MICRO-OPTICS IS...

Phabulous

Phabulous –
Fabrication technologies for free-form optics

T. Offermans
EPIC TechWatch at ECOC
21 September 2022
Basel, Switzerland

EPIC
European Photonics Industry Consortium

Outline

- What is **PHABULOμS**
- Overview of the Phabulous **Fabrication Technologies**
- Applications of free-form optics - **Use Case examples**
- Applications in **Telecommunication**

Introduction to PHABULOuS

- **PHABULOµS** is a European funded project / pilot line within the Horizon H2020 Program for the manufacturing of free-form micro-optics
- **PHABULOµS Pilot Line Association** is the legal entity created within this project to continue the offering of services after the project.

MICRO-OPTICS IS...

Phabulous

Funded by:

PHOTONICS 21

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

Our Goals

MICRO-OPTICS IS...
Phabulous

- **Unify** European research and technology organisations and industrial partners into a **Pilot Line for the design and manufacturing** of free-form micro-optics solutions.
- **Promote** advanced micro-optics technologies and solutions and **offer a single-entry point** (one-stop shop) in order to facilitate access to the complete production chain.
- **Represent** the interests of the **micro-optics community** on a national and international basis.

MICRO-OPTICS IS...

Phabulous

Pilot Line for design and manufacturing

Unify European research and technology organisations and industrial partners into a Pilot Line for the design and manufacturing of free-form micro-optics solutions.

csem

JOANNEUM RESEARCH

VTT

Fraunhofer FEP

leti cea tech

SÜSS MicroOptics

morphotonics

NANOCOMP

Wielandts upmt

LASEA

PowerPhotonic

EPIC European Photonics Industry Consortium

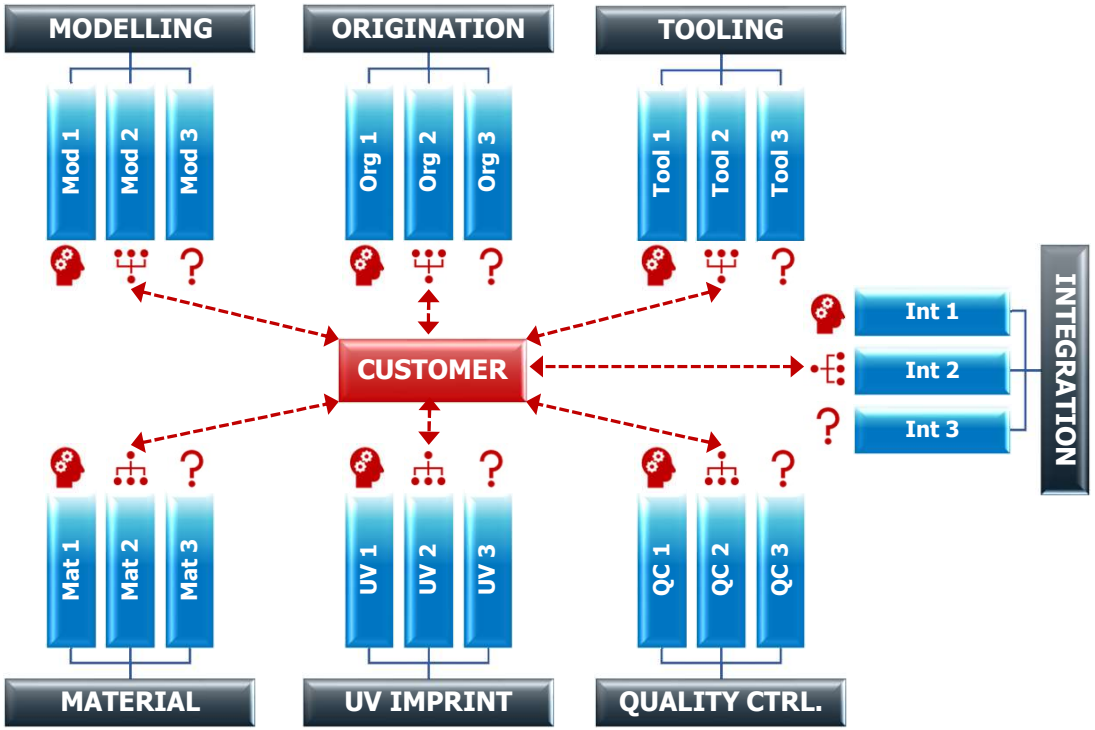
AMIRES

MICRO-OPTICS IS...

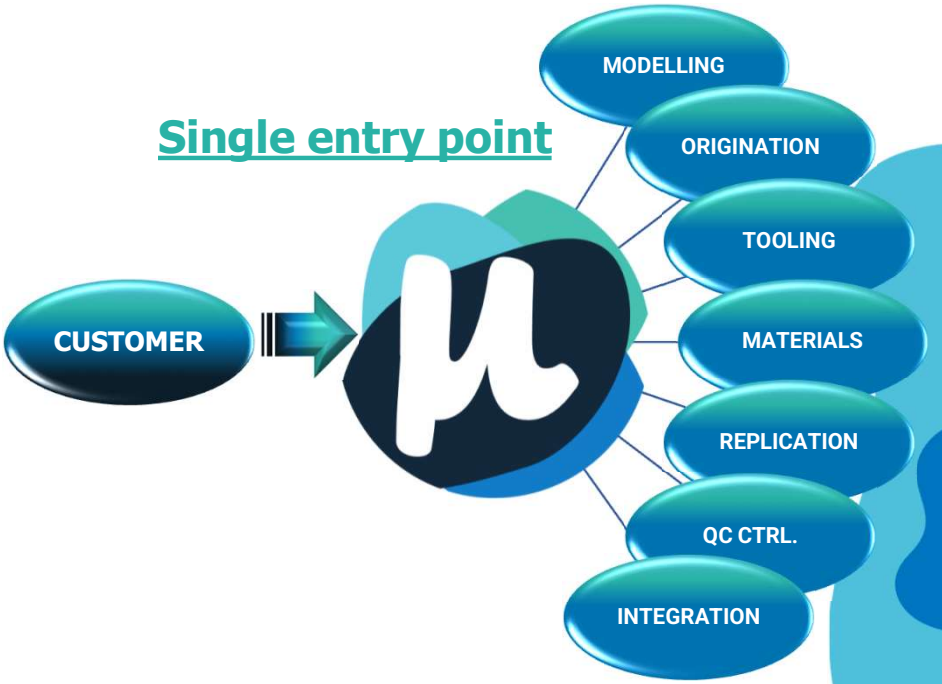
Phabulous

Pilot Line for design and manufacturing

Without PHABULOuS



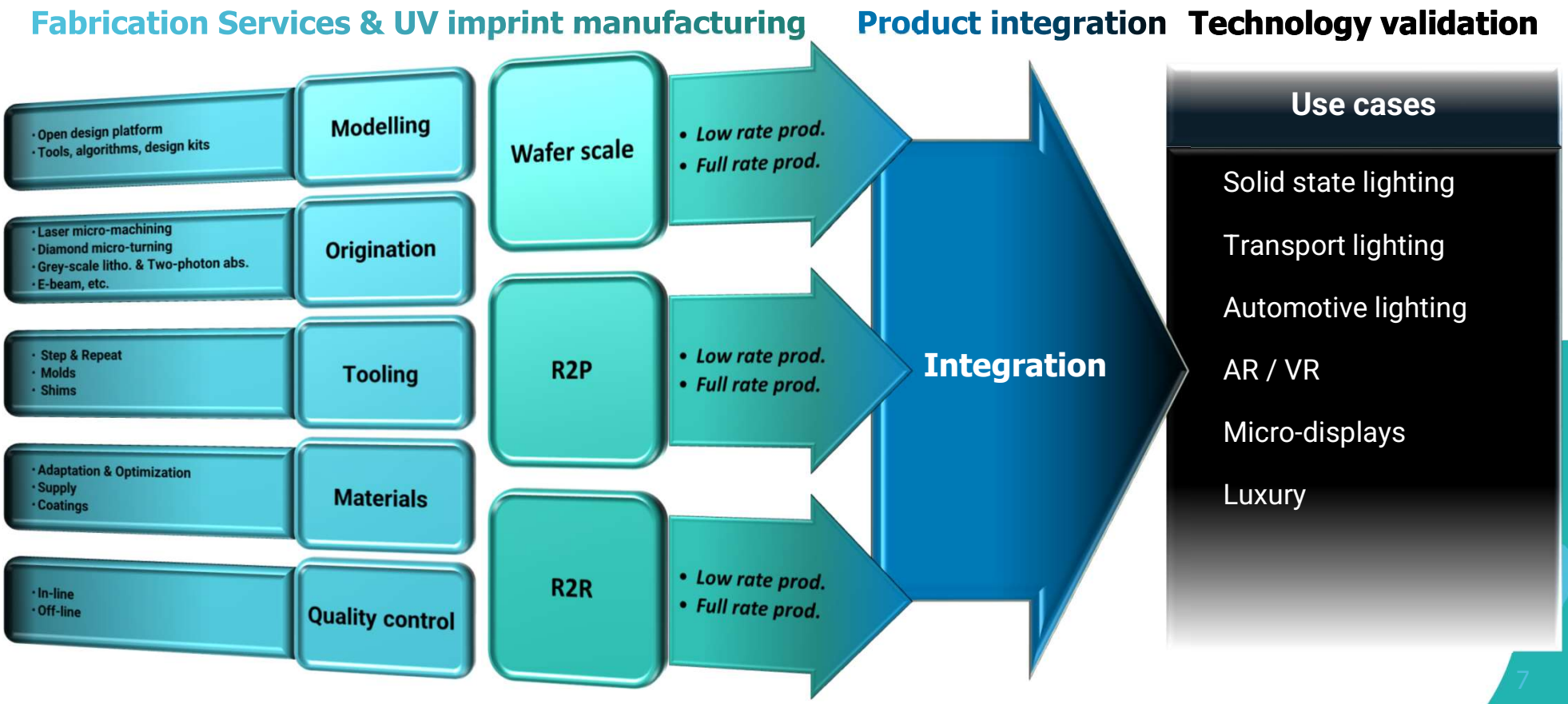
With PHABULOuS



MICRO-OPTICS IS...

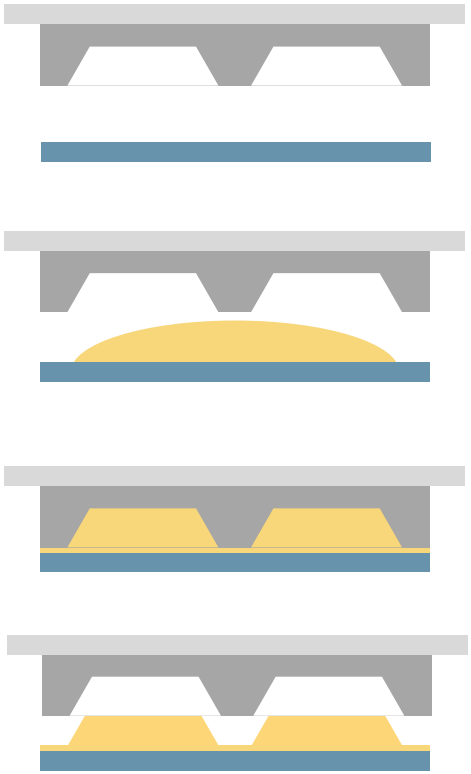
Phabulous

Pilot Line for design and manufacturing



UV Imprinting

Wafer scale



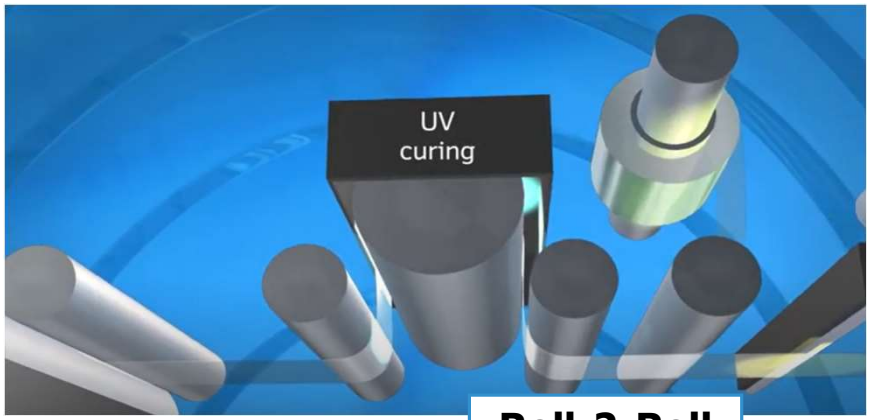
Stamp

Prepared substrate

Dispensing of imprint resist Alignment

Imprint and curing

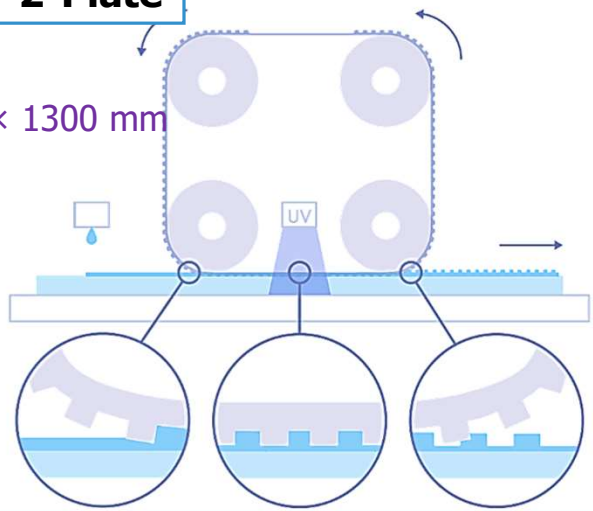
Release and posttreatment



Roll-2-Roll

Roll-2-Plate

1100 × 1300 mm

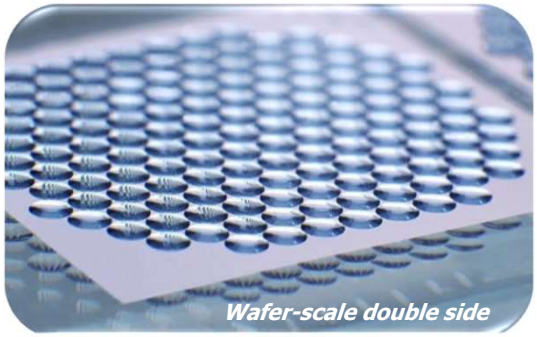


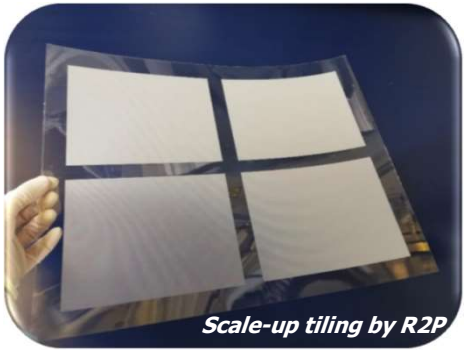
MICRO-OPTICS IS...

Phabulous

UV Imprinting

Replication	Wafer-scale	R2P	R2R	
Max. area	200 mm round	1100 × 1300 mm	250 mm x 10 km	480 mm (width)
Shape limitations	Angles <45°, height < 500 micron, preferred element size < 20 x 20 mm	max. aspect ratio 3:1 max. height 500 µm	No undercut	No undercut
Manufacturing time / m^2	10 h	up to 10 seconds/m^2	0.5 – 30 m/min	max 100 m^2/h
Form fidelity	20 nm	2 to 8% vertical shrinkage	5%	±50 nm
Alignment accuracy	3 micron	± 100 µm	mm range	n/a


Wafer-scale double side


Scale-up tiling by R2P

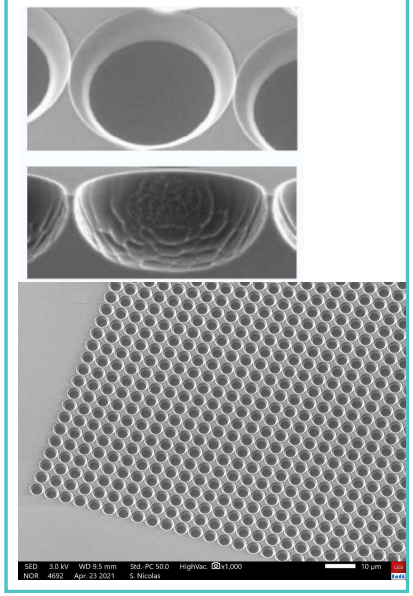

R2R

MICRO-OPTICS IS...

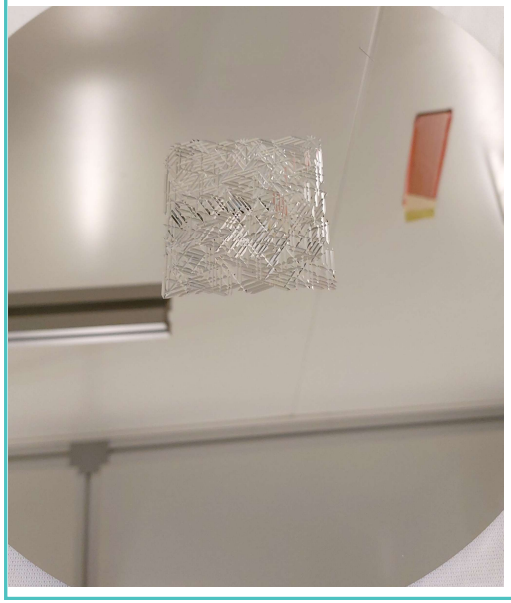
Phabulous

Origination Technologies

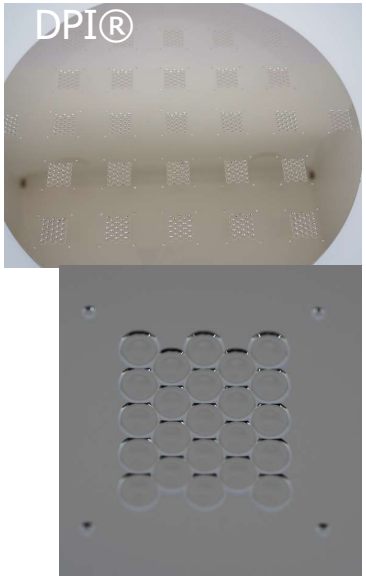
Silicon etching



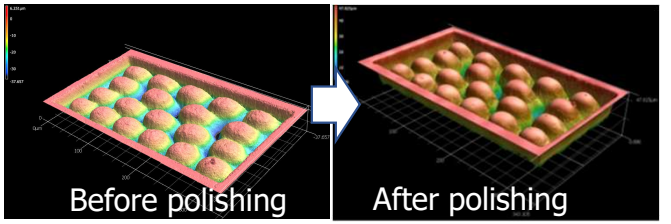
Diamond ruling

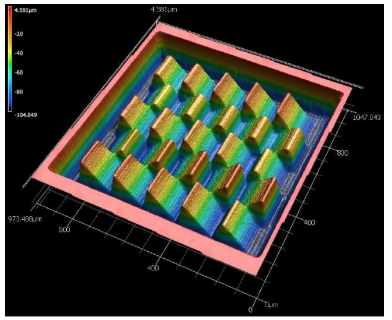


Diamond turning



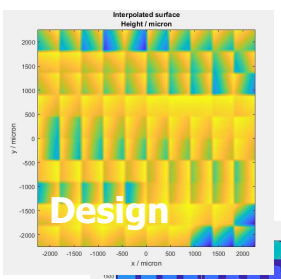
Laser ablation

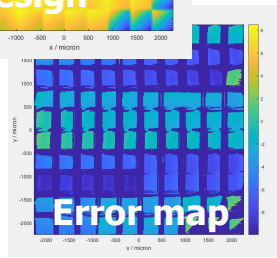




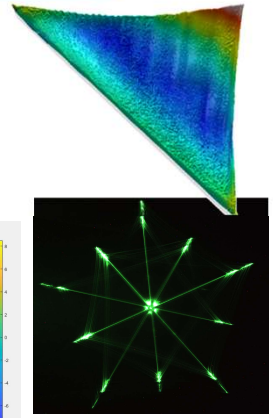
Origination Technologies

Laser micro machining



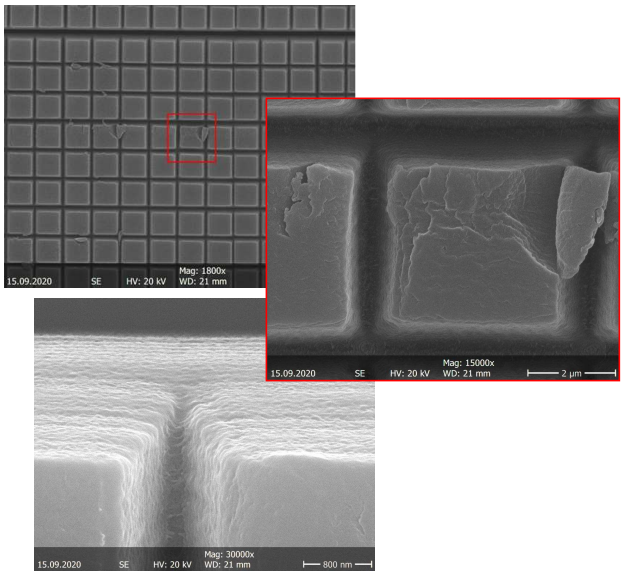


Form correction

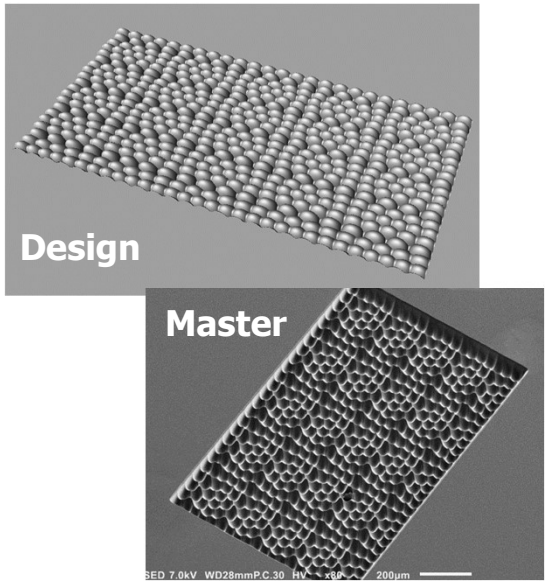


Removal of curvature

Classical Two Photon Absorption



Gray scale laser lithography

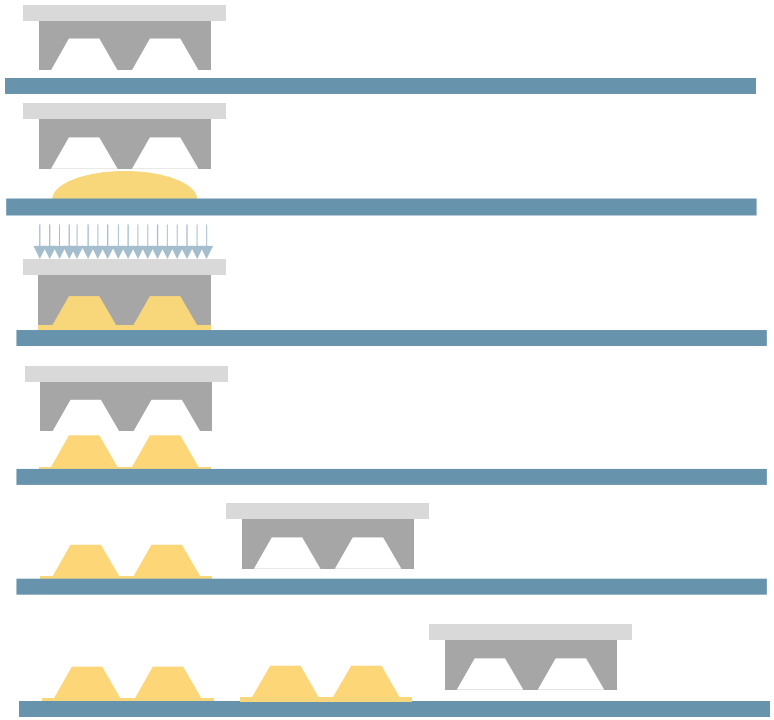


MICRO-OPTICS IS...

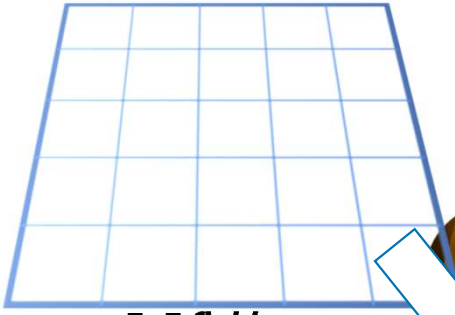
Phabulous

Upscaling

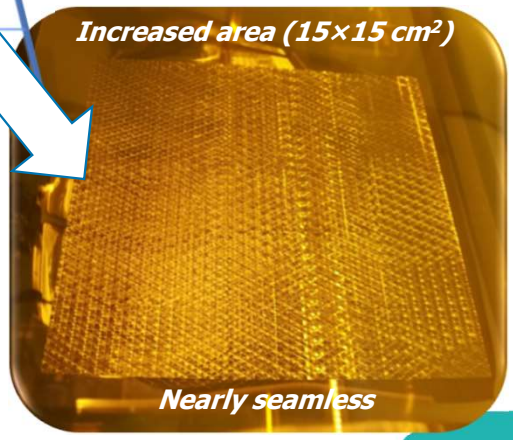
Step & repeat upscaling



+ Start position
+ Dispensing and application of stamp
+ UV Curing
+ Stamp release
+ Move to new position and repeat process
+ Move to new position and repeat process



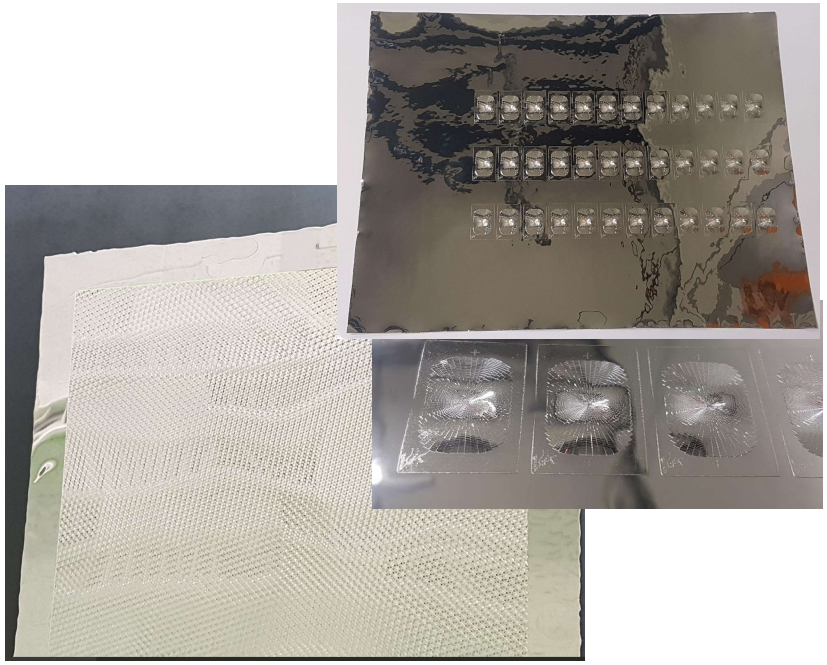
5x5 fields = 15x15 cm²



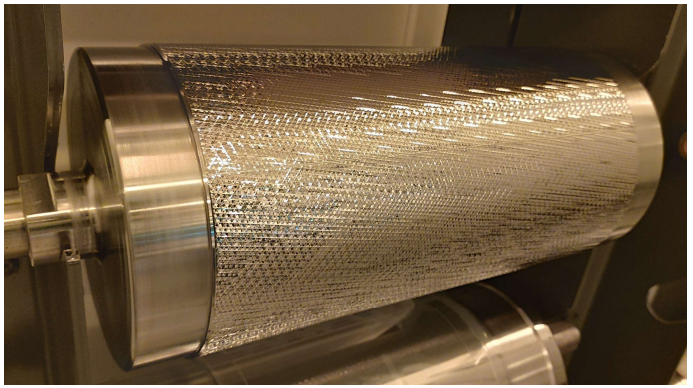
MICRO-OPTICS IS...

Phabulous

Stamp/tool fabrication
Nickel metal tools



Large area Ni shims



Large area R2R tool

Metallized polymer shims

Tooling	
Max. area	30x35 cm^2 current 35x55 cm^2 planned
Shape limitations	Overhangs / undercuts
Form fidelity	Typically ±50nm
Manufacturing time /shim	5-16 hours

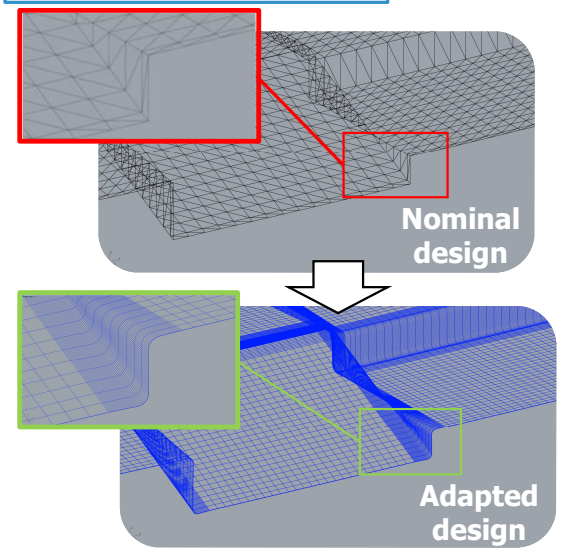
MICRO-OPTICS IS...

Phabulous

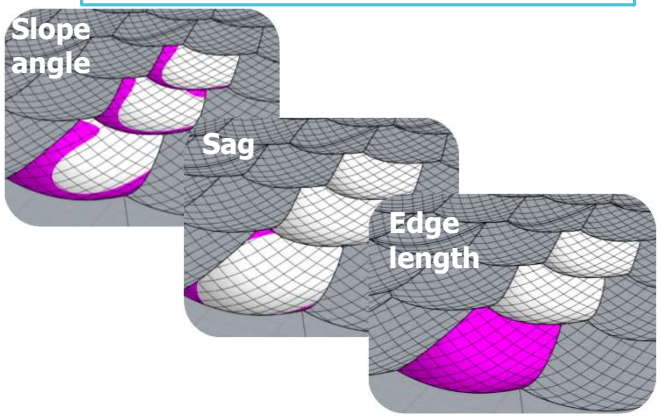
Design and modelling

Design tools for manufacturing

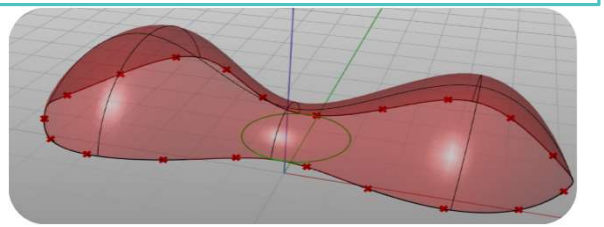
Edge smoothening



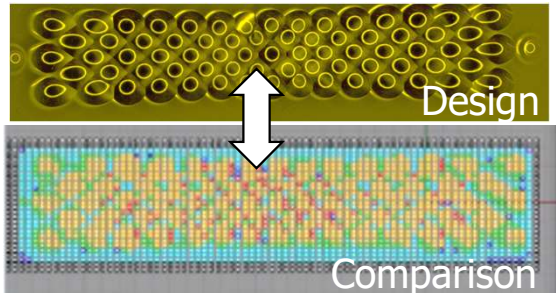
Visualization of constraints



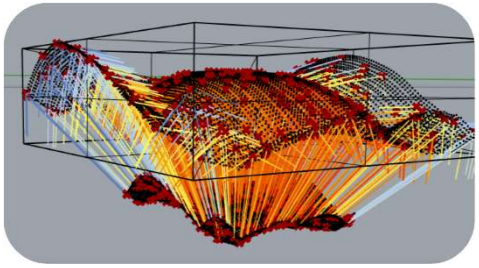
Minimal feature size



CAD comparison tool



Visualization of shrinkage

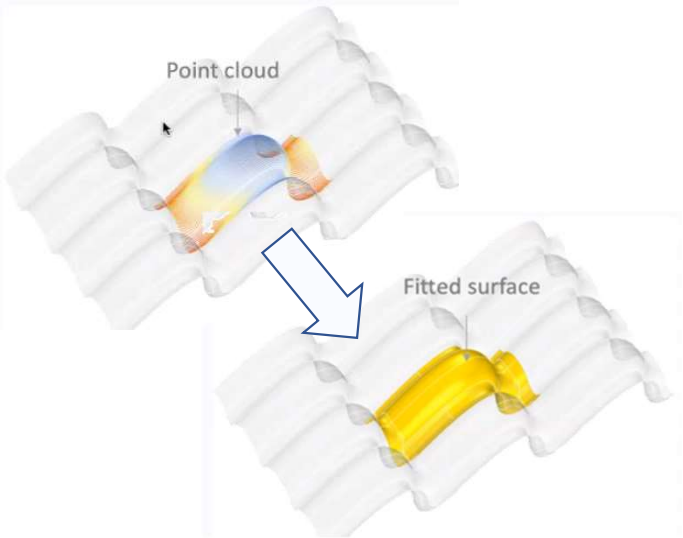


MICRO-OPTICS IS...

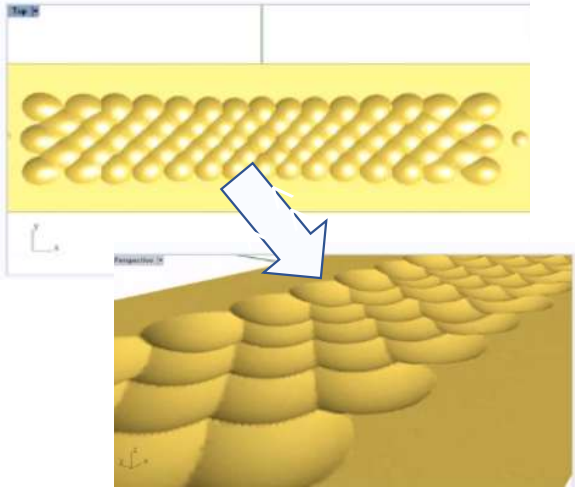
Phabulous

Quality control
Performance evaluation

Point cloud into ray traceable solid using NURBS



From **design** CAD to
ray traceable solid



From **measured point cloud** to
ray traceable solid

- **Rapid evaluation** of manufactured parts by simulation
- **Avoid** costly and time consuming integration and functional testing

Applications

Use cases

SWAROVSKI

MICROOLED

limbak

ZUMTOBEL

SEISENBACHER

FORVIA HELLA

Demonstrating the capabilities of the PHABULOuS Pilot Line

Use Case:
Brilliance in luxury

- **Goal:** Seamless manufacturing of µ-structured foils with gemstone appearance

- **Phabulous solution:**
  - New origination technologies
  - Step&Repeat UV-replication
  - R2R production
  - Coating



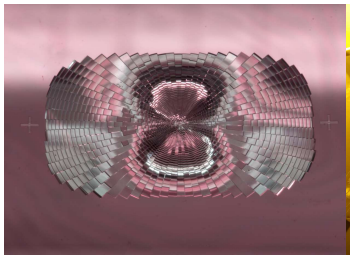

Phabulous PHOTONICS 21 PHOTONICS PUBLIC PRIVATE PARTNERSHIP

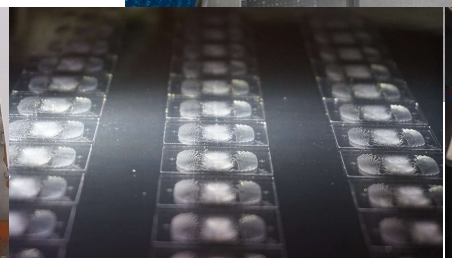
SWAROVSKI

Use Case:
Transportation interior lighting

- **Goal**: Large-area direct-lit LED luminaires with better performance, small form factor

- **Phabulous solution:**

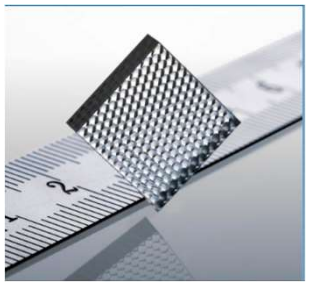


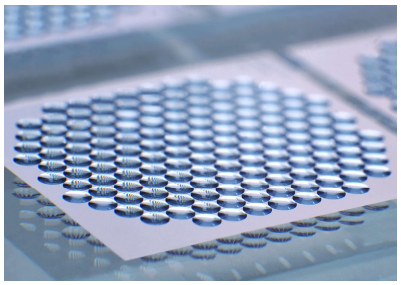




Mastering → Upscaling → Galvanization → R2P replication → Integration

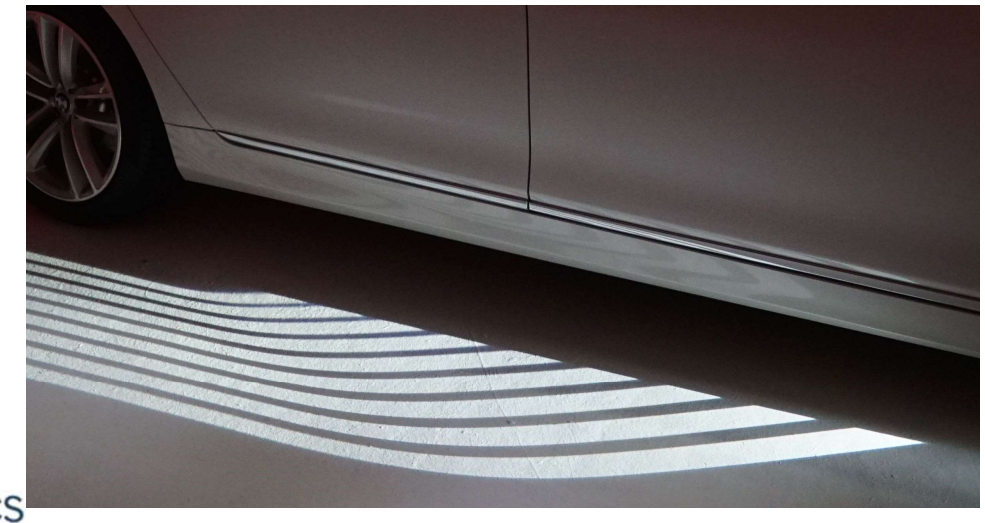
Application example
Automotive Lighting

Light-carpet





- UV-imprinted micro lens arrays (MLAs)
- Wafer scale based
- High volume production

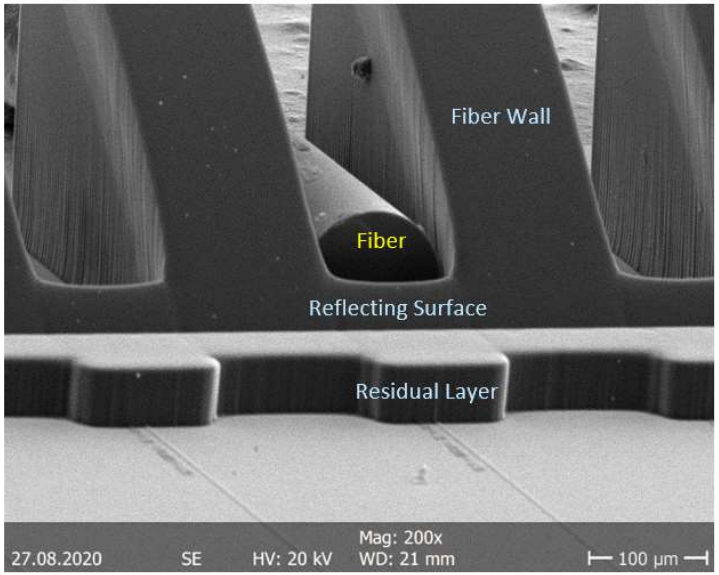


SÜSS MicroOptics

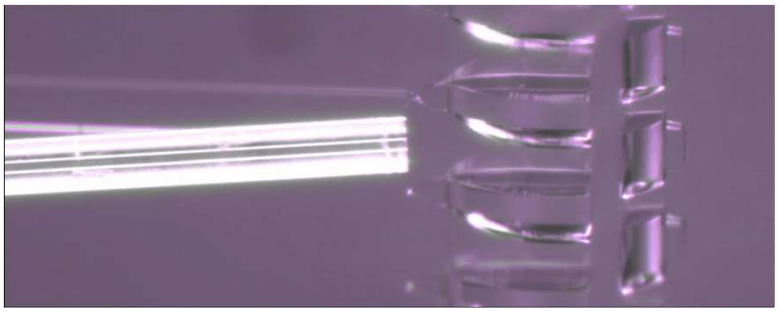
Application example
Telecommunication

Optical interconnects

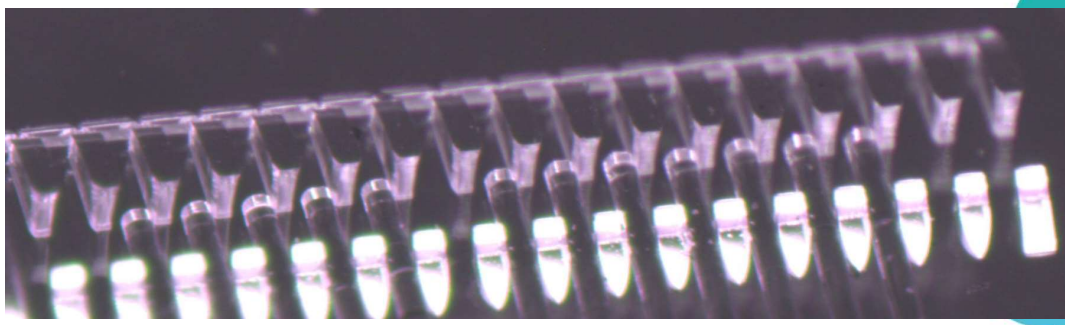
- UV-Replication of in-plane micro-optical interconnects on SiN waveguides
- Plug & Play assembly of fibers with self-alignment structures



Krähenbühl et al. ESTC 2022



Fiber self alignment

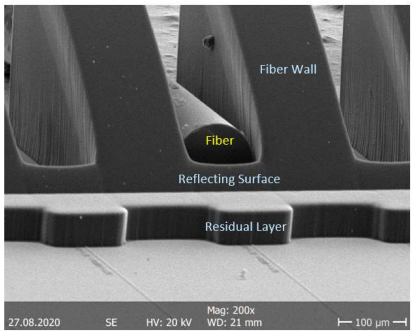


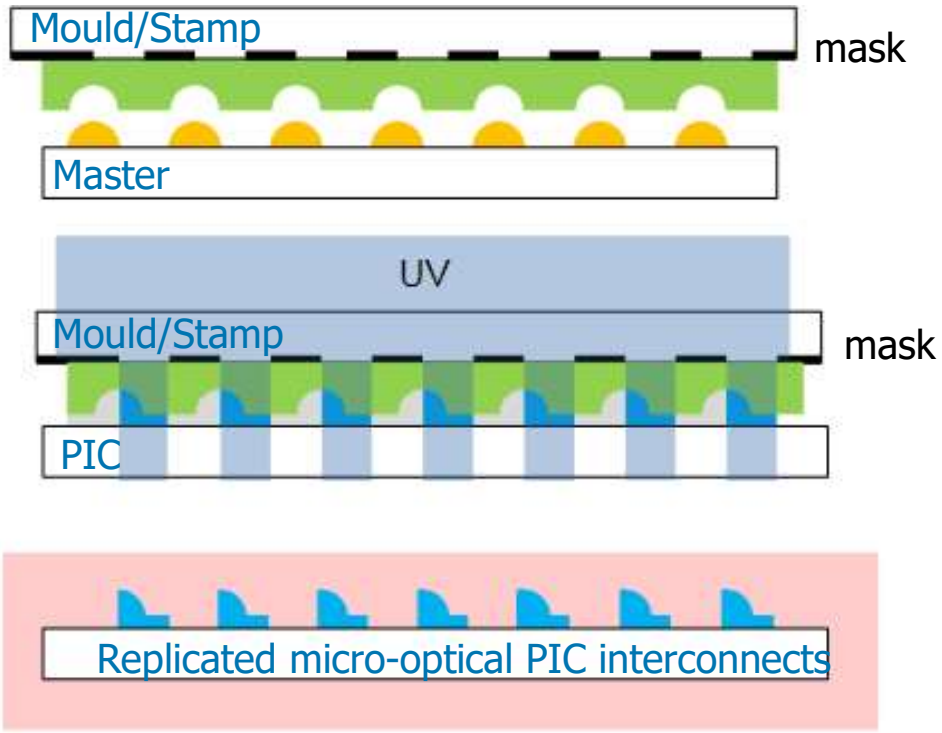
partly inserted fiber array

csem

Application example
Telecommunication
Optical interconnects

- Wafer-scale UV replication
- Precise control of the alignment of the replicated elements



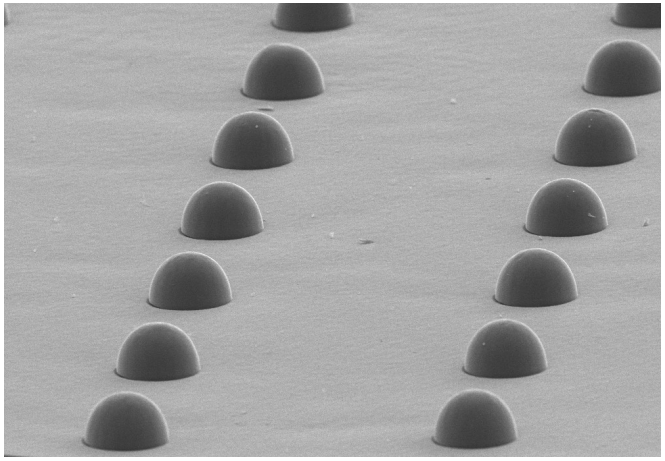


Krähenbühl et al. ESTC 2022

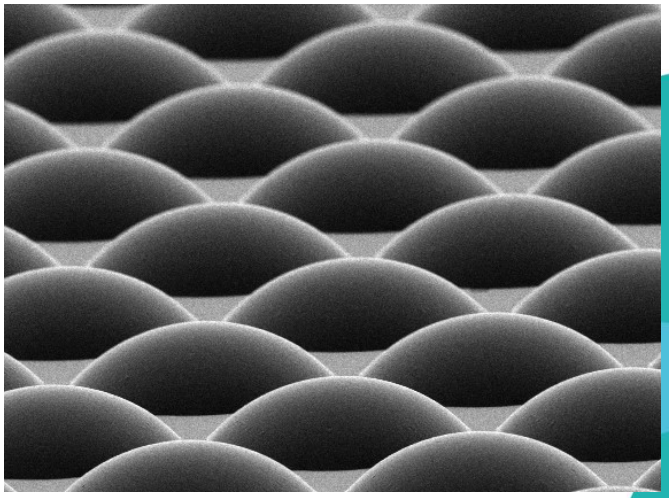
csem

Application example
Telecommunication

High coupling efficiency

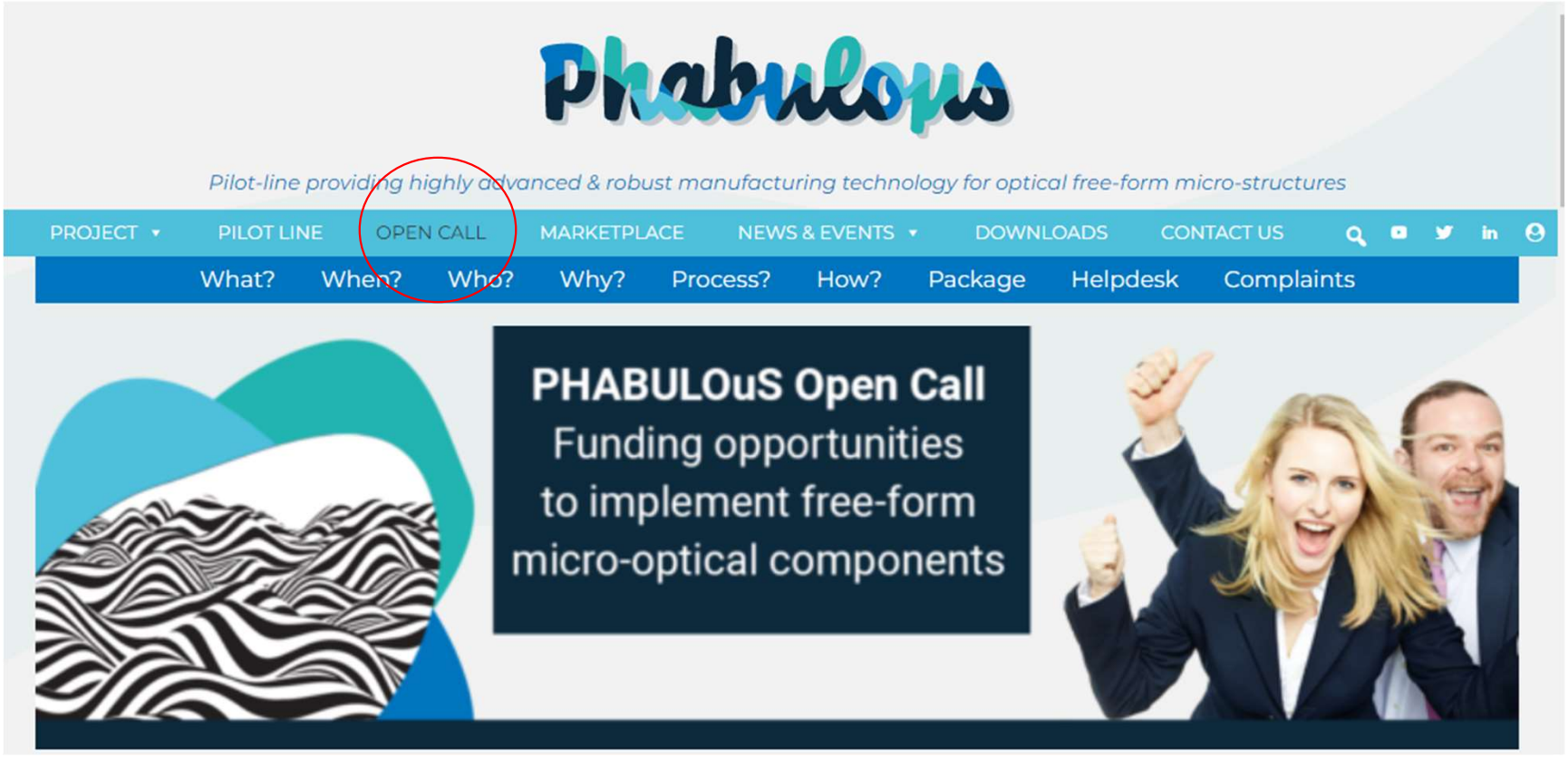


- High Refractive Index UV Imprinting
- Refractive index 1.7 (from ellipsometry and OCT)
- Solvent-free, Low haze (<1%)
- Alternative to etching-based fabrication?



csem

Pilot Cases – Open Call



www.phabulous.eu/open-call/

MICRO-OPTICS IS...

Phabulous

www.phabulous.eu

Pilot Line Front Office

FOLLOW US

@PHABULOuS_eu

PHABULOuS Pilot Line

PHABULOuS EU

Jessica van Heck

Managing Director

jessica.vanheck@phabulous.eu

Ton Offermans

Technical Coordinator

ton.offermans@phabulous.eu

PHOTONICS21

PHOTONICS PUBLIC PRIVATE PARTNERSHIP

COME AND SEE US AT **BOOTH 25**

Thank you


csem
JOANNEUM RESEARCH
VTT
Fraunhofer FEP
SUSS MicroOptics
leti
morphotonics
NANOCOMP
Wielandts upmt
LASEA
limbak
PowerPhotonic
MICROOLED
SEISENBACHER
SWAROVSKI
FORVIA HELLA
ZUMTOBEL
EPIC European Photonics Industry Consortium
AMIRES
phabulous


PHOTONICS21
PHOTONICS PUBLIC PRIVATE PARTNERSHIP


EPIC
European Photonics Industry Consortium