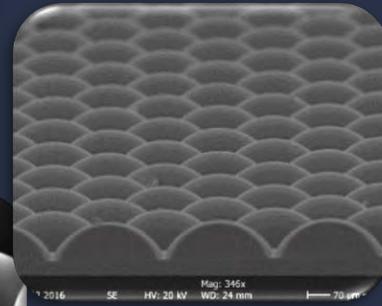
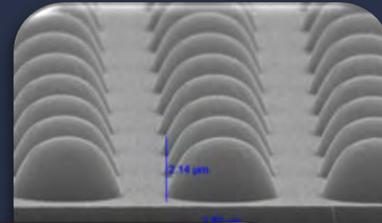
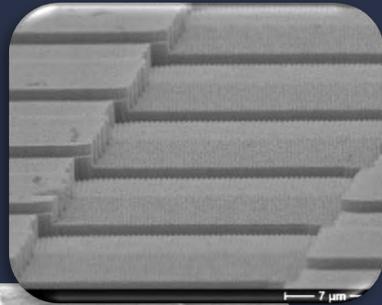
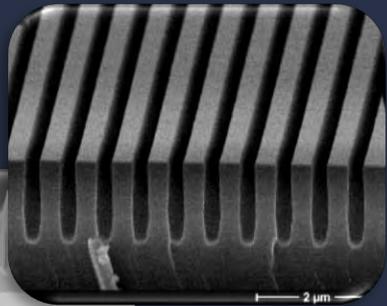
Replication



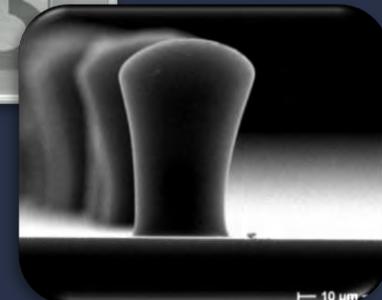
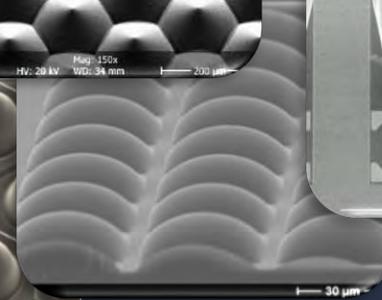
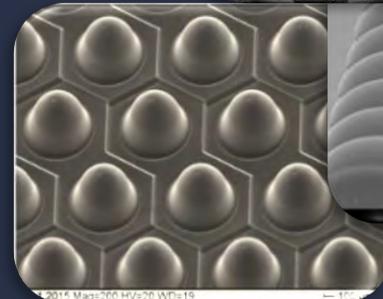
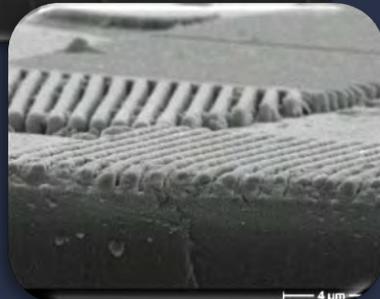
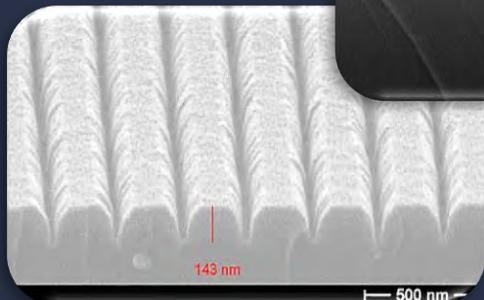
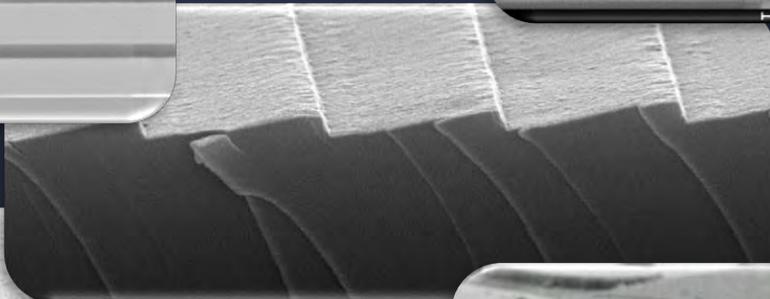
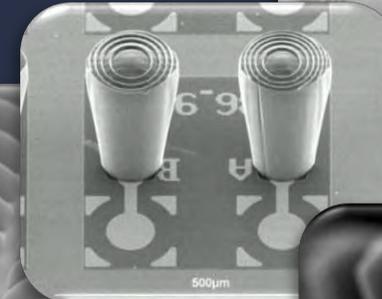
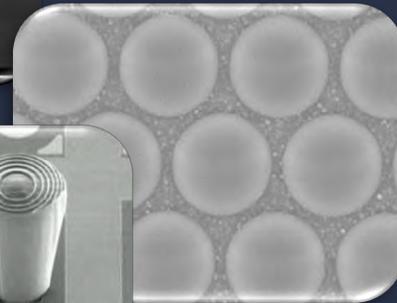
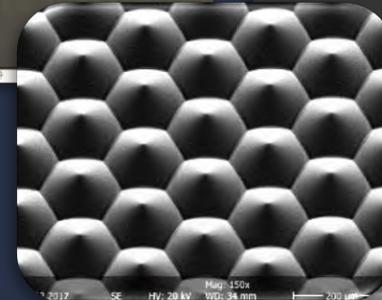
Nano- & Micro-optical structures

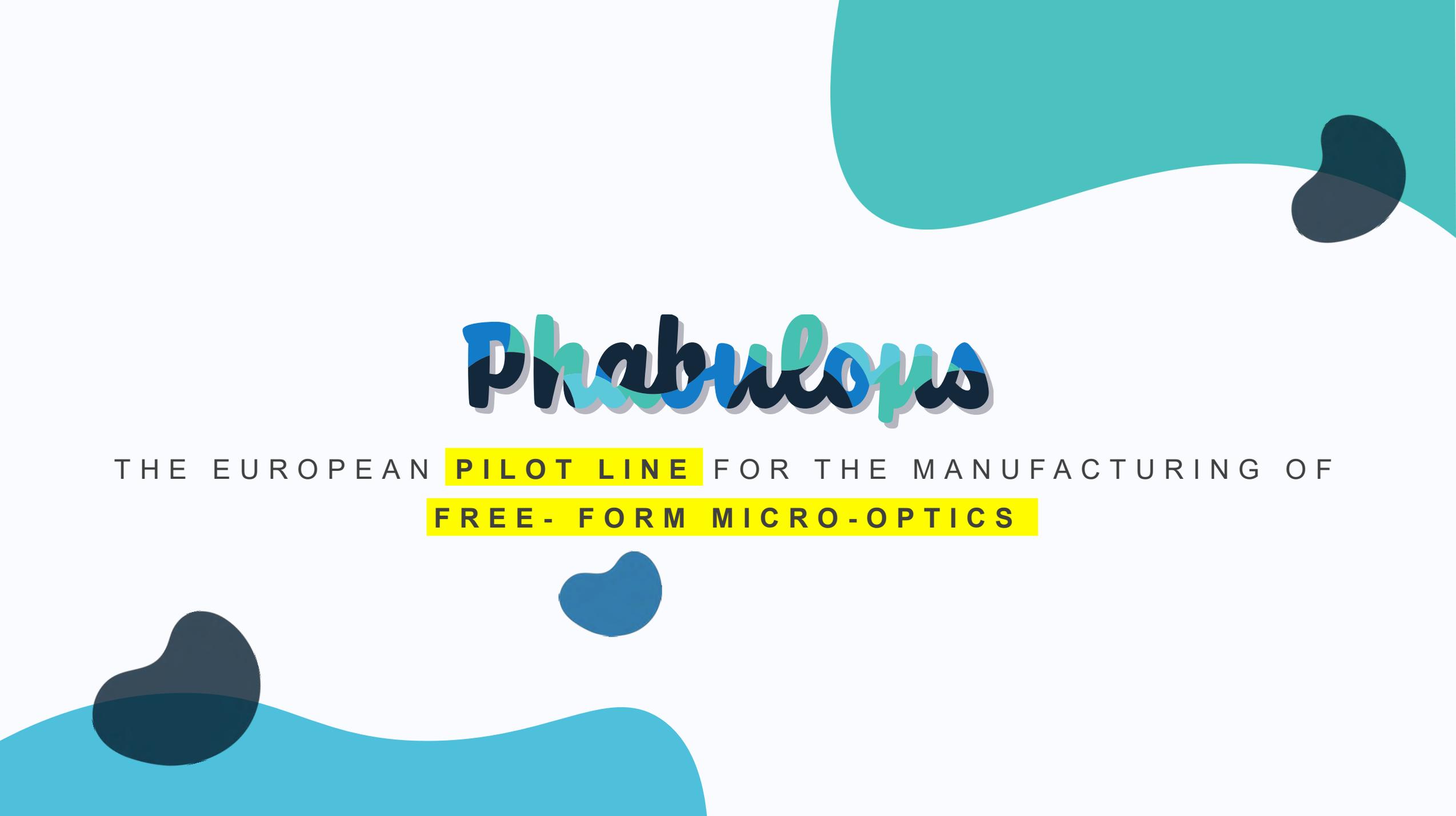
Nano

Micro



4





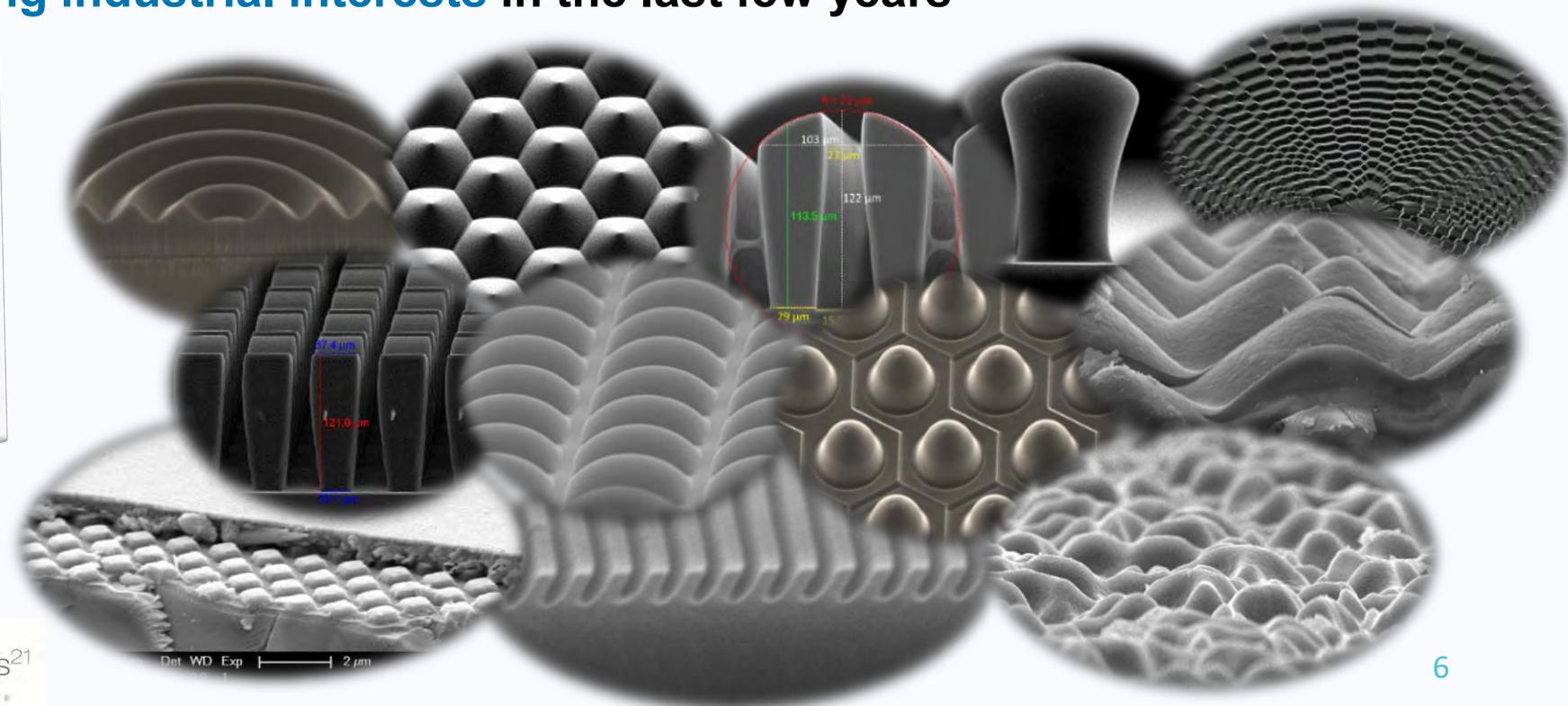
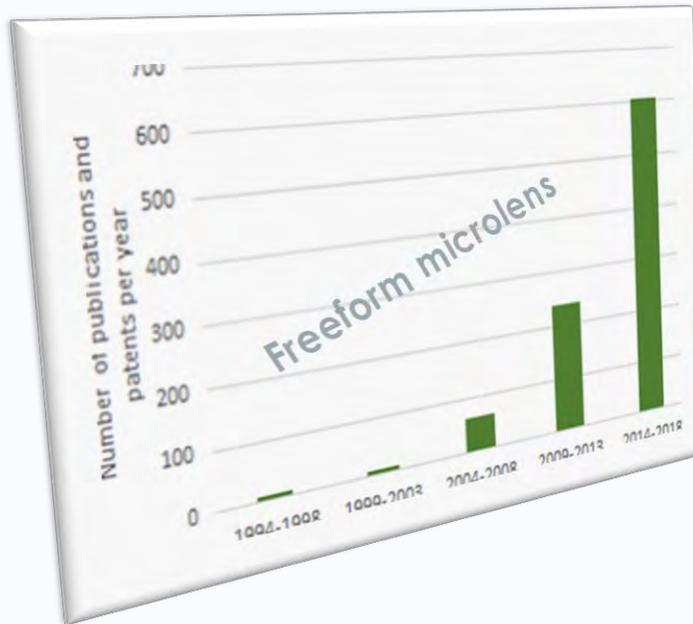
Phabulous

THE EUROPEAN **PILOT LINE** FOR THE MANUFACTURING OF
FREE-FORM MICRO-OPTICS

Free-form micro-optics

Free-form micro-optics consists of micro-optical components

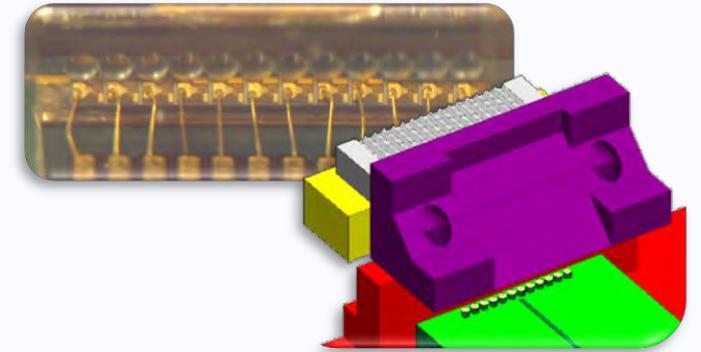
- with no symmetry restrictions
- gaining an increasing industrial interest in the last few years



Free-form optics for PICs

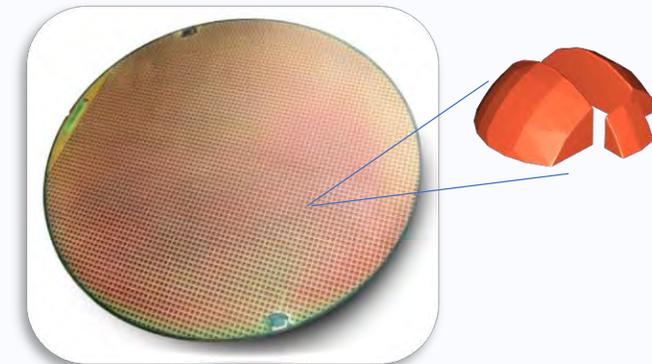
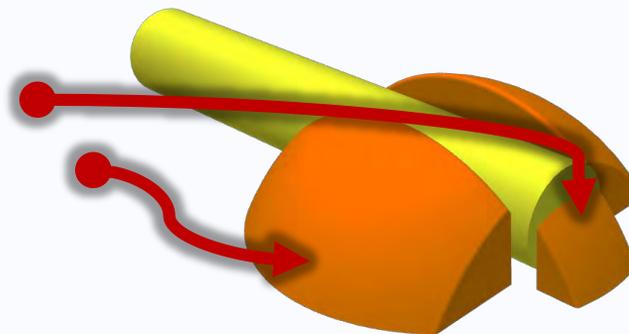
□ Folded interconnects: Current solutions

- Optical connectivity is based principally on collinear solutions
- Folded connectivity is mainly done with additional components, such as parabolic mirrors, optical benches, lens mirror systems etc.

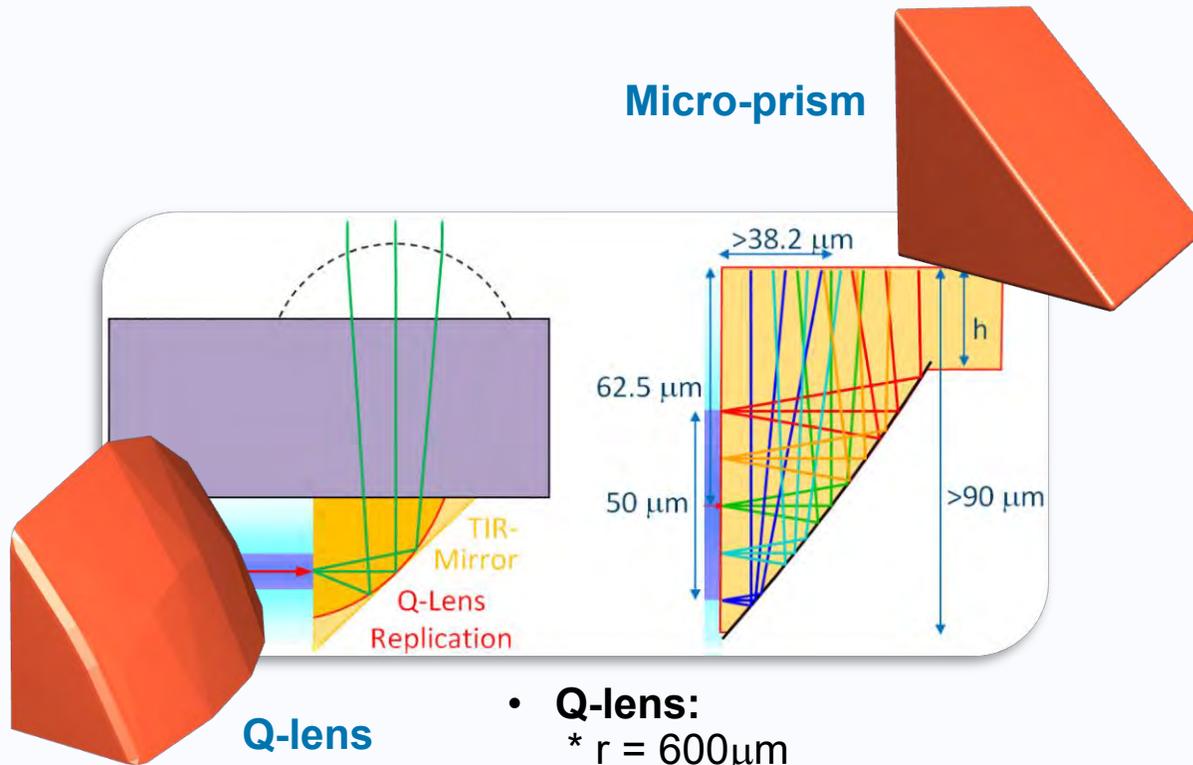


□ Folded interconnects: CSEM solution

- Operational for all standard telecom optical fibers (SM & MM, 850-1650nm)
- Integrated micro-optical component
- Light bending → TIR (Total Internal Reflection)
- Fiber coupling → Self-alignment micro-structures
- **Wafer-scale compatible**



Design & Fabrication

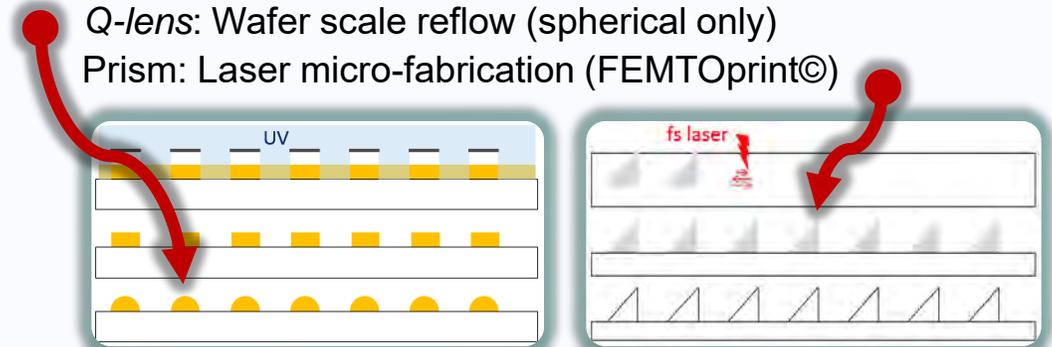


- **Q-lens:**
 - * $r = 600 \mu\text{m}$
 - * $r = 780 \mu\text{m}$
- **Micro-prism:**
 - * $a = 45 \text{ deg}$; $h = 80 \mu\text{m}$

- **Master origination**

Q-lens: Wafer scale reflow (spherical only)

Prism: Laser micro-fabrication (FEMTOprint©)

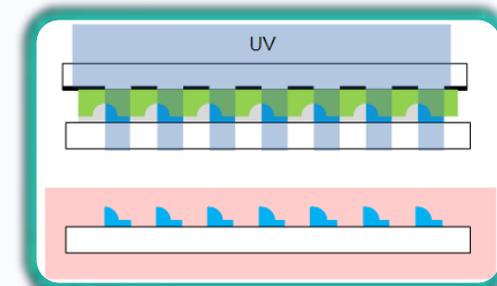


- **Mould tool on structured mask**



- **Lens replication and alignment structures**

Single process step

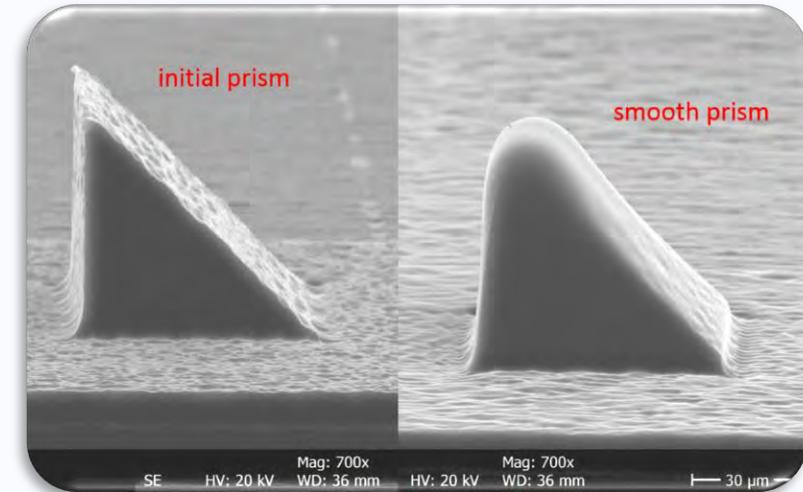


Fabricated folded interconnects

□ Replication of Micro-prisms

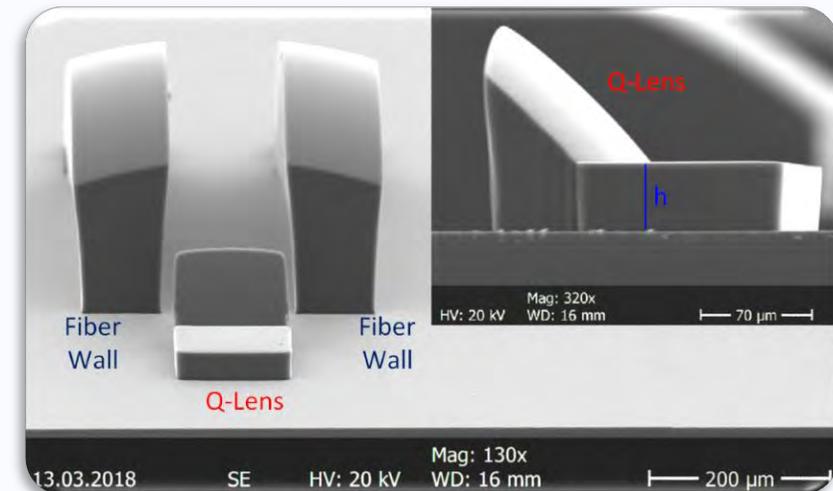
- without smoothed master → rough surface
- with smoothed master → good surface / rounded edge

Commercial micro-prism as master benchmark

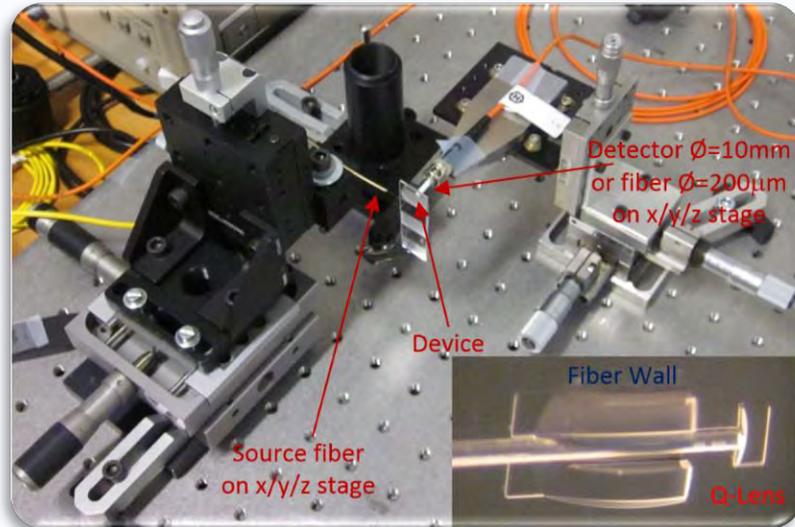


□ Replications of Q-lens

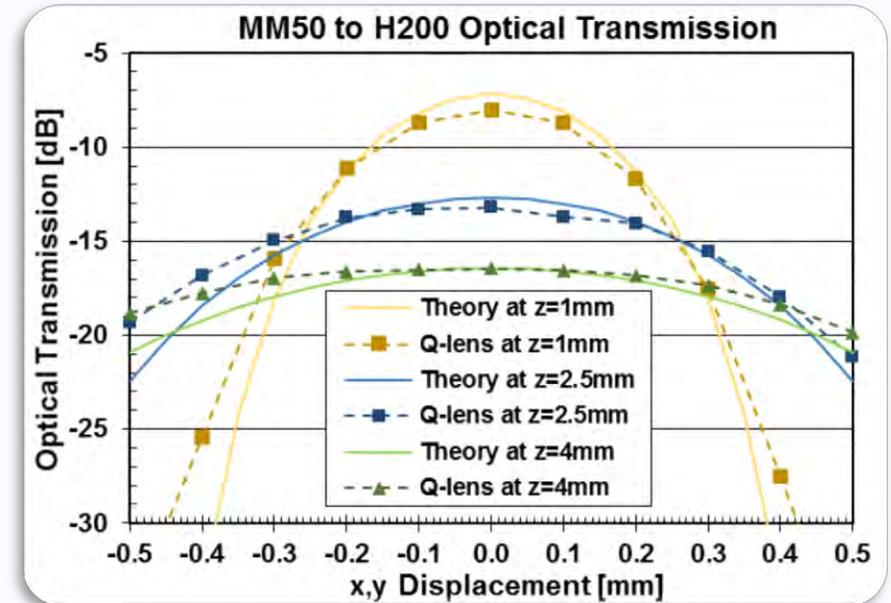
Nice surface & edges also for the alignment fiber walls



Optical losses & Mode profile



Device	SM loss [dB]	MM loss [dB]
45° Prism (replicated from commercial μ prism)	0.35	0.42
Q-lens 600	0.42	0.48
Q-lens 780	0.36	0.38



Results of Q-lens ($r=780 \mu\text{m}$) with MM as input fiber at different z-distances in comparison to simulations

□ Optical losses below 0.5 dB

□ The optical mode profile and the angular directivity are well maintained

What's PHABULO_μS

PHABULO μ S ...

... is the European **one-stop shop** for the manufacturing of **free-form micro-optics**

... offers

- ❑ accelerated innovation & production cycles
- ❑ manufacturing services
- ❑ prototyping → piloting → large volume production



« Who »

We are ...

Phabulous

EU

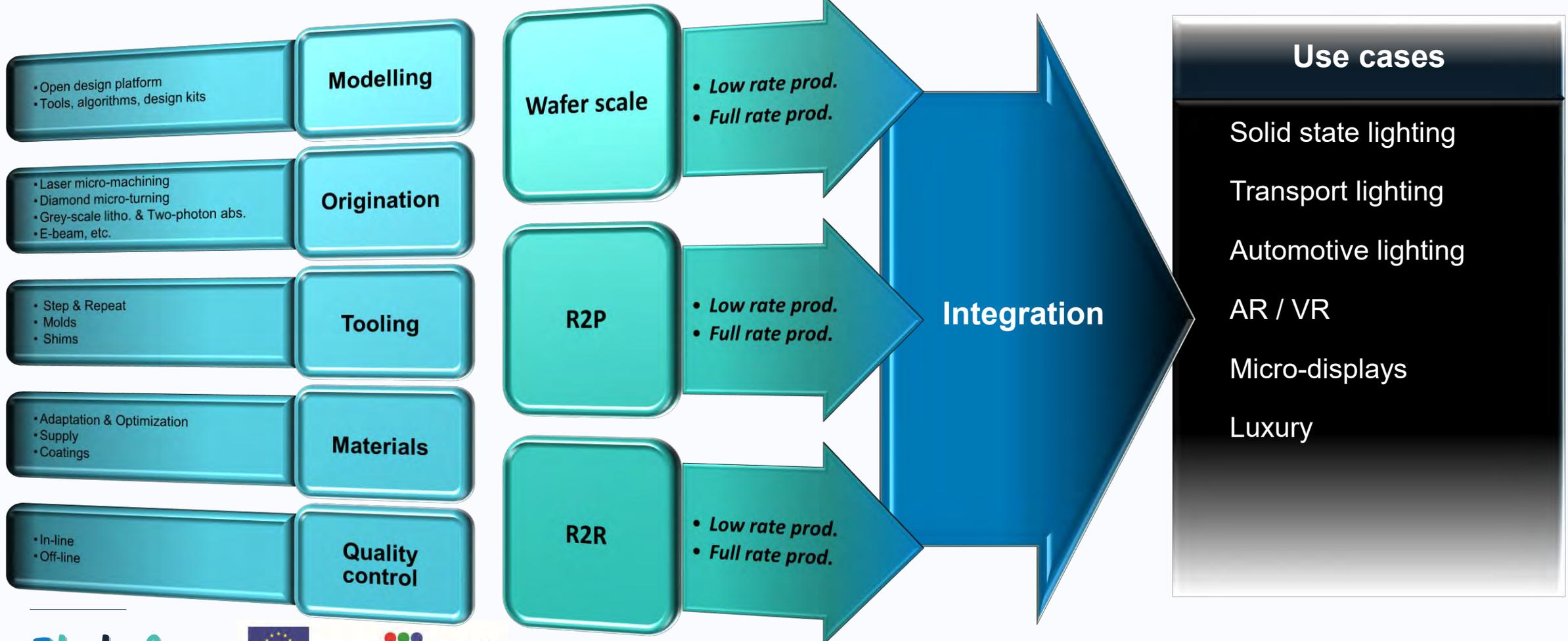
- csem
- JOANNEUM RESEARCH
- Fraunhofer FEP
- VTT
- leti
- SDSS MicroOptics
- monophotonics
- NANOCOMP
- Power Photonics
- lasea
- Wielandts upmt
- HELLA
- limbak
- microoLed
- ZUMTOBEL
- SEISENBACHER
- SWAROVSKI
- EPIC
- AMIRÈS

« What »

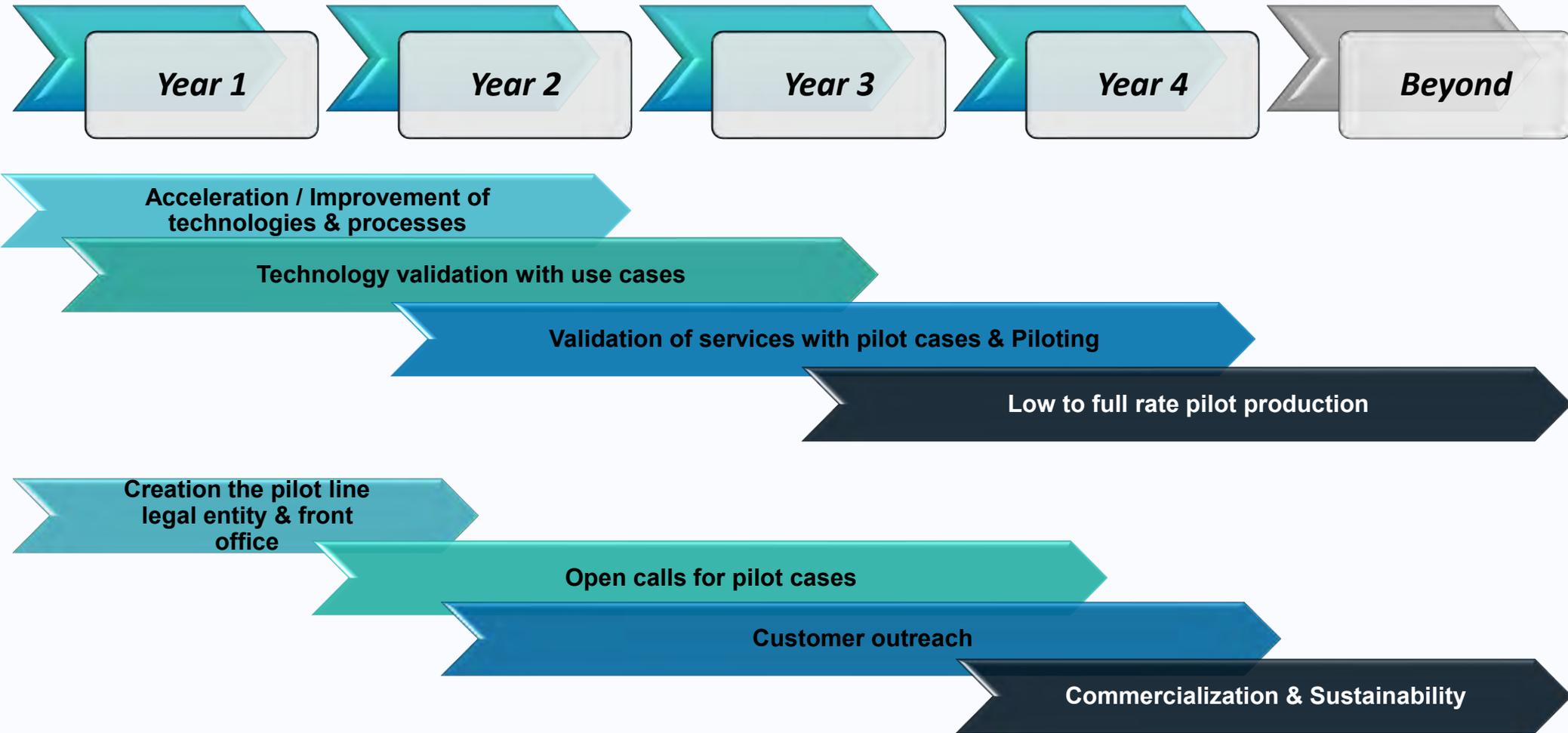
Production Services & UV imprint manufacturing

Product integration

Technology validation

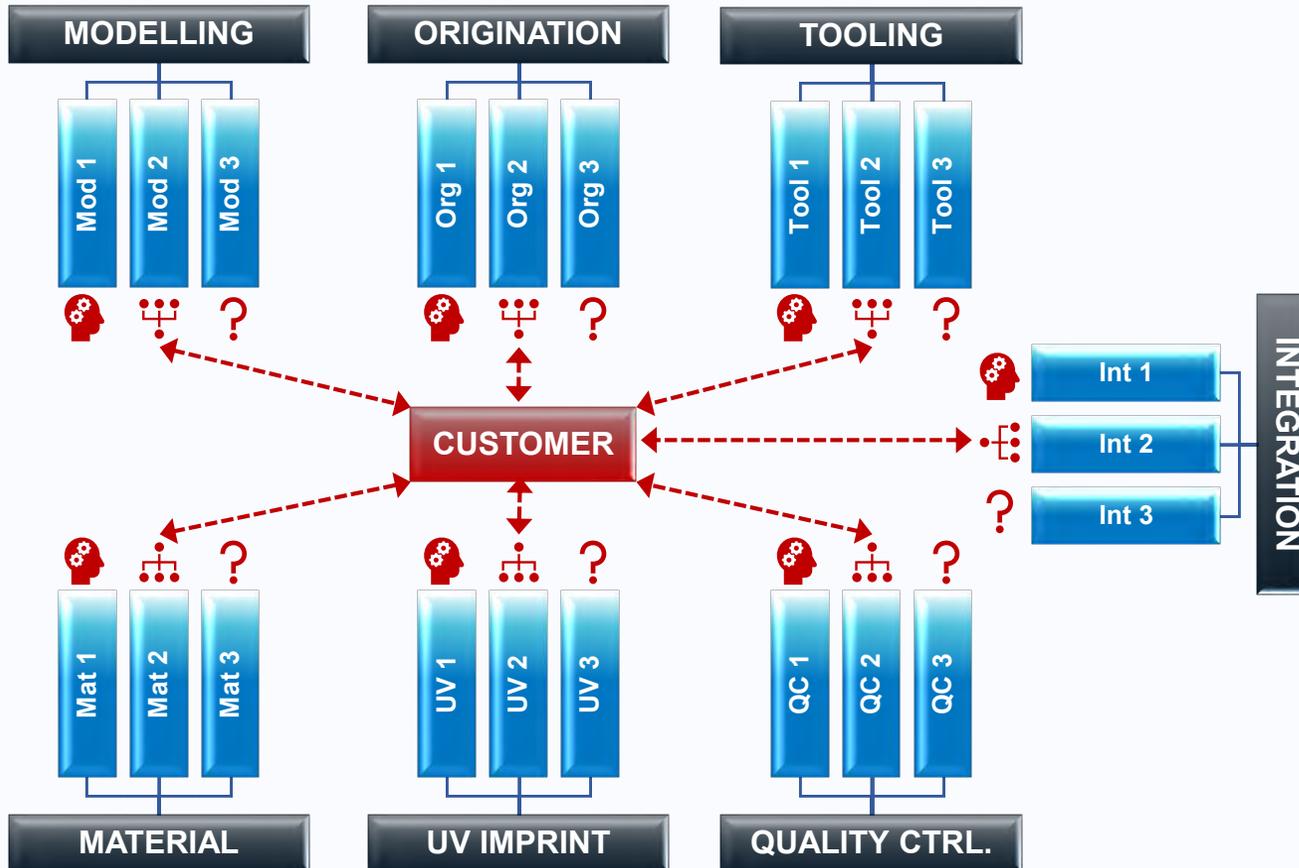


« How »

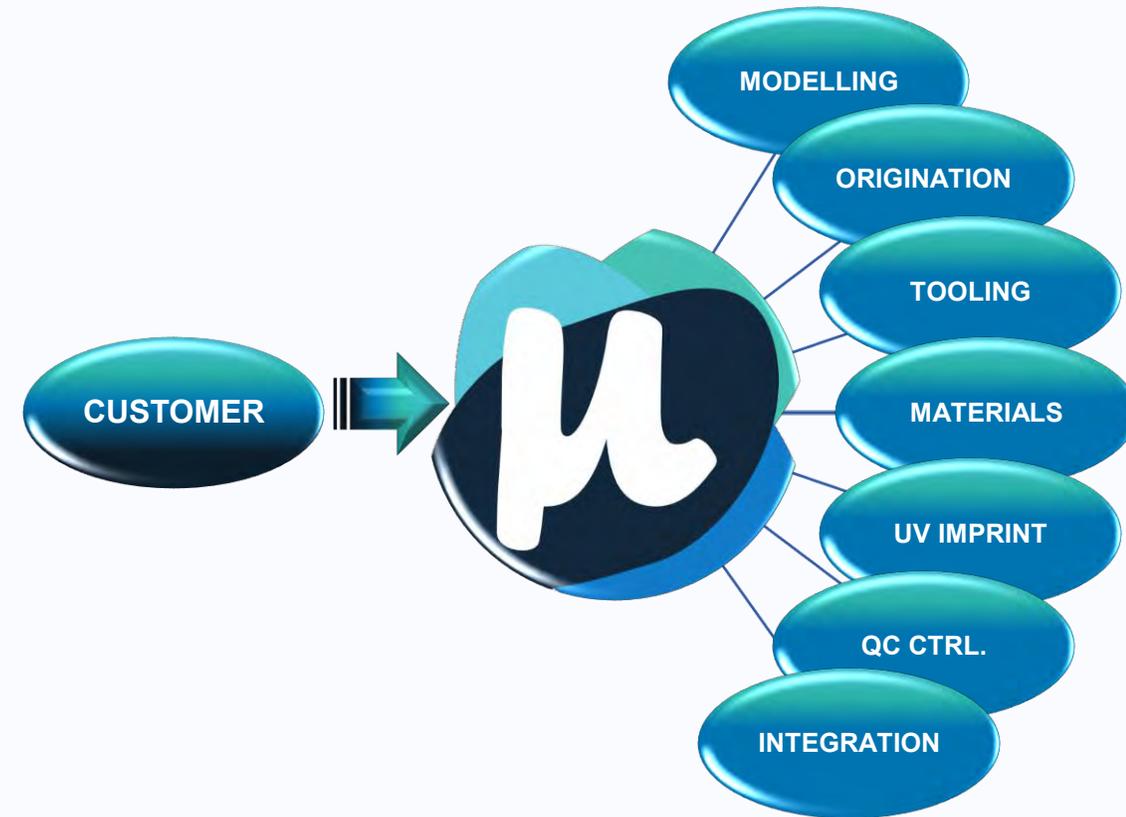


« Why »

Without PHABULOU μ S



With PHABULOU μ S

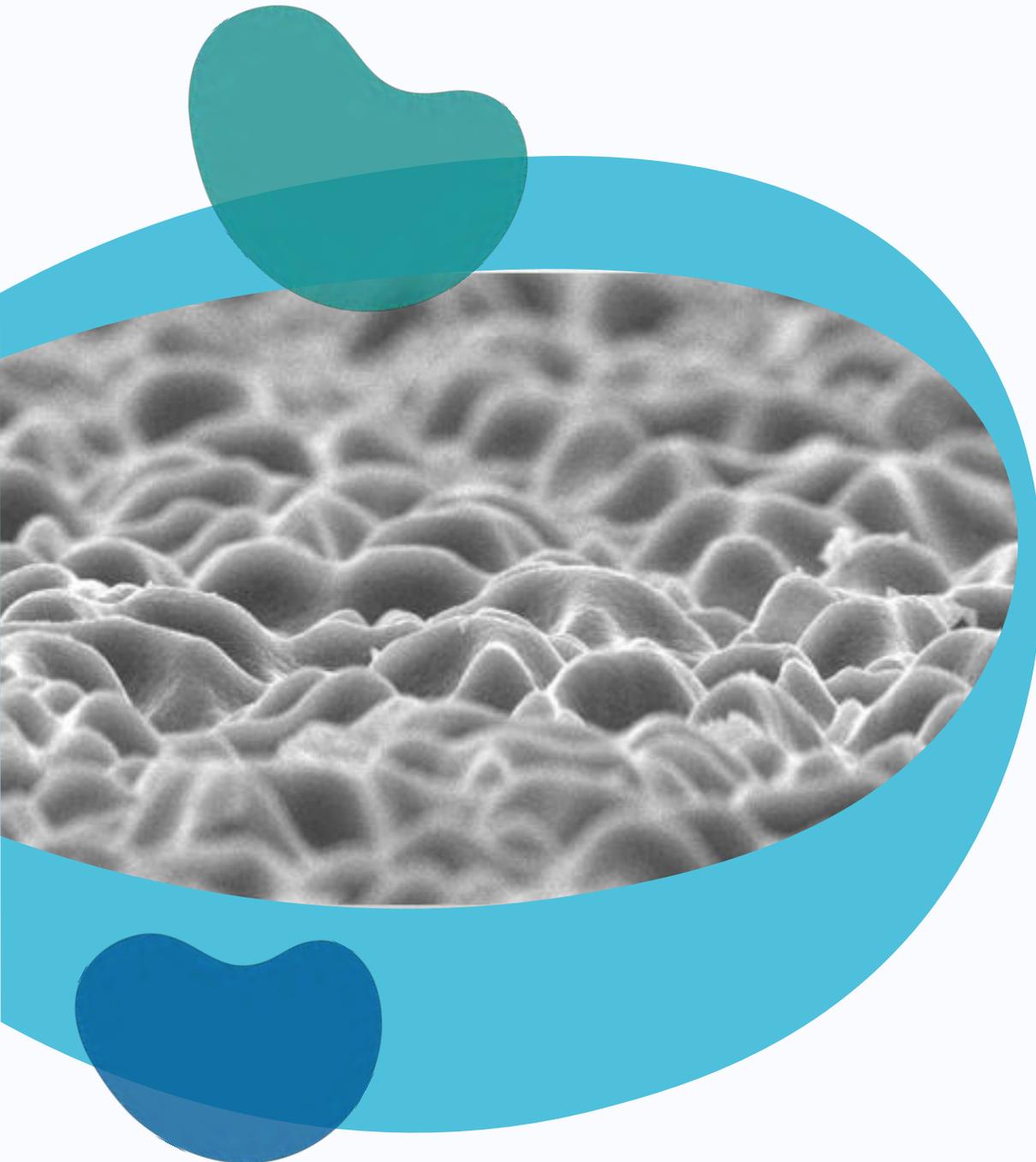


« For whom »



Micro-optics is ...

Phabulous



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