MICRO-OPTICS IS...

Phabulous

Unlocking Innovation

The European Value Chain for Advanced & Free-Form Micro-Optics

Event

Optica Design and Fabrication Congress

16 - 19 June 2025

Introduction

Jessica van Heck

CEO & Chairman

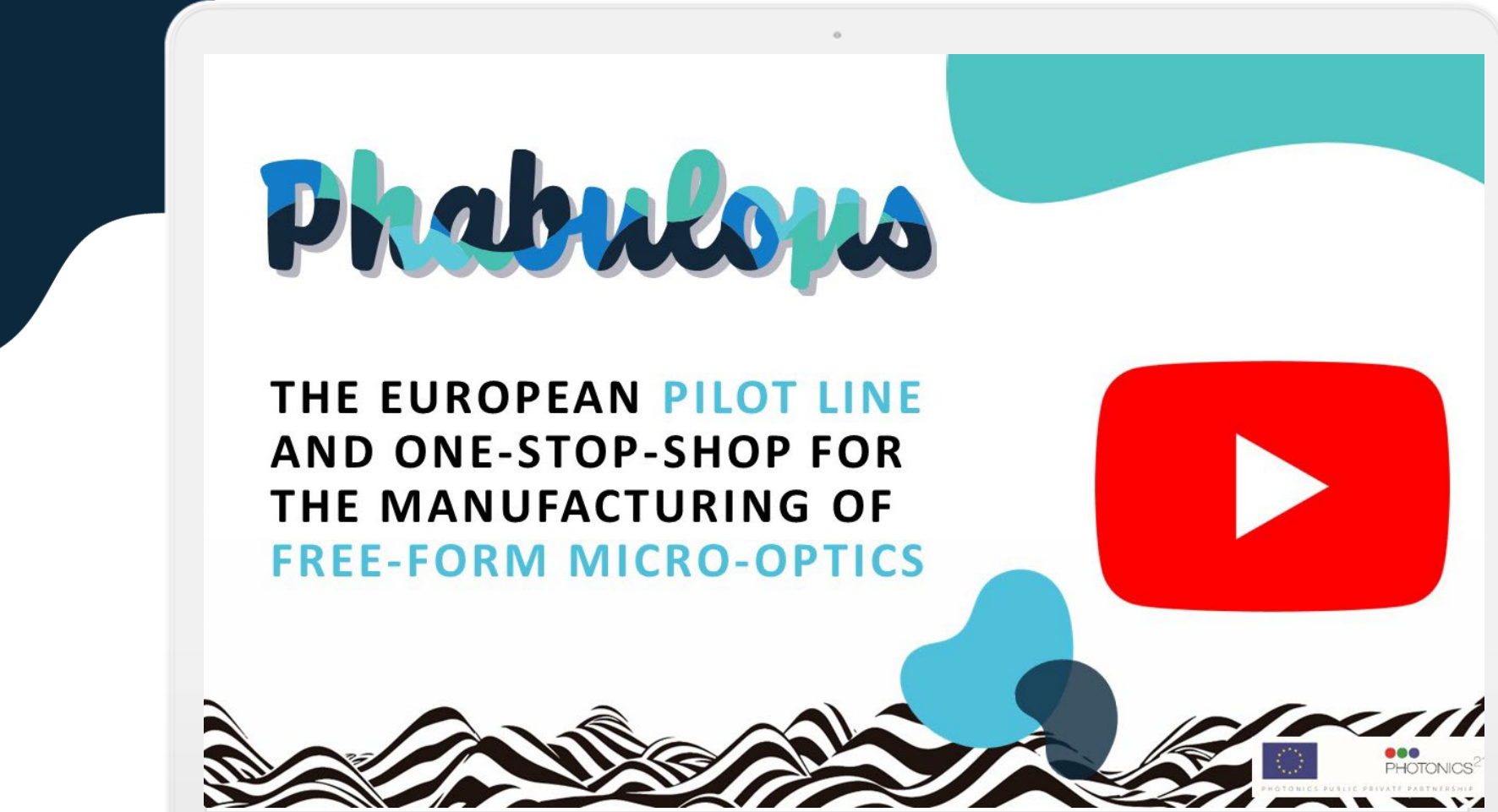
MICRO-OPTICS IS...

Introduction to PHABULOuS

- Started in 2019 as a European funded project / pilot line within the Horizon H2020 Program for the manufacturing of free-form micro-optics.
- Created a legal entity in 2021 within this project to continue the offering of services after the project.

PHOTONICS 21

PHOTONICS PUBLIC PRIVATE PARTNERSHIP



[Click to visit YouTube and watch our introduction video]

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Our goals

- Be a **gateway to a collaborative ecosystem**
  driving innovation, excellence, and growth in micro-optics technology.
- Unite a **full value chain consisting of Europe's leading companies**
  and research and technology organisations in the field of micro-optics.

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Our PHABULOuS partners

csem

JOANNEUM RESEARCH

VTT

Fraunhofer FEP

leti cea tech

FOCUSLIGHT Never stop exploring

morphotonics

NANOCOMP

Wielandts upmt

LASEA

PowerPhotonic

EPIC EUROPEAN PHOTONICS INDUSTRY CONSORTIUM

AMIRES

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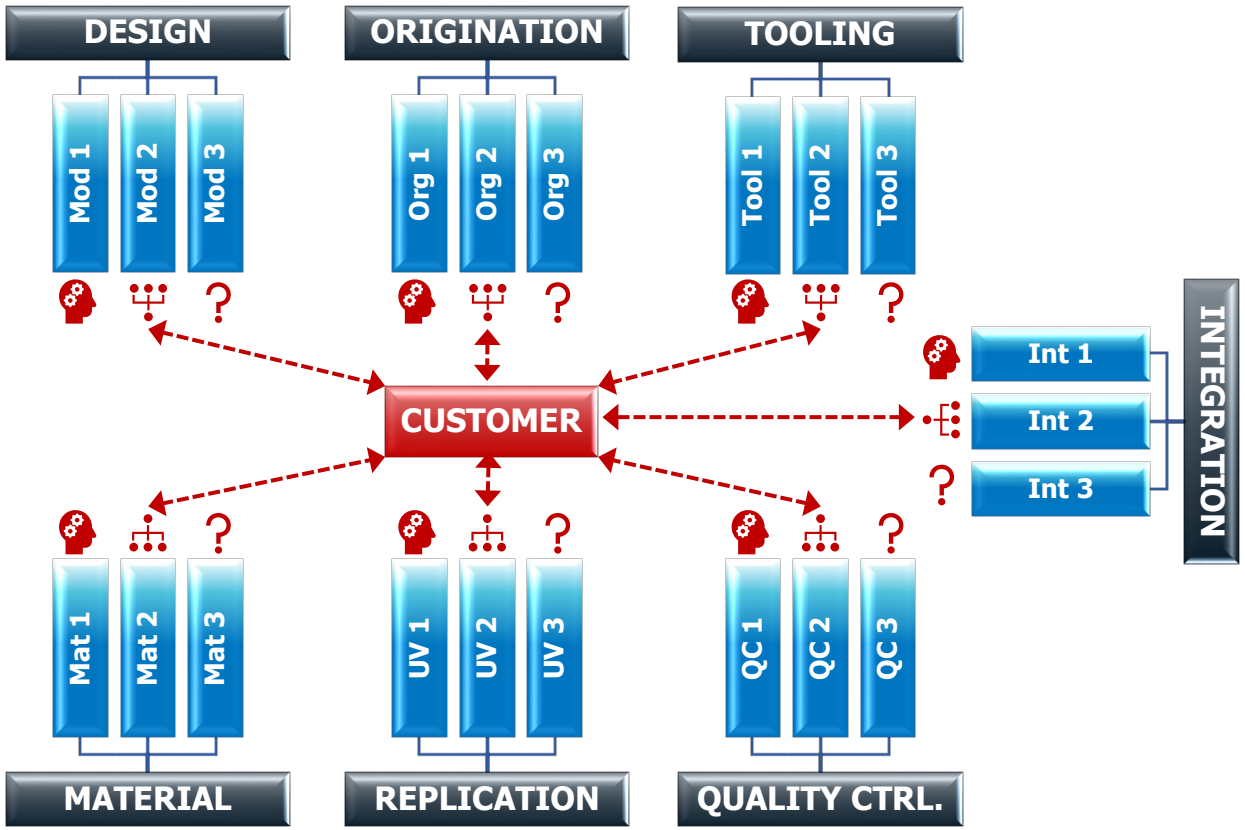
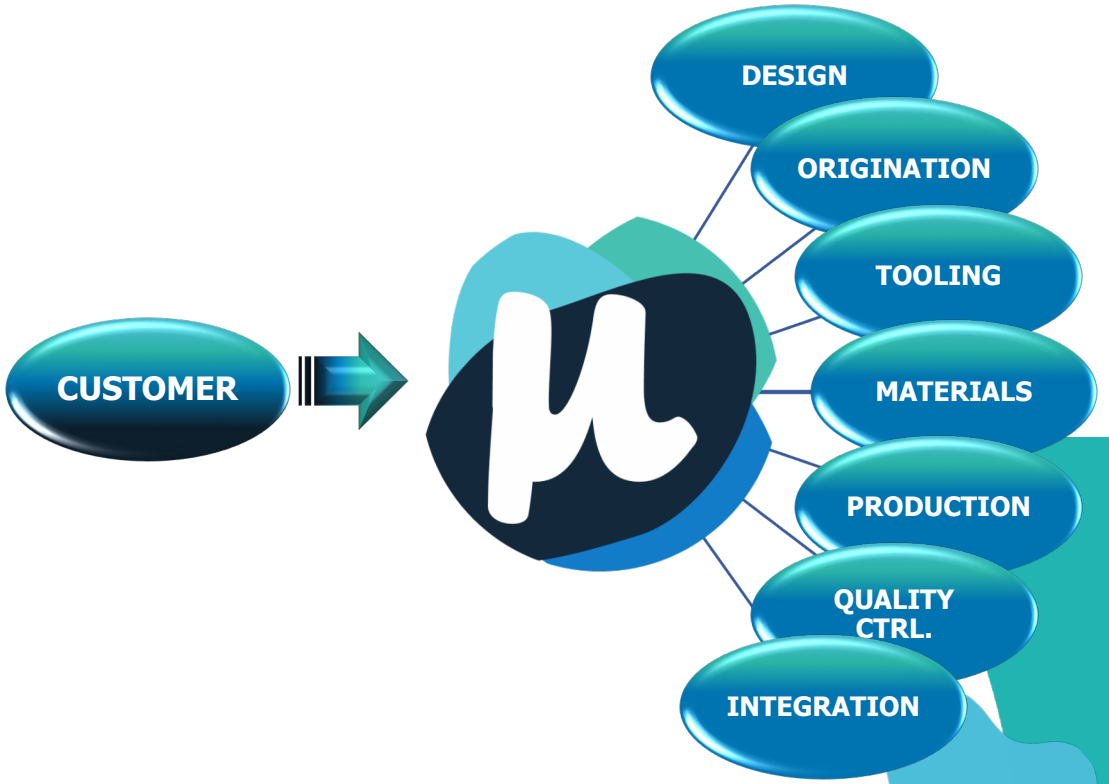
Single-entry-point





Without PHABULOuS

With PHABULOuS

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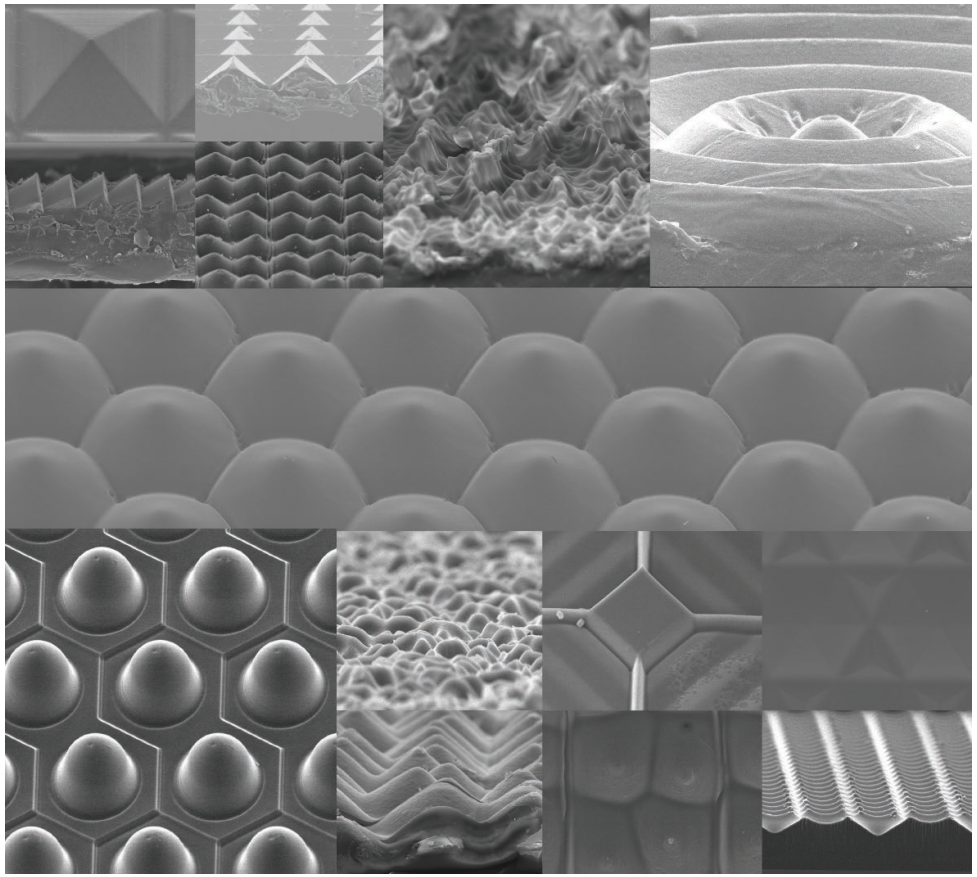
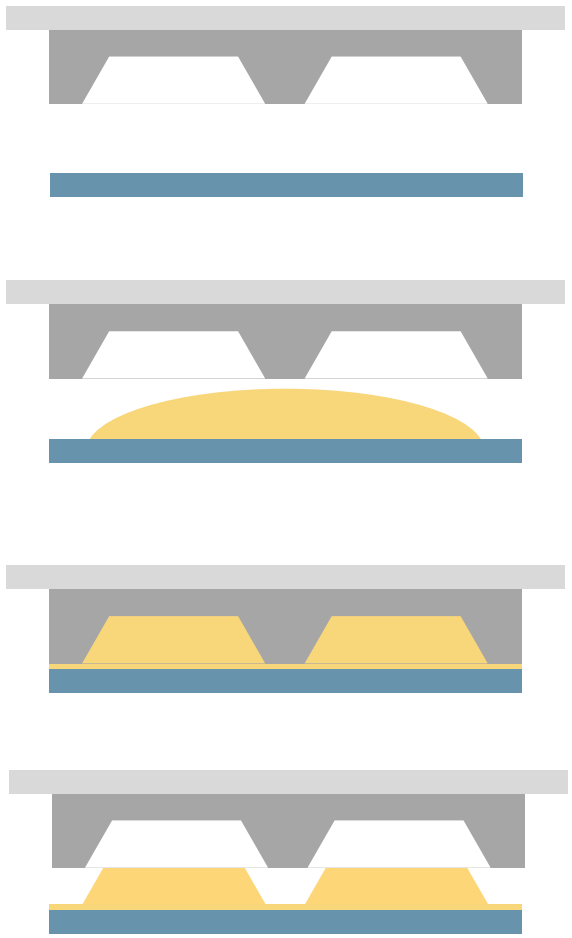
Focussed on advanced and free-form micro-optics

- Optical components **without symmetry constraints**
- Gaining an **increasing industrial interest** in the last few years



UV Imprint Manufacturing

Waferscale



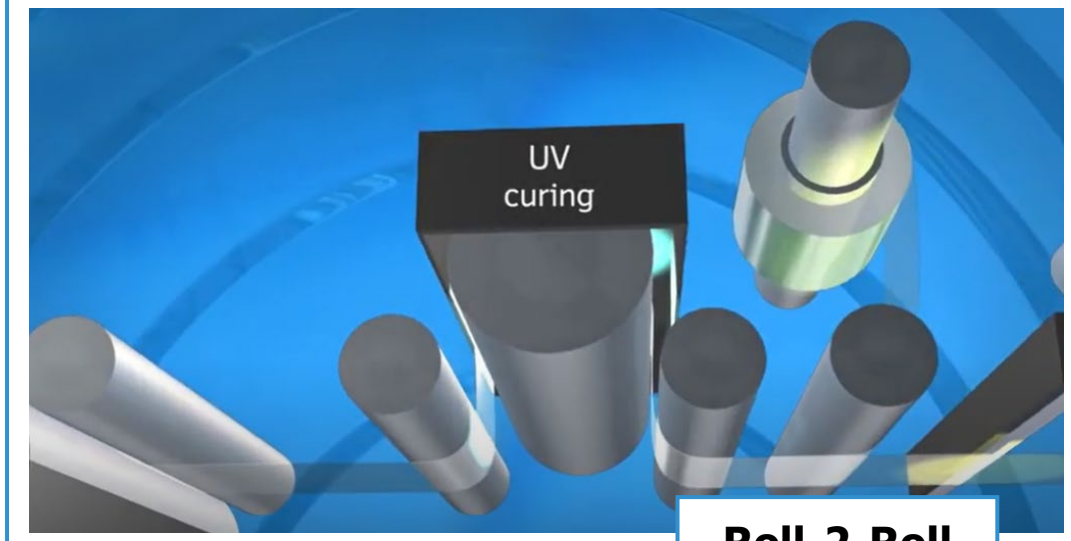
Stamp

Prepared substrate

Dispensing of imprint resist Alignment

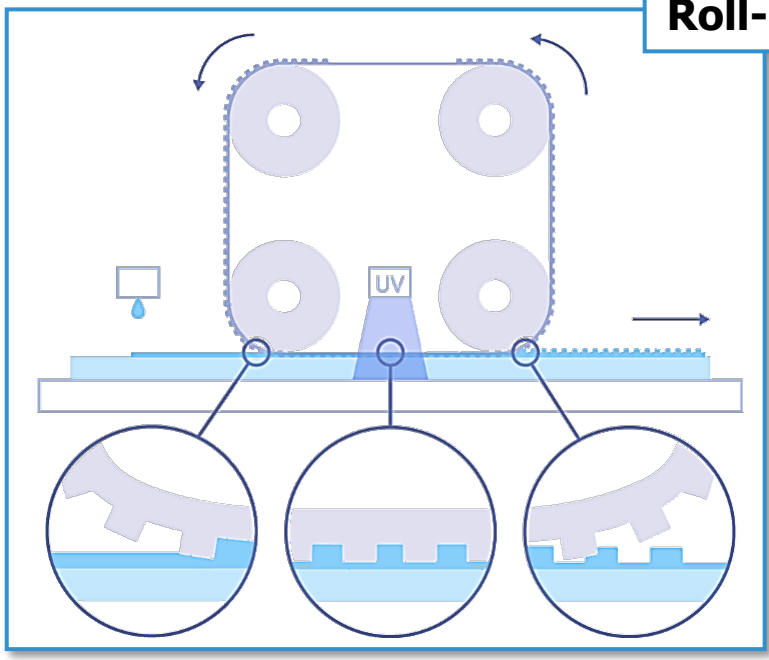
Imprint and curing

Release and posttreatment



Roll-2-Roll

Roll-2-Plate



PRODUCTION

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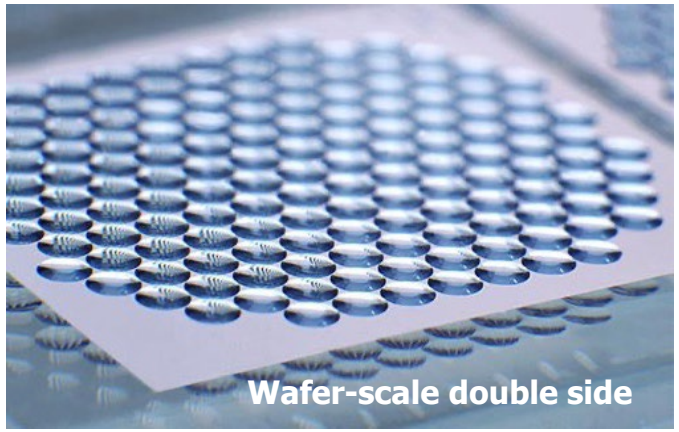
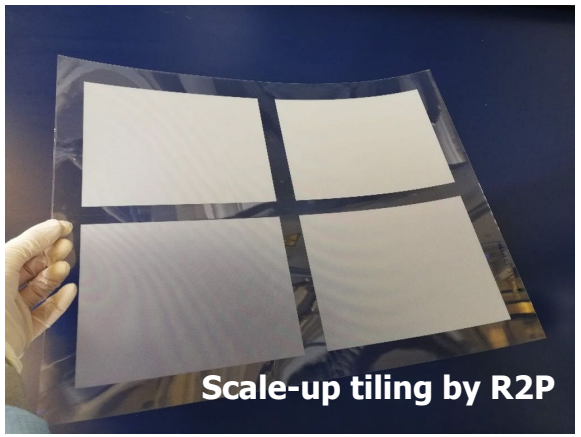
UV Imprint Manufacturing

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

PRODUCTION

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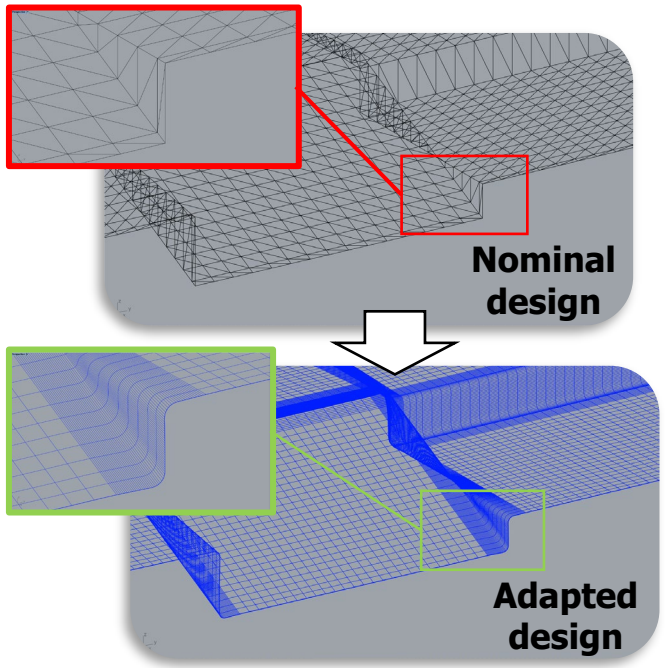
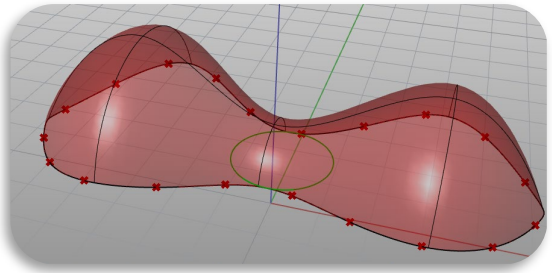
Design Tools for Manufacturing

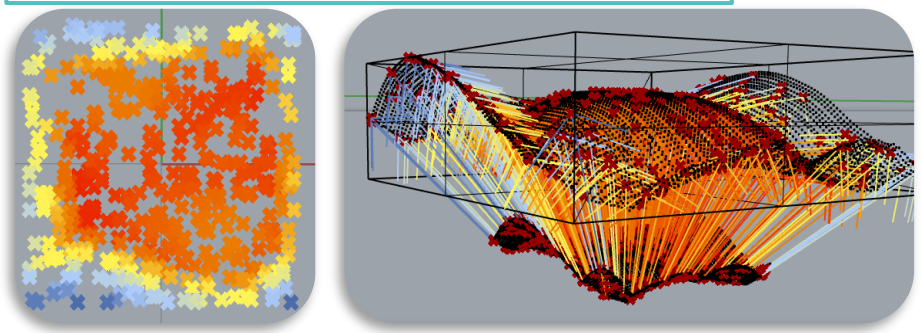
Edge smoothening



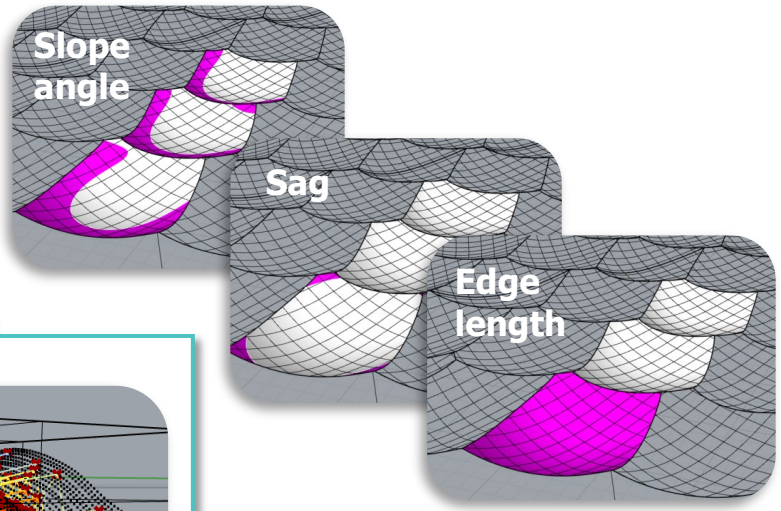
Minimal feature size



Visualization of shrinkage



Visualization of constraints



DESIGN

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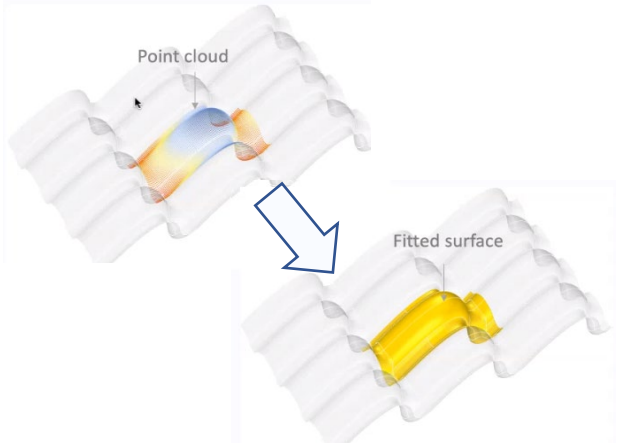
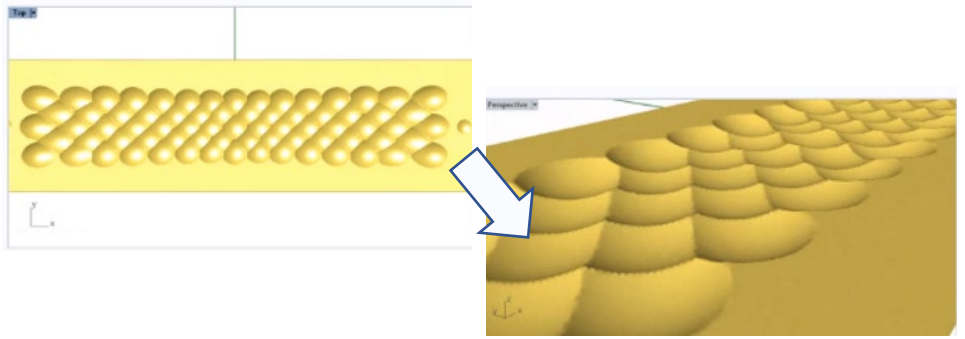
Design Tools for Manufacturing

Point cloud into ray traceable solid

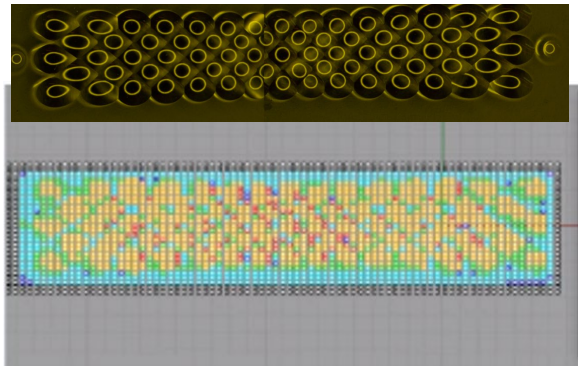


From design CAD to ray traceable solid



From measured point cloud to ray traceable solid

CAD comparison tool



- Comparison of actual master/imprint to design
- Accelerated evaluation

DESIGN

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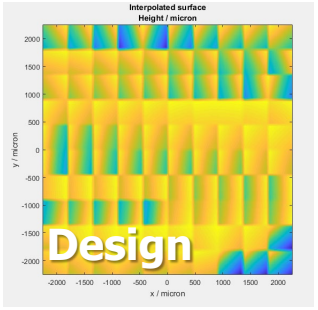
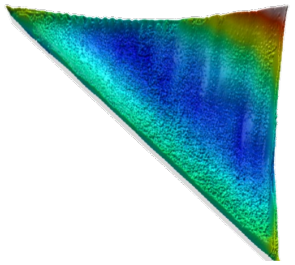
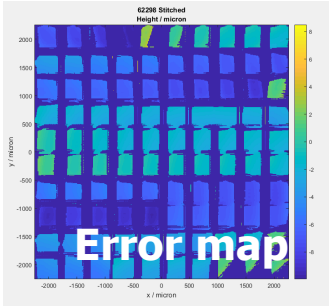
Origination Technologies

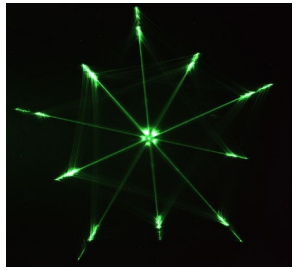
Laser micro machining





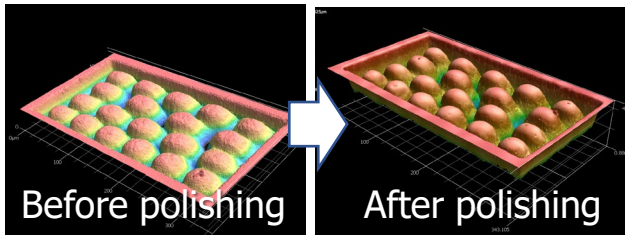


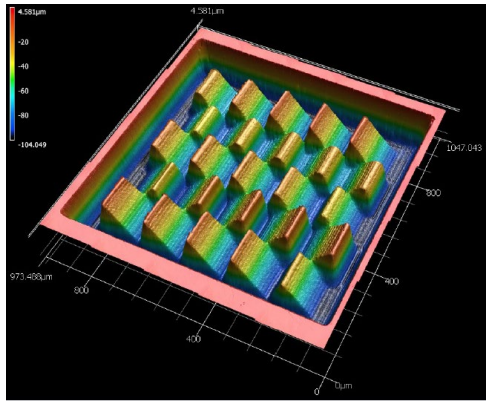
Form correction



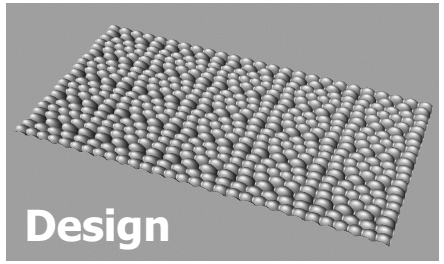
Removal of curvature

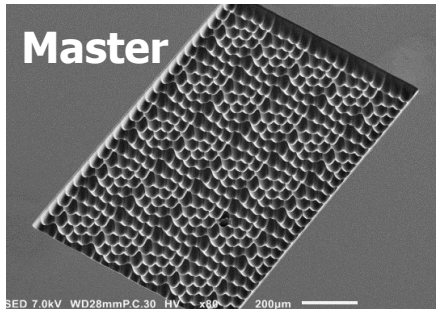
Laser ablation



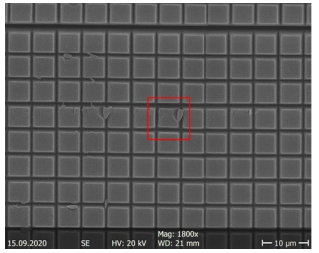


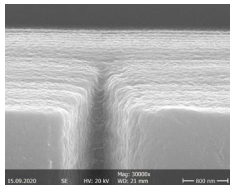
Grayscale laser lithography

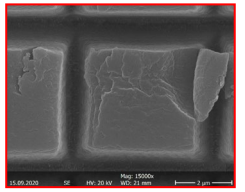




Two Photon Absorption







MASTERS & TOOLING

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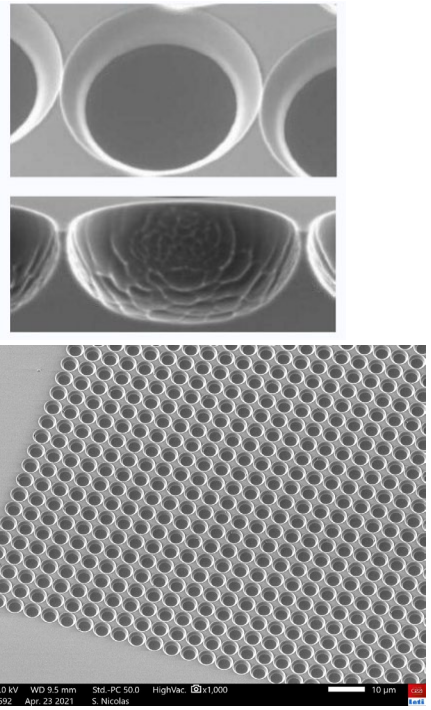
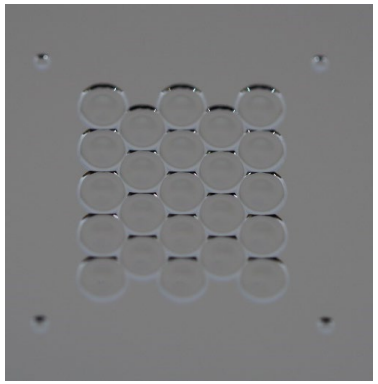
Origination Technologies

Silicon etching



Diamond turning



Diamond ruling

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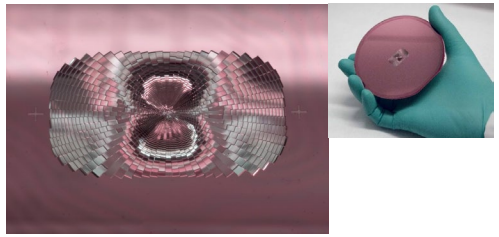
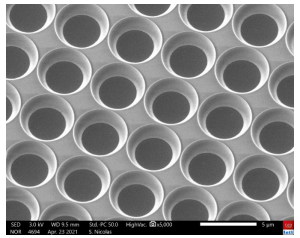
Origination Technologies

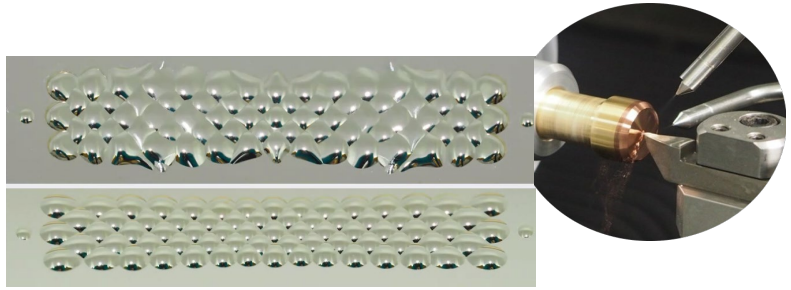
ORIGINATION	LMM	fs-LA	GSLL	PL / Si-etch	UP - DMM
Max. area	Diameter 80mm	20x20mm → 200x200mm	10 cm x 10 cm	200 mm wafers	Diameter 200mm
Max. height	200µm	200µm	50µm (-60µm)	2µm	<10mm
Form fidelity	Subject to surface shape (<50nm…<200nm)	High	± 5 – 10%		150nm P.V.
Surface roughness	1nm	300nm → 50nm	< 10 nm		3nm Ra
Design flexibility (high/medium/low)	High	High	High	Medium: only hemisph. shapes	Medium/High
Manufacturing time / cm²	Depending on geometry & sizes	Depending on depth: e.g. 2.73min/mm² for ~50µm depth	2 cm²/h	Microelectronic standard processes on 200mm wafers	Depending on geometry



Grayscale Laser Lithography (Mask-less)



Photolithography Si-Etch (Mask based)



Ultraprecision diamond micromachining

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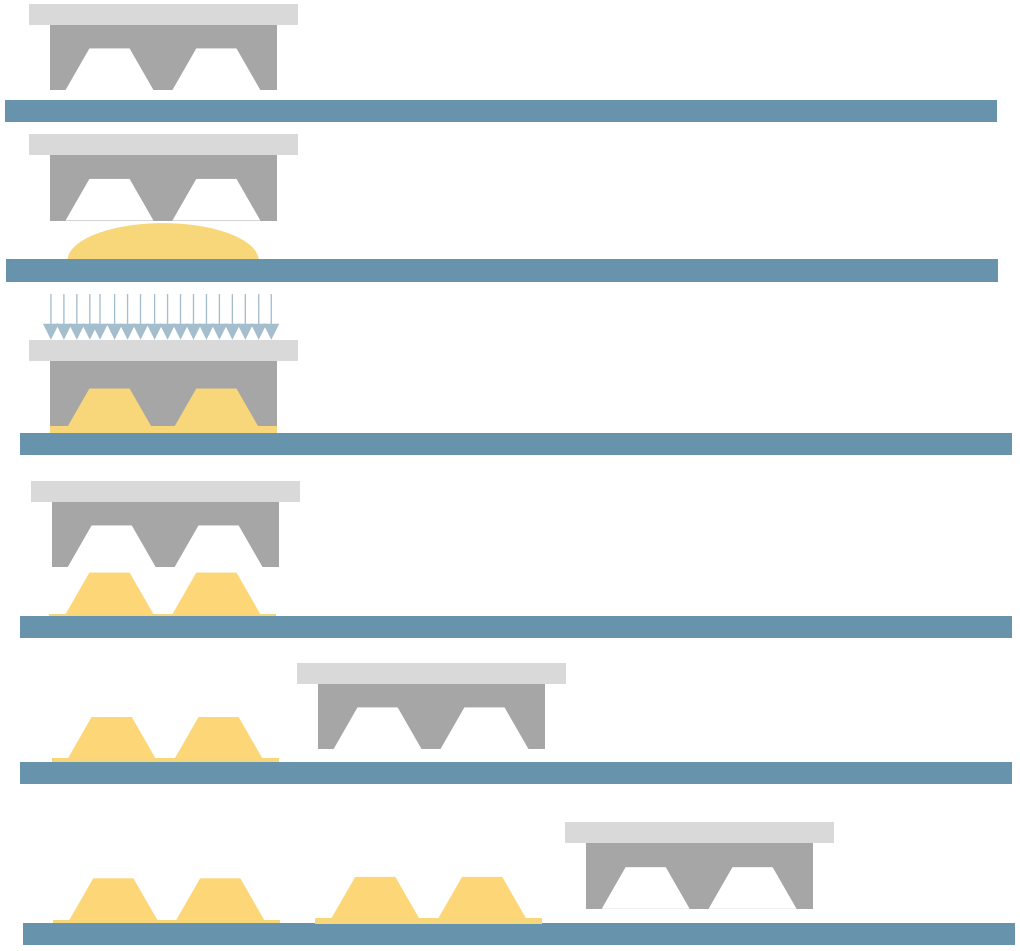
Step & Repeat Upscaling



+ 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

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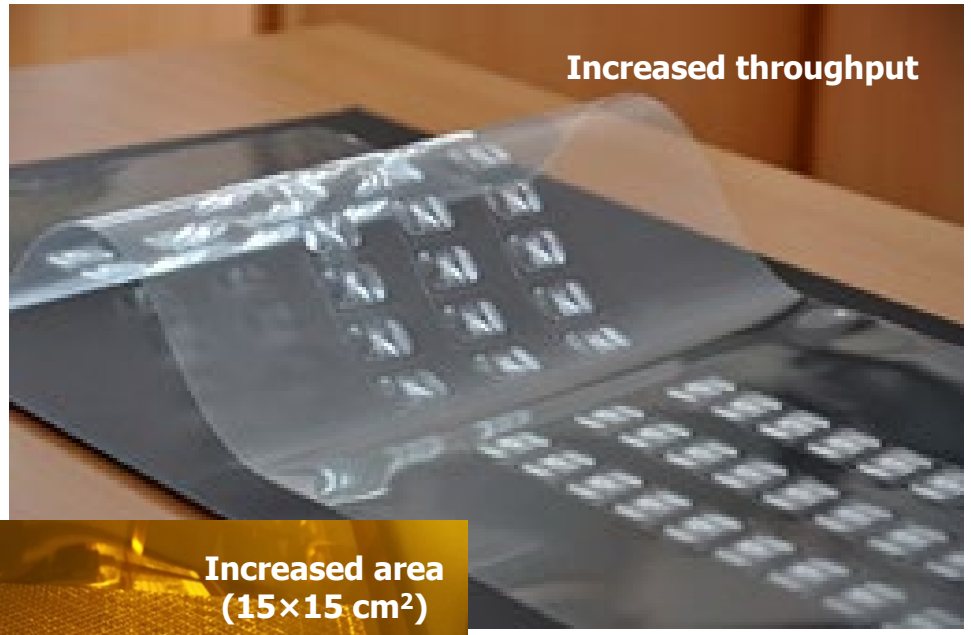
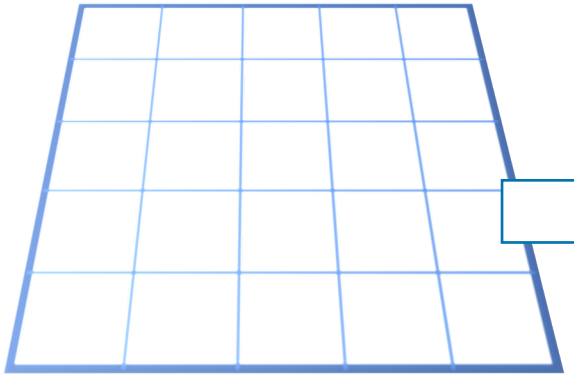
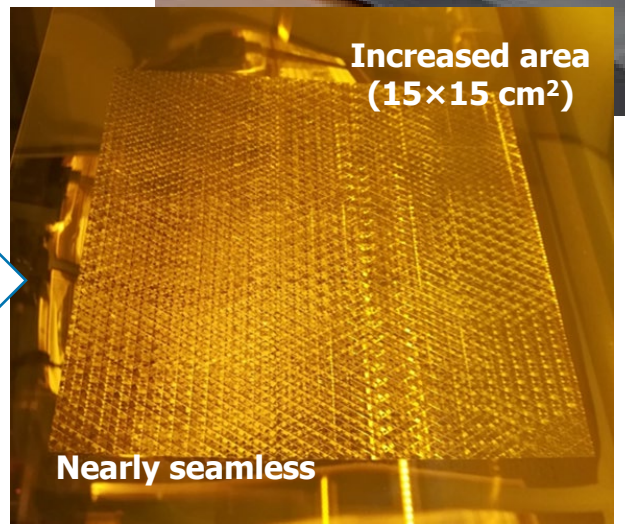
Step & Repeat Upscaling

Upscaling (Step & Repeat)	
Max. area	600*280 mm² (in 2 steps)
Shape limitations	No undercut
Form fidelity	3-5% shrinkage
Alignment accuracy	3 µm
Stitching	Nearly seamless
Manufacturing time / m²	Depending on master size and number of imprints: 12-24h





5x5 fields = 15x15 cm²



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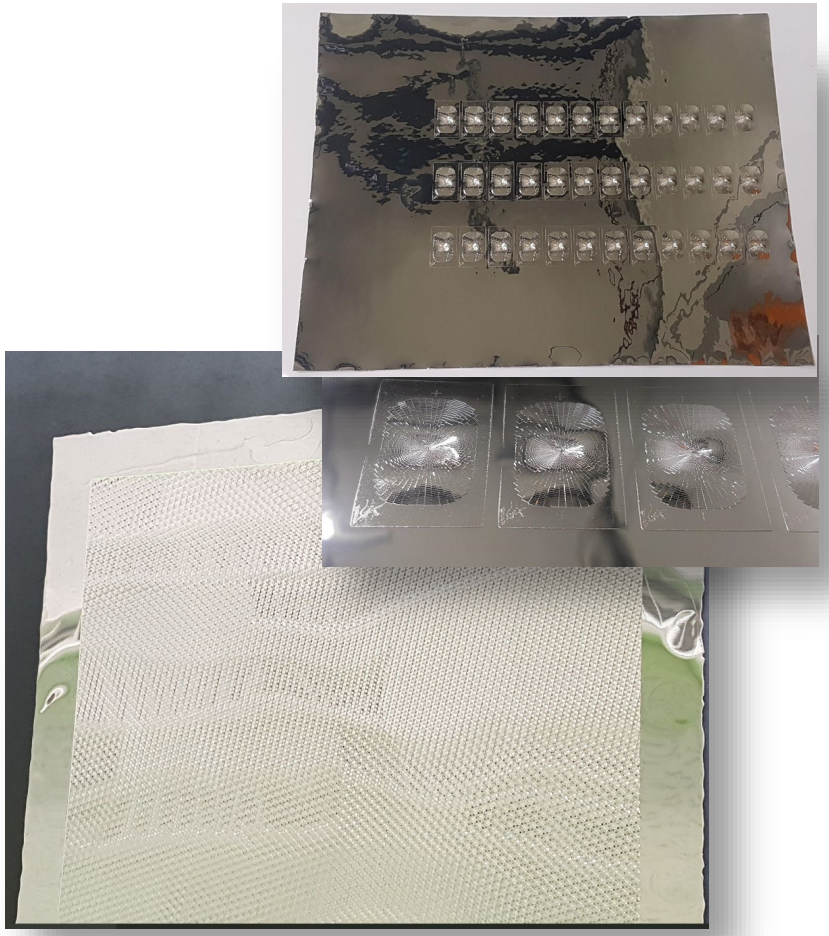
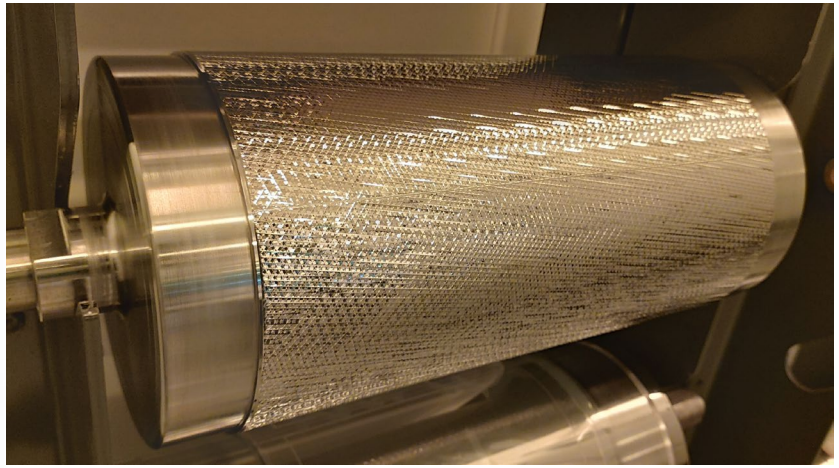
Stamp/tool fabrication

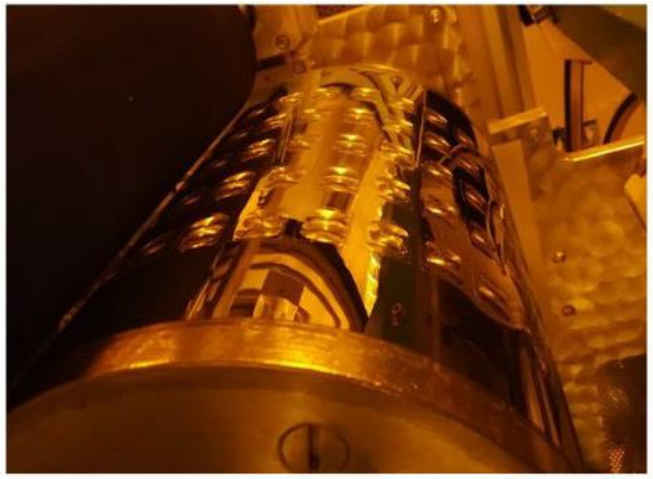
Large area Ni shims



Large area R2R tool



Metallized polymer shims



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

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Material Portfolio

Property	Wafer-scale	R2P	R2R	
Refractive index	1.5 - 1.6	1.45 - 1.85	1.40 – 1.70	1.43-1.58 (uncured resin)
Transparency	>90%	>99%	Negligible (Fresnel-losses) in the Vis range	~90 %
Max. height	500 µm	500 µm	100 µm	90 µm
Shrinkage (%)	1-5%	2 to 8% vertical shrinkage	3-8%	3-5 %
Stability	Automotive qualified	>3000 h DH (85°C/85%RH)	UV stability up to n=1.6	85 °C (tested)
Characterization	Optical and mechanical, surface shape, aesthetics and functional test	Confocal microscopy ellipsometry	-	Reliability tested for consumer electronics
Other relevant prop. (adhesion, mechanical, etc.)		Adhesion to polymers, glass, metal	tuneable	Substrate film material: PC. PMMA, PET, and TPU

MATERIALS

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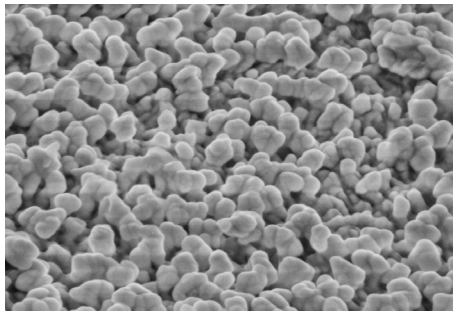
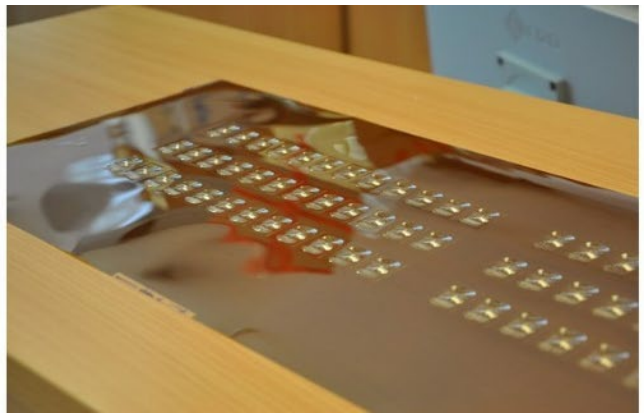
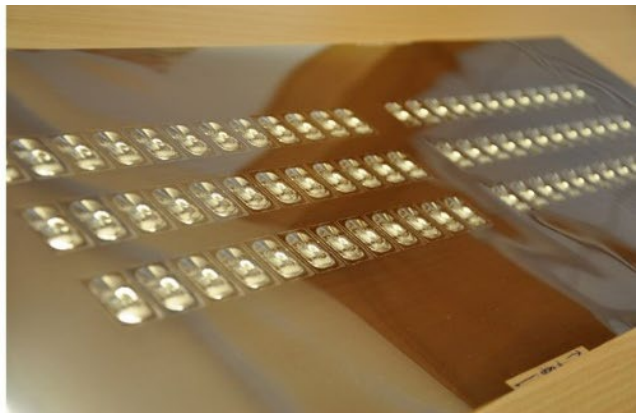
Optical Coatings

Magnetron sputtering of anti-reflective (AR) coatings

- for the imprinted micro-optical systems
- Optical filters (low-, high- and band-pass)
- Highly-reflective layers
- Anti-adhesive metallization of replication stamps with UV-reflective properties for enhancement of UV-curing procedure of resins







COATINGS

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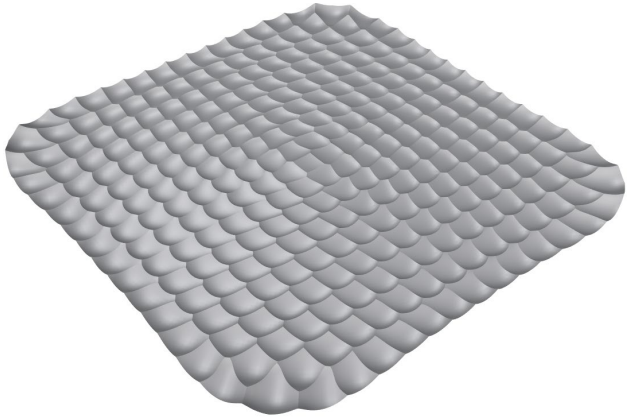
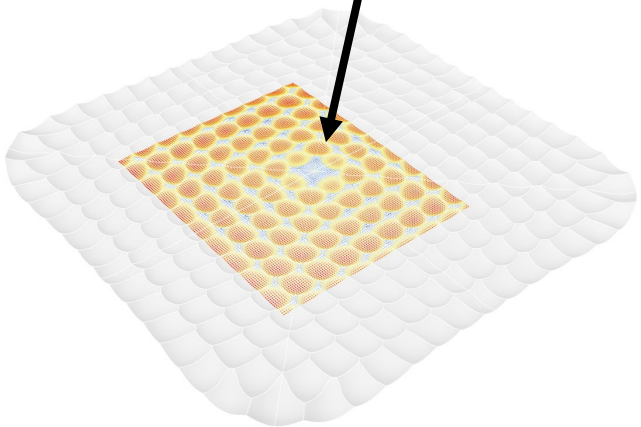
Performance evaluation

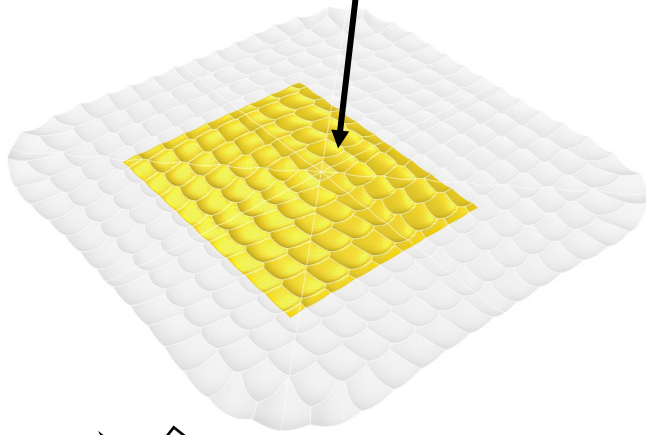
Measured profile
(tactile or optical profilometry)

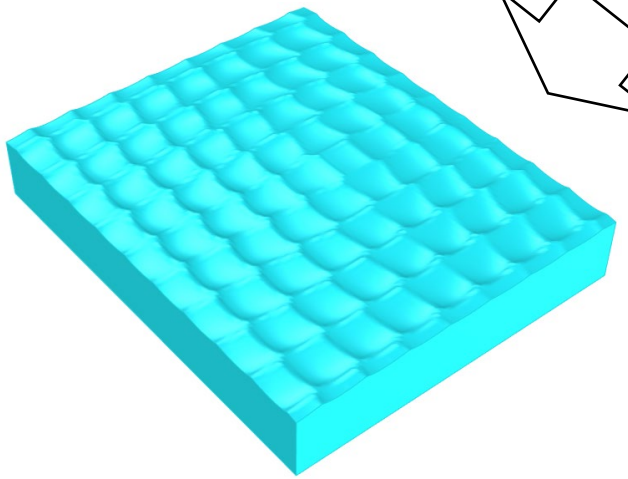


Point cloud



Fitted surface





CAD model
(ray-traceable)

Ray-tracing
Optical simulation
Software

QUALITY CONTROL

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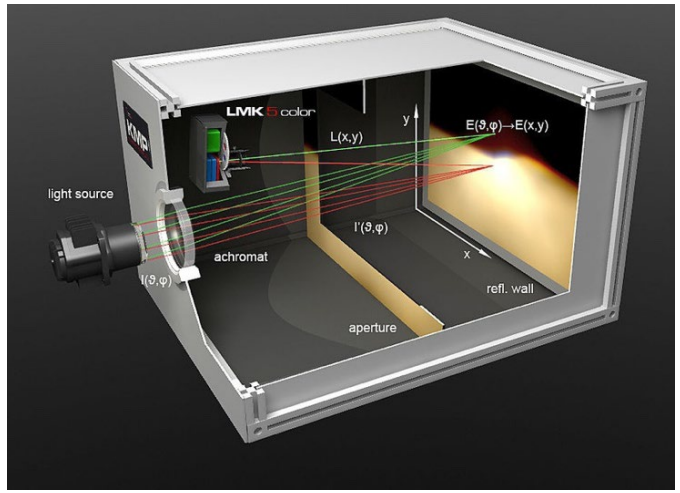
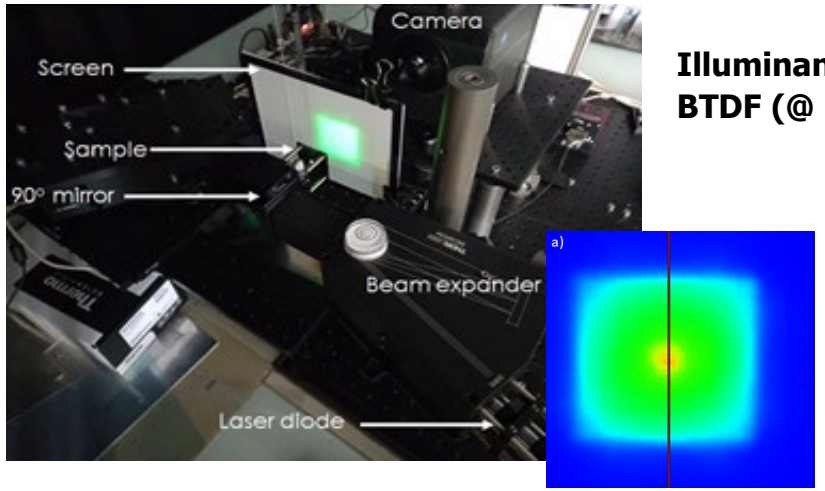
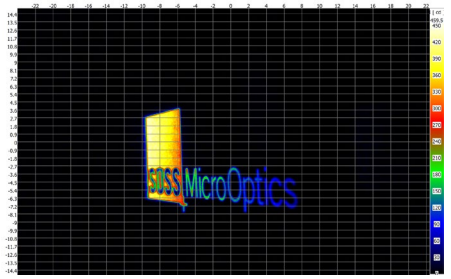
Functional testing

- Functional testing equipment for small-area prototypes and large-area products
- Calibrated light level measurement
- Angular range: horizontal (-24°, +24°), vertical (-15°, +15°)
- Luminance intensity distribution measurement range: up to 500’000 cd
- Evaluation of contrast & absolute light level at specific points in the field
- Testing according to automotive regulations





Illuminance map (far field)
BTDF (@ normal inc. calculated)



QUALITY CONTROL

Enable Innovative Product Development

Automotive

Optical Communication

Healthcare & Life Sciences

AR/VR

Solar, Energy & Daylight

Solid-State Lighting

Decoration & Luxury

Consumer Products

Transportation

MICRO-OPTICS IS...

Phabulous

Advanced FMLAs for next generation headlights

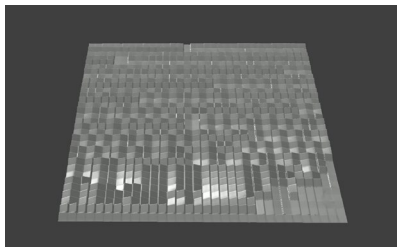
Enable headlights with optimized light distribution and low installation space and weight.

FORVIA

HELLA

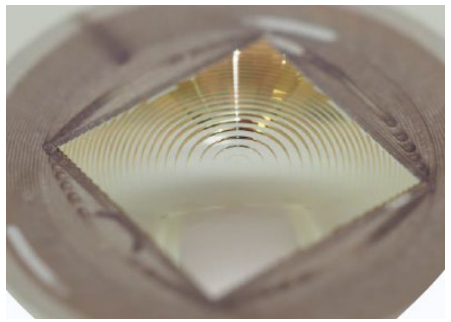
DESIGN

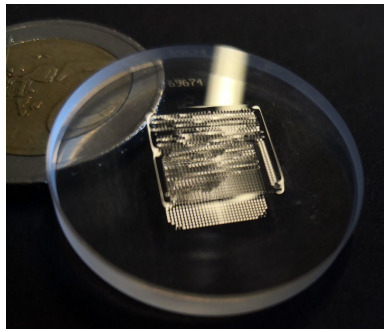
Micro-facets that are oriented and arranged in a specific way to generate the light distribution and reduce the stray light.



MASTERS & TOOLING

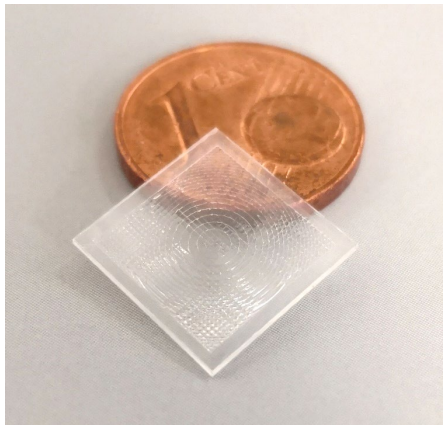
One side a micro-Fresnel lens by ultra-precision machining. Other side a facet array by laser micro-machining.





PRODUCTION

Replicate the master structures but also to accurately combine the two functional surfaces.

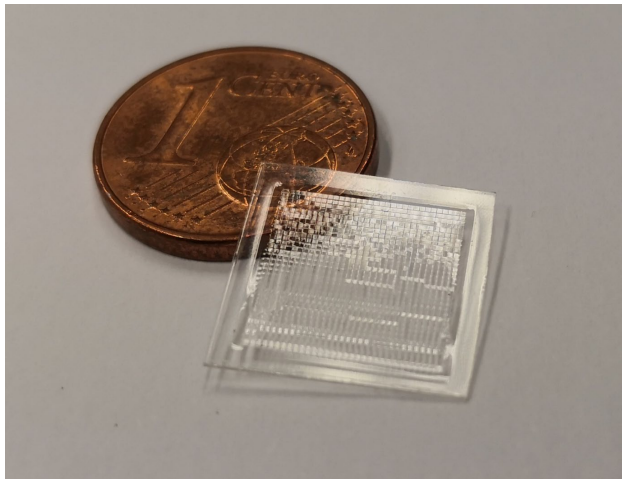


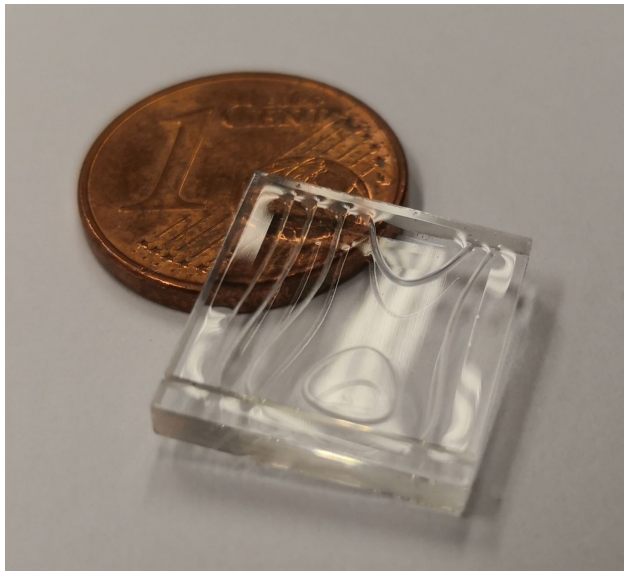
MICRO-OPTICS IS...

Phabulous

[Click to visit YouTube and watch the video of HELLA]

Results



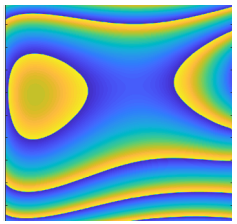


Free-form micro-optical component

Size (H x W) = 10 x 10 mm²

Thickness = 3.3 mm

Material = glass-substrate + uv resin



Advantages

- **Low thickness < 10mm (LED to shutter) -** Comparable series systems are more than 20 mm thick
- **Reduction of number of optical elements -** just one double sided element is needed (instead of primary and secondary optics)
- **Low material consumption optics -** thickness is 3.3 mm (a classic aspheric primary optics is >10 mm thick)

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Novel lighting solutions

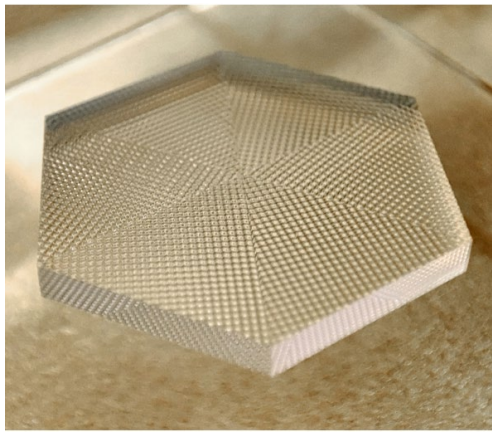
Luminaires with asymmetric

uniform light distribution.

ZUMTOBEL

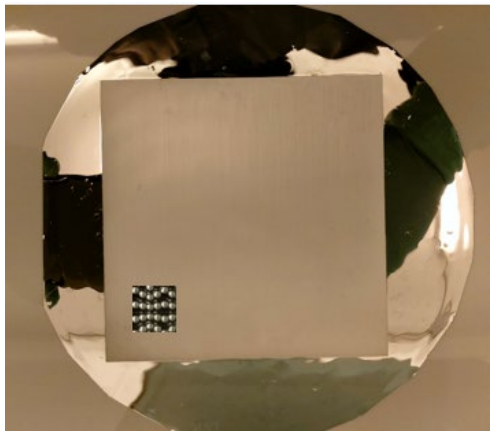
DESIGN

Design to achieve a high asymmetric distribution and enable a very homogeneous distribution.



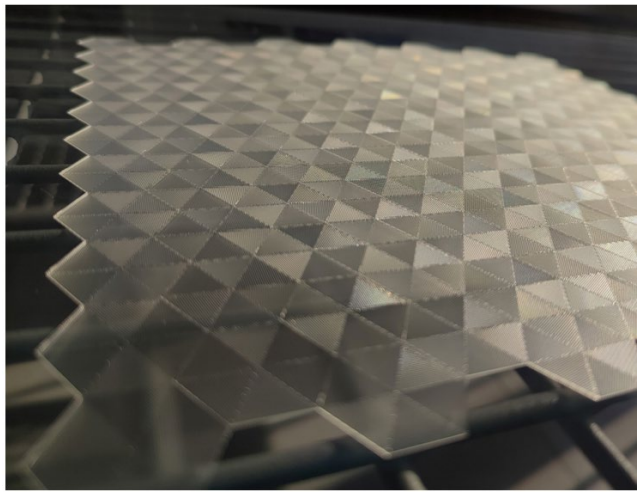
ORIGINATION

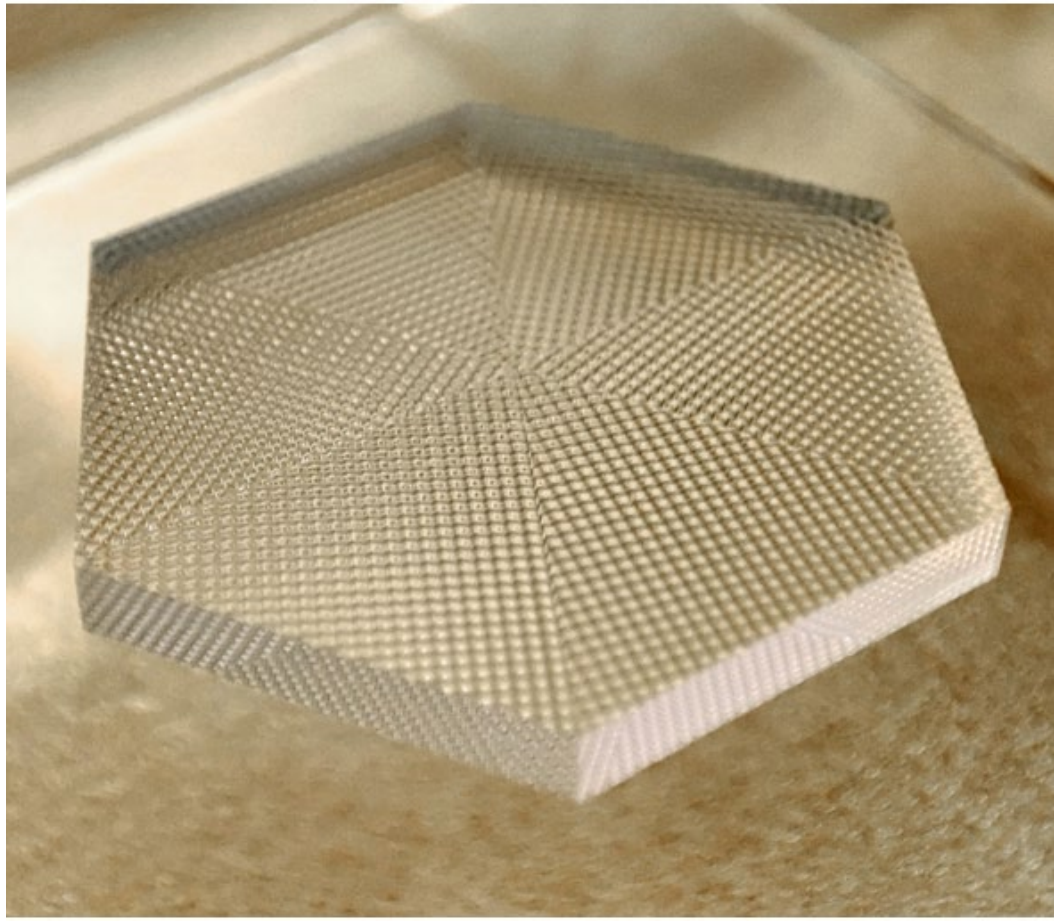
Different technologies have been benchmarked making sample coupon of the design in different scales.



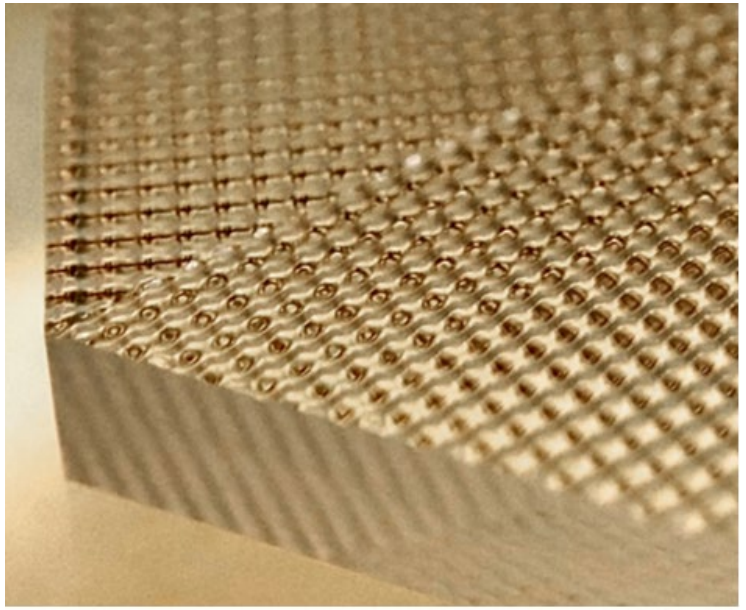
PRODUCTION

Replica on plate and imprints in Roll-2-Roll (R2R) technology.





master



MICRO-OPTICS IS...

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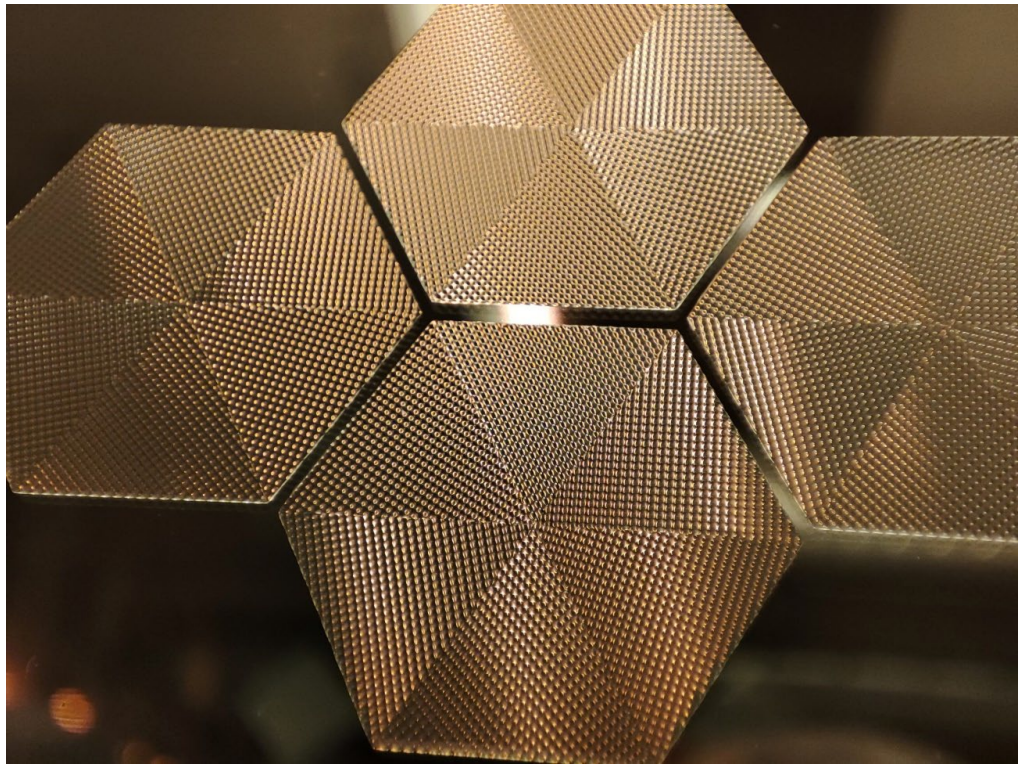
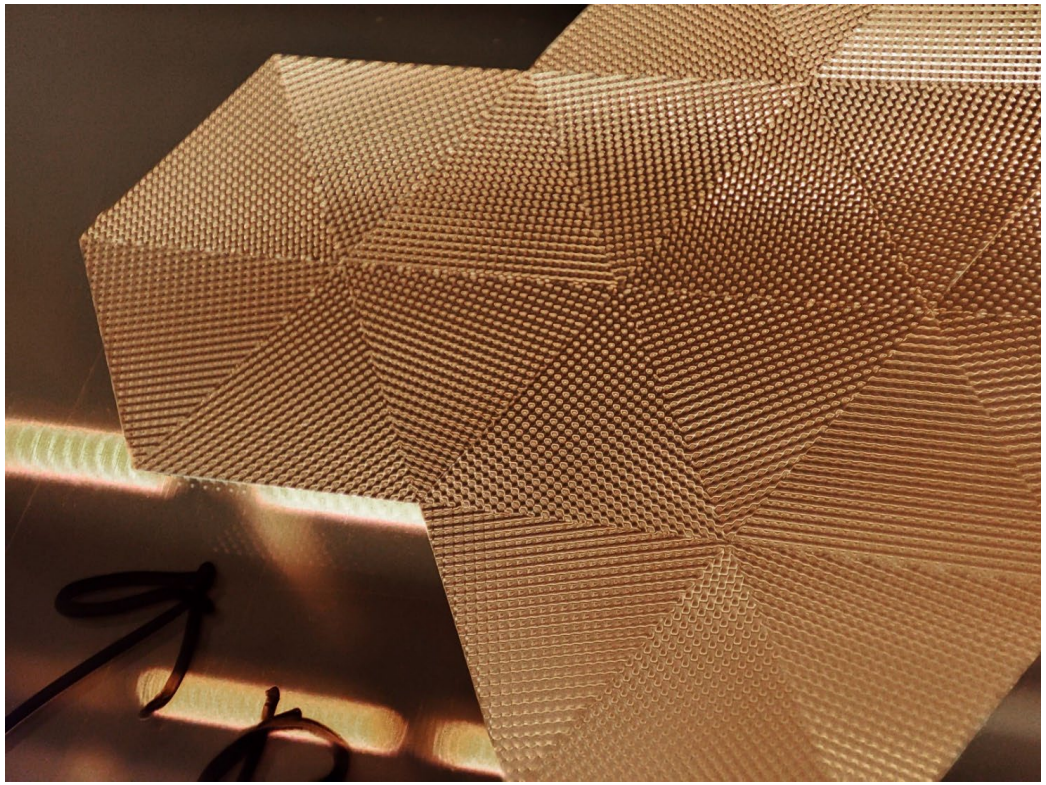




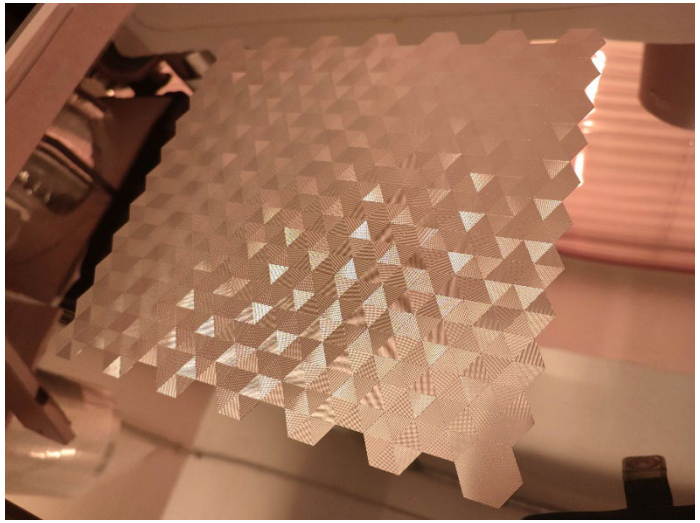
Step & Repeat UV imprints on
PET foil distance = 1 mm

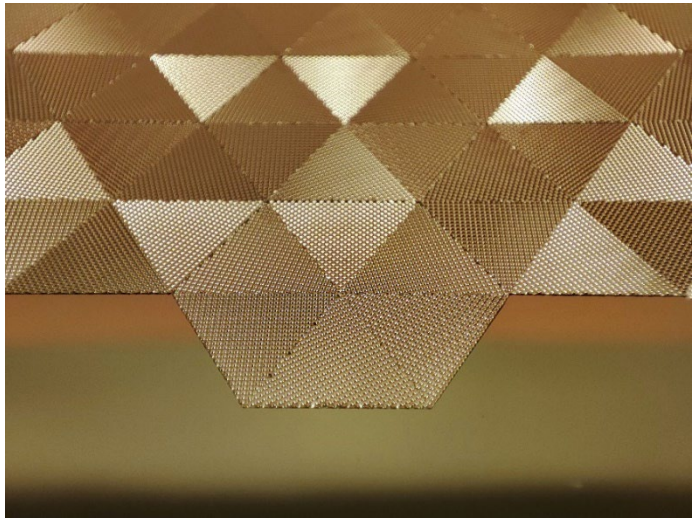
Distance and
rotation optimization

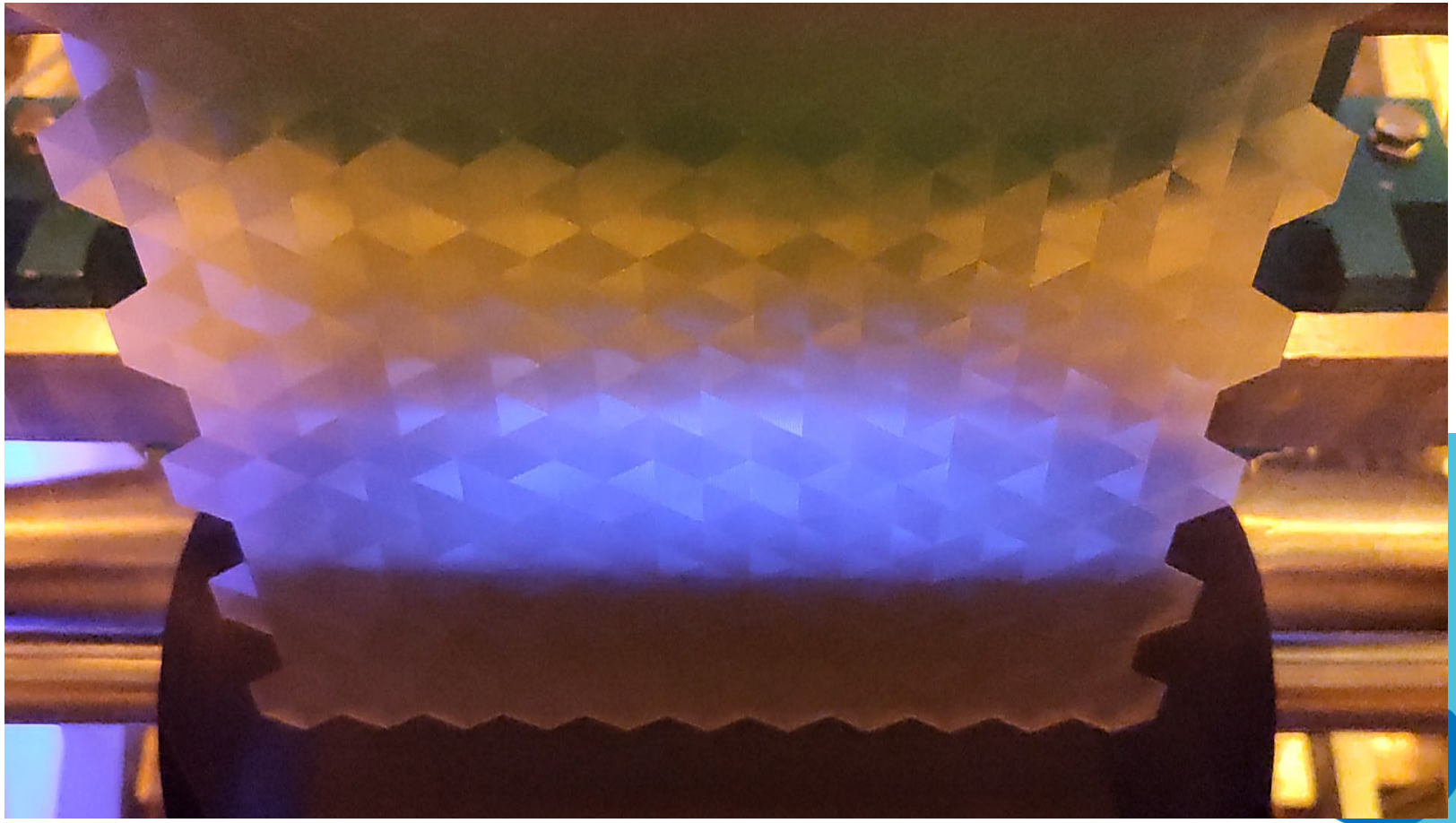
MICRO-OPTICS IS...
Phabulous

Converting the poly-shim to a durable Ni tool

MICRO-OPTICS IS...
Phabulous







[Click to visit YouTube and watch the video of Zumtobel]

MICRO-OPTICS IS...

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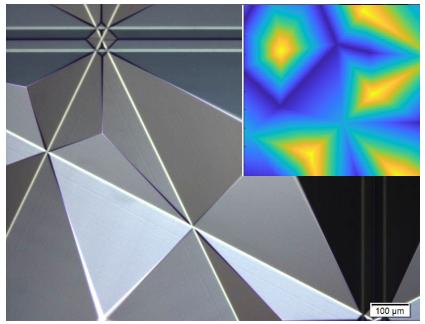
Brilliance in Luxury

Seamless manufacturing of micro-structured foils with gemstone appearance.

SWAROVSKI

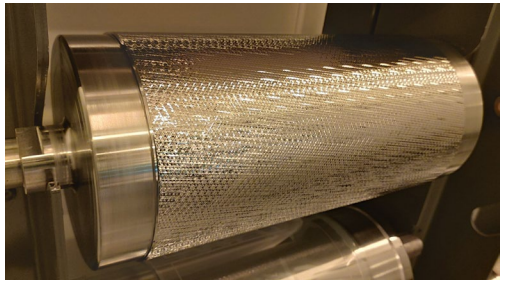
DESIGN

Free-form micro-optics structure based on the faceted-structure of cut crystals.



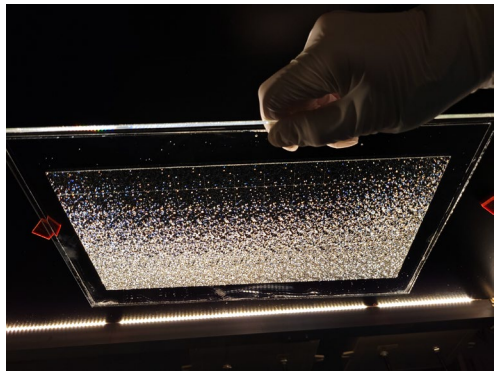
ORIGINATION

Laser ablation and ultra-precision diamond ruling were tested for different structures.



PRODUCTION

Roll-2-roll replication and roll-2-plate on a glass substrate were tested.



COATINGS

Roll-2-roll application of silver mirror on the back of the structure.

MICRO-OPTICS IS...

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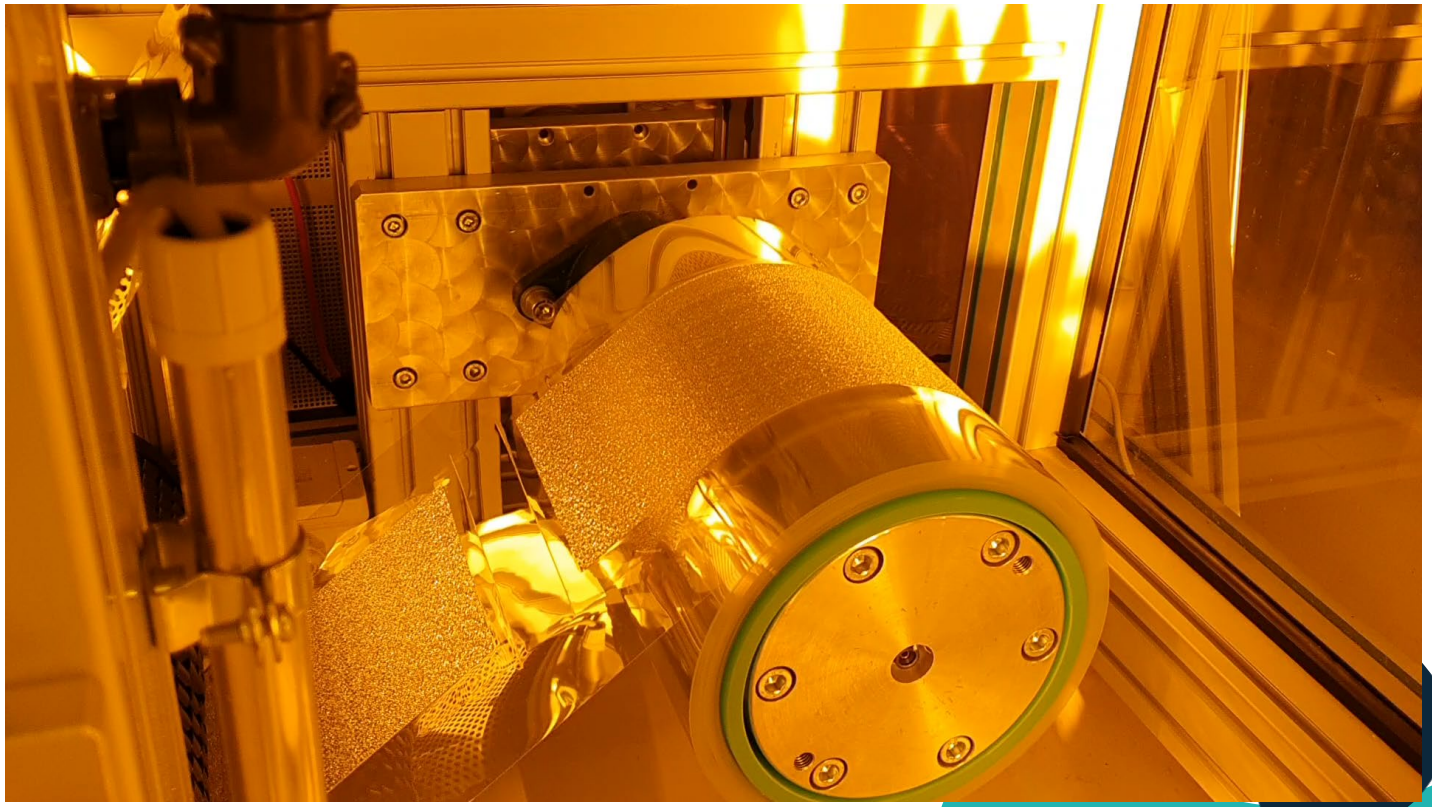
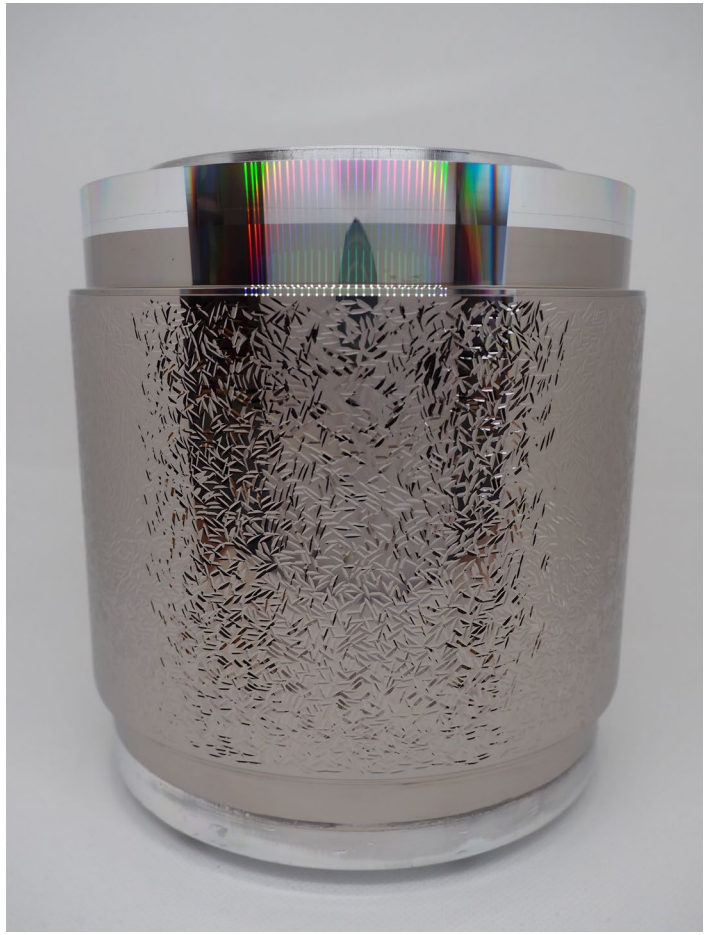
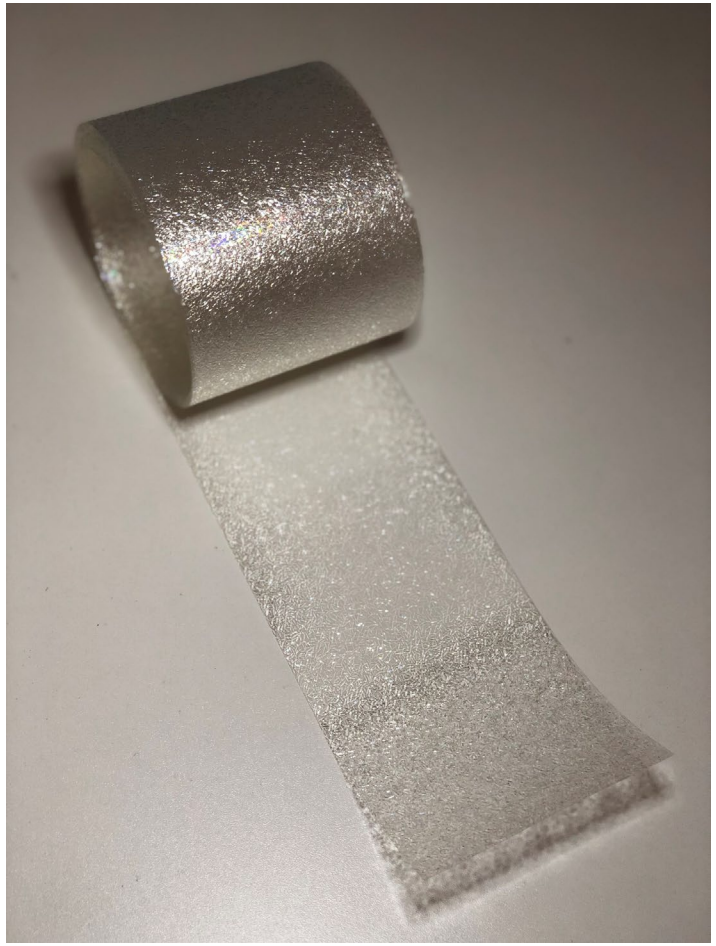
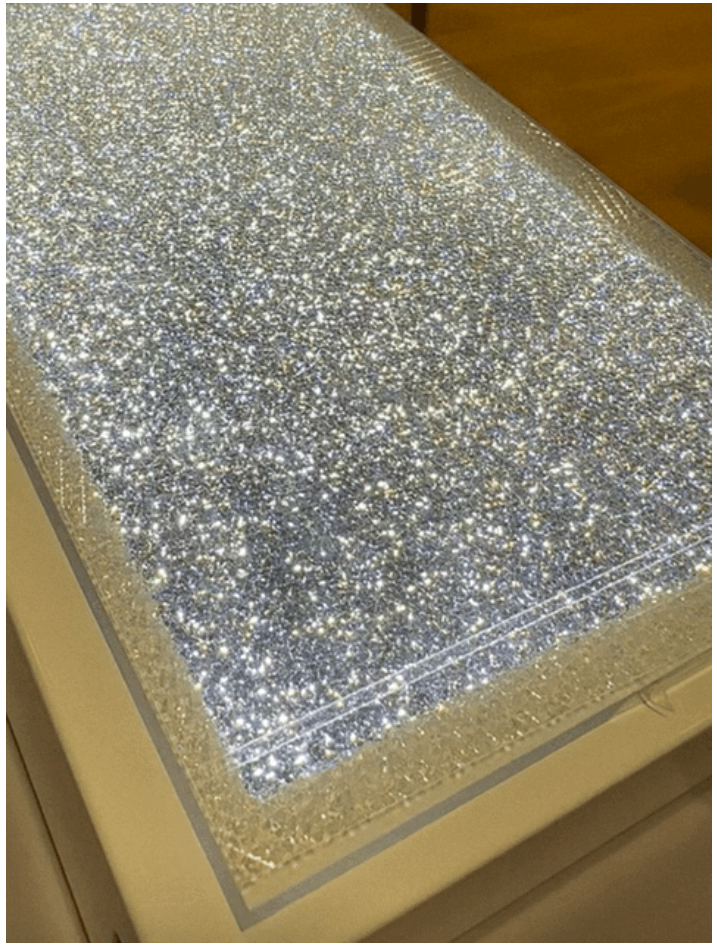
Double side imprinted „crystals“









MICRO-OPTICS IS...

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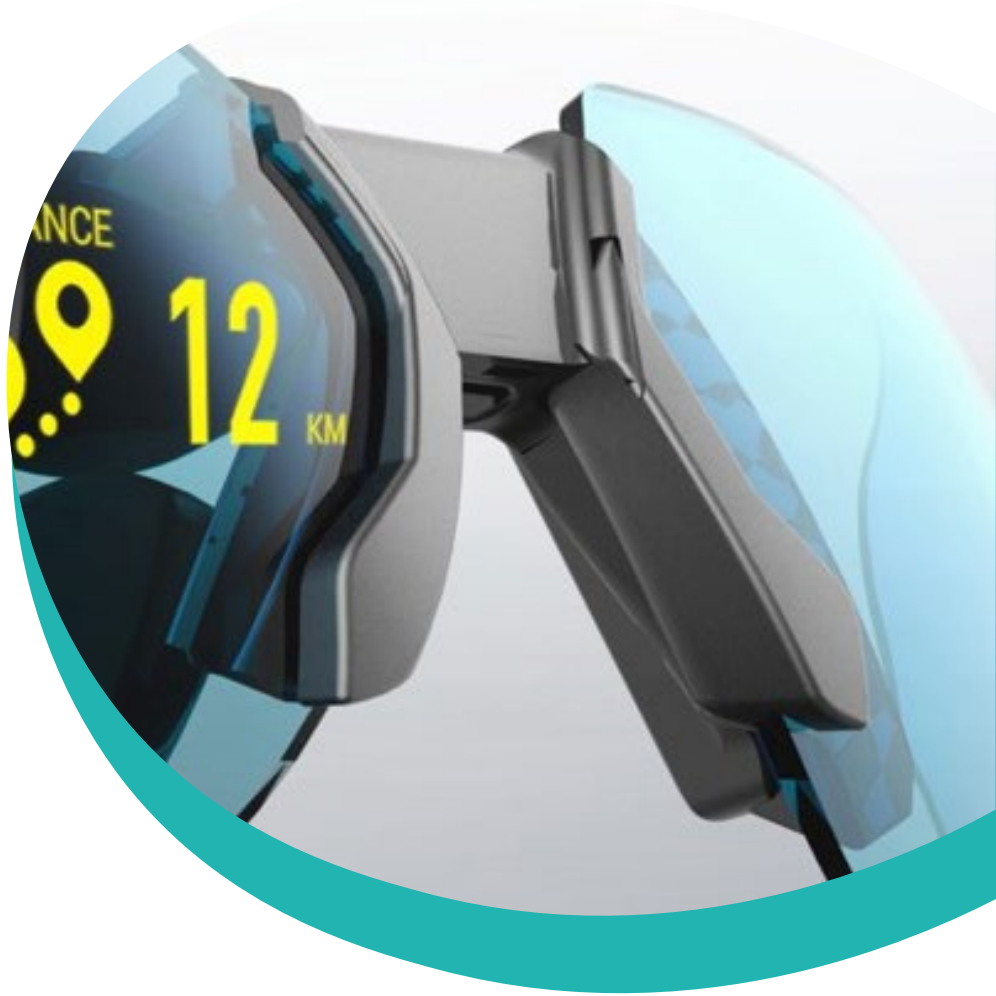
MICRO-OPTICS IS...

Phabulops

ActiveLook®

Micro Displays for Augmented Reality solutions



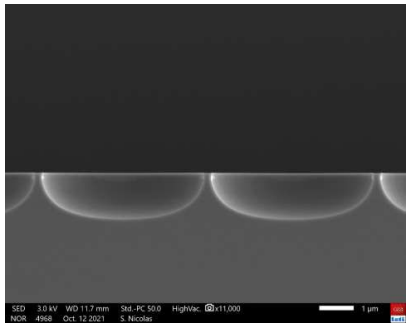
Control the angular shape of light output

and to enhance brightness.

MICROOLED

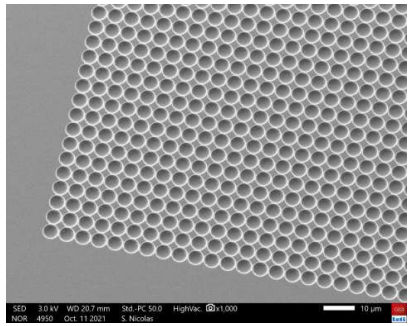
DESIGN

The design is characterized by a small pitch together with a high aspect ratio.



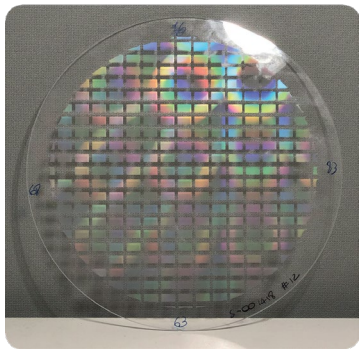
ORIGINATION

Silicon etch technologies as well as by laser grayscale lithography.



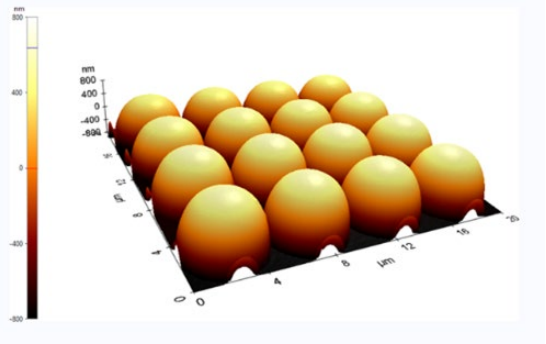
PRODUCTION

On a 200mm glass wafer using a suitable polymer material.



INTEGRATION

Assembly to the micro-display chips.



MICRO-OPTICS IS...

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MICRO-OPTICS IS...

Phabulous

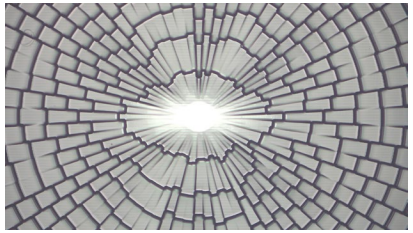
Transportation Interior Lighting

Develop ultrathin luminaires or luminaires with a significantly reduced number of LEDs and with a customized illumination pattern.

SEISENBACHER

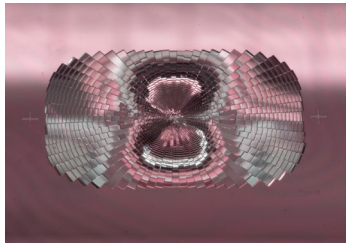
DESIGN

A free-form structure realizing a very homogeneous irradiance on the diffuser plane.



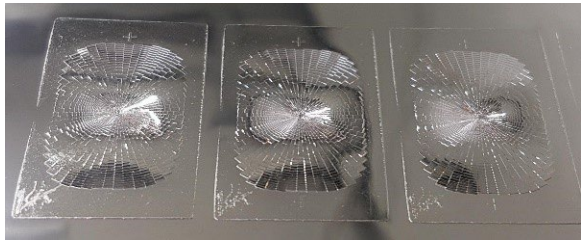
ORIGINATION

Laser-based mastering technology produced with a high accuracy.



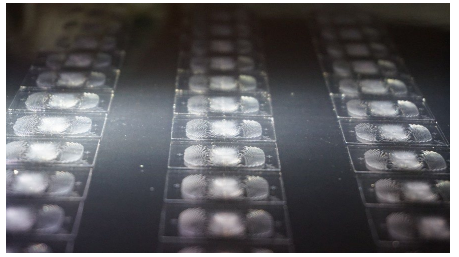
TOOLING

Upscaled into a so-called multi-lens-array. Then the galvanized multi-lens-array to create the final tool for replication.



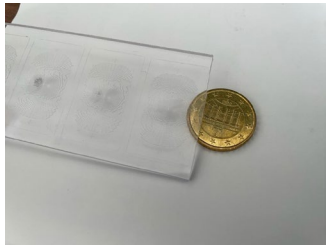
PRODUCTION

Replicas using UV-imprint R2P (roll-to-plate) technology.



INTEGRATION

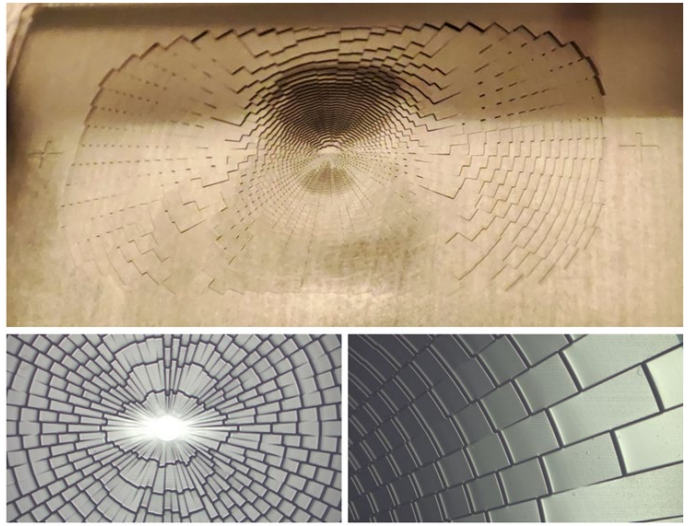
Integration into the luminaires.



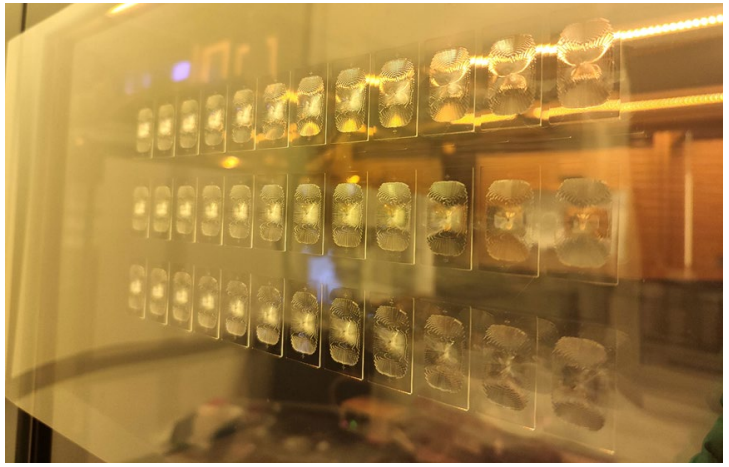
MICRO-OPTICS IS...

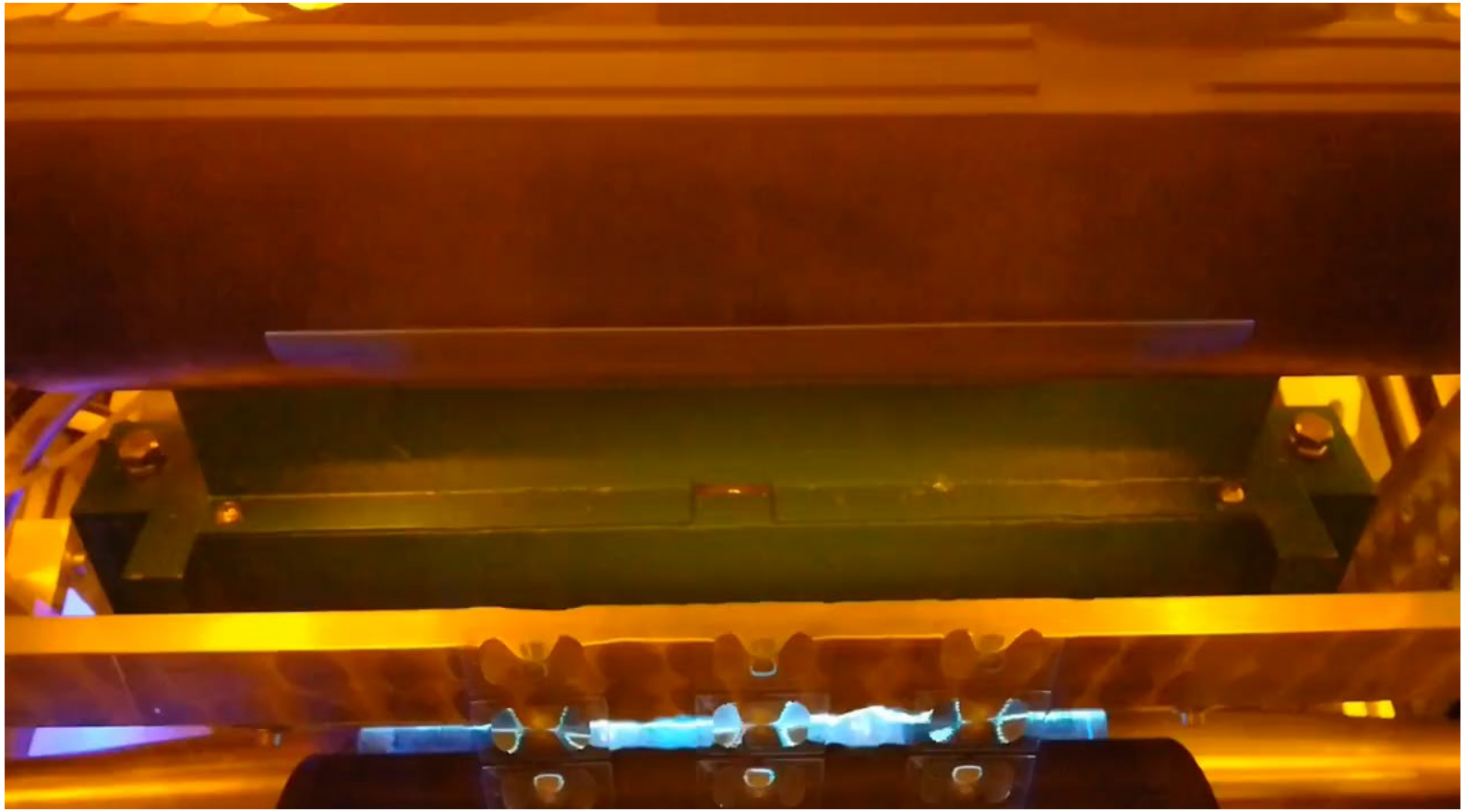
Phabulous

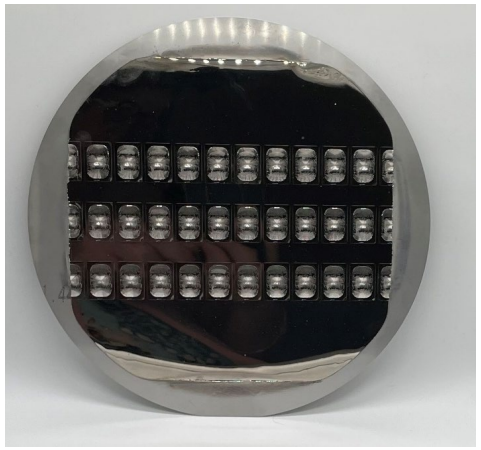
S&R working stamp



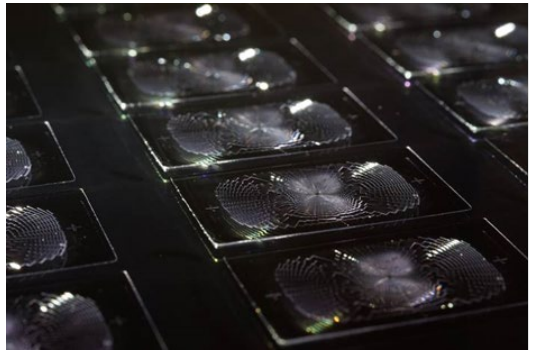
Polymer shim

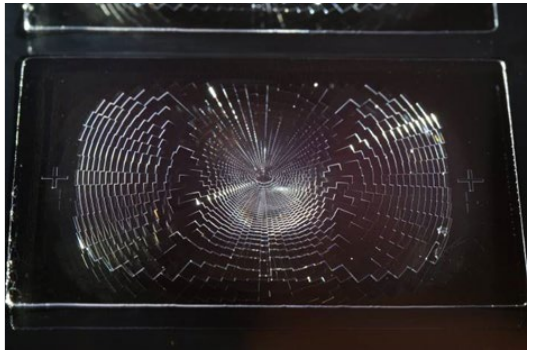


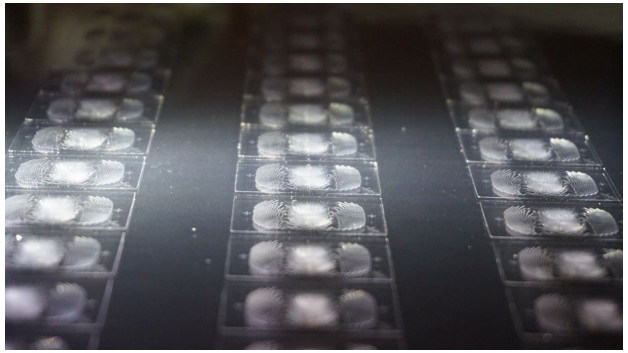


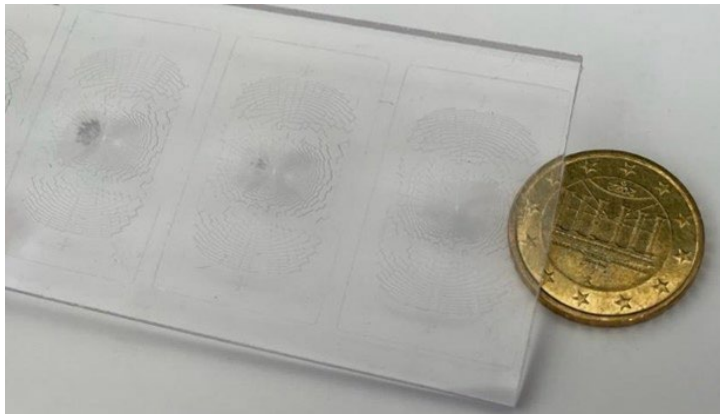


Calvanised master









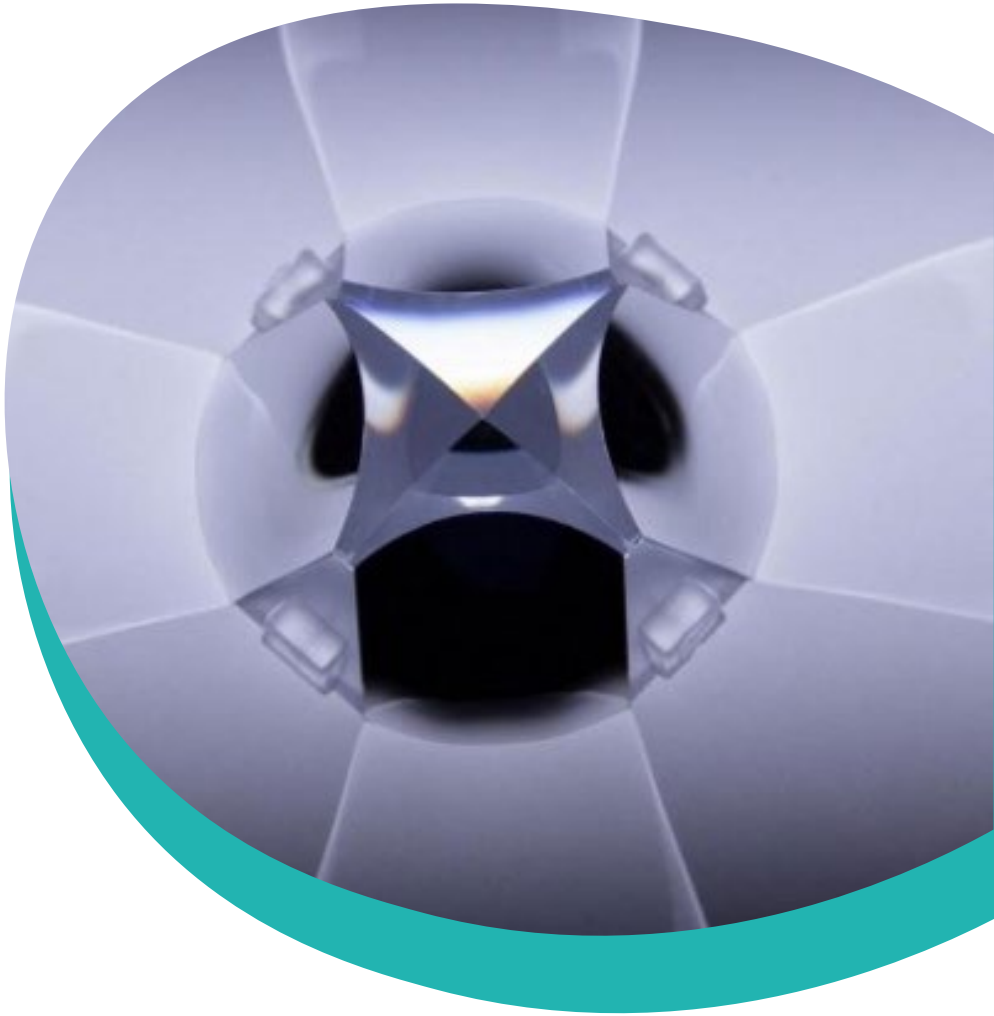
Roll-to-Plate lens arrays

MICRO-OPTICS IS...

Phabulous

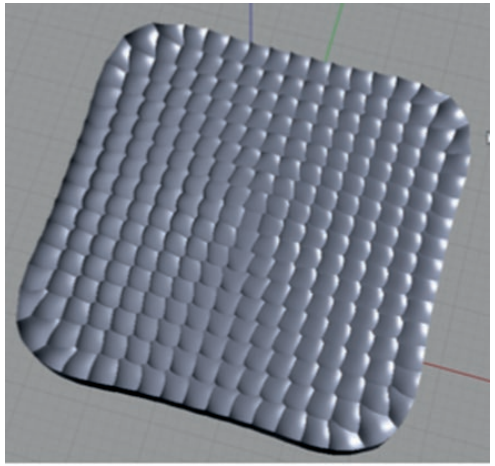
Optical system for VR headsets

VR/AR headsets with improved performance and reduced volume.



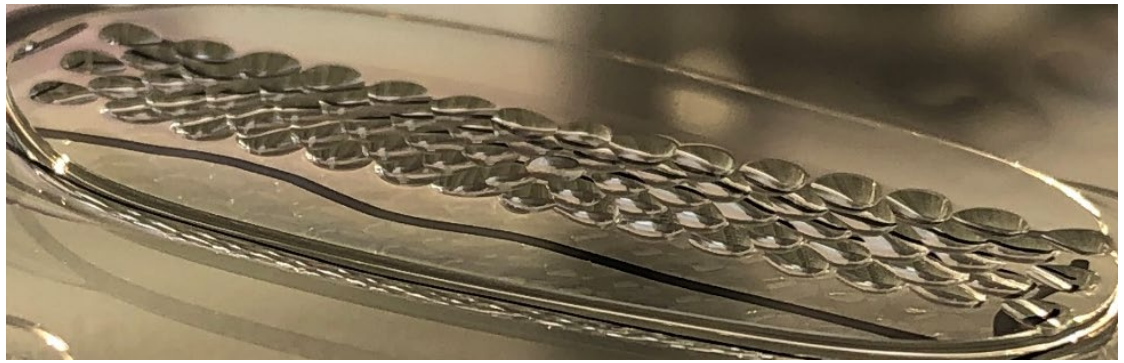
DESIGN

The MLAs of this design include 4 arrays of free-form lenses working in parallel, through ~ 300 optical channels.



ORIGINATION

Required the advanced optical manufacturing technologies available within PHABULOuS.



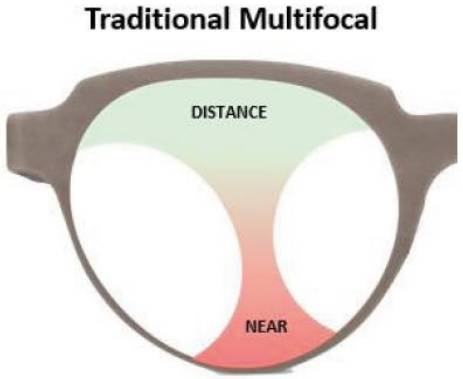
MICRO-OPTICS IS...

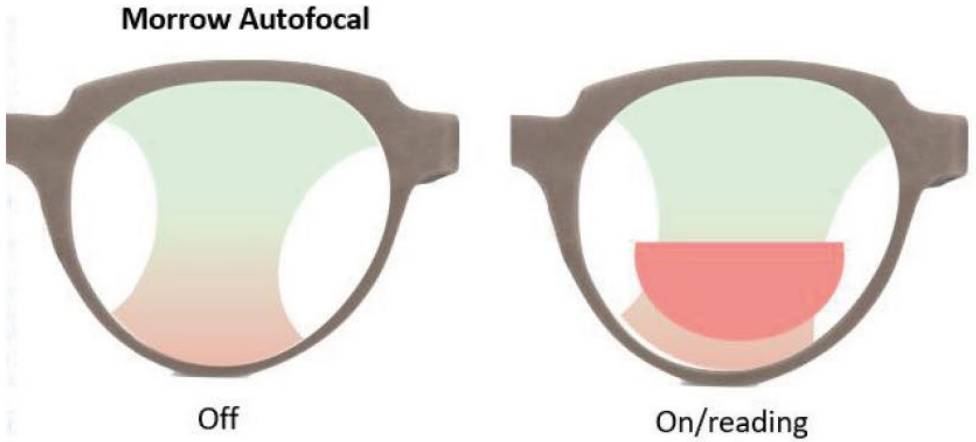
Phabulous

Advanced Free-Form Optics for Autofocal Eyewear

By moving manufacturing pillars from waferscale to roll-2-plate, significant production costs are enabled that would get the product more affordable for the mass market.

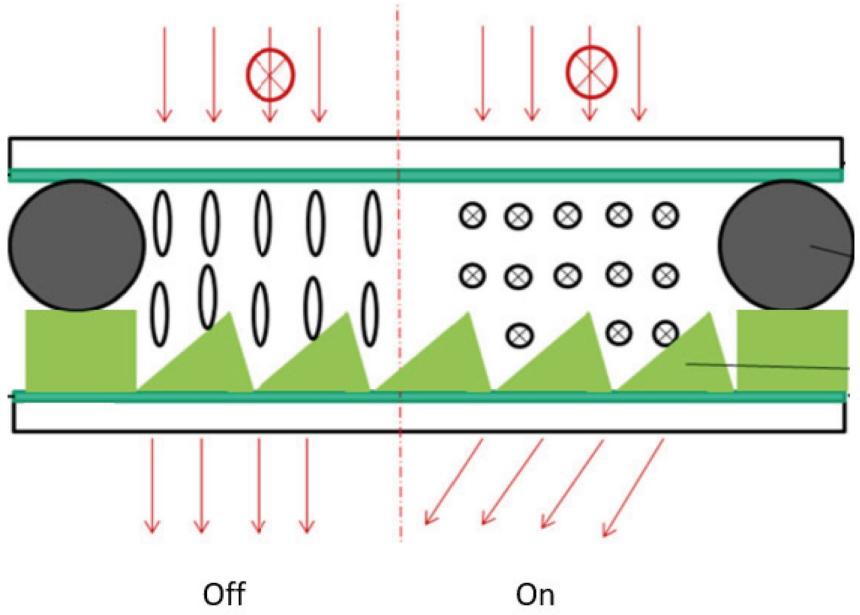
MORROW





Concept

Foil based electrotunable liquid crystal lens in a conventional ophthalmic lens. The foil is a multi-layered structure, containing a nanoimprinted Fresnel type lens with a liquid crystal residing on top of this lens. In the off-state the refractive index of the liquid crystal is matched with the Fresnel lens' refractive index, effectively making it optically invisible.

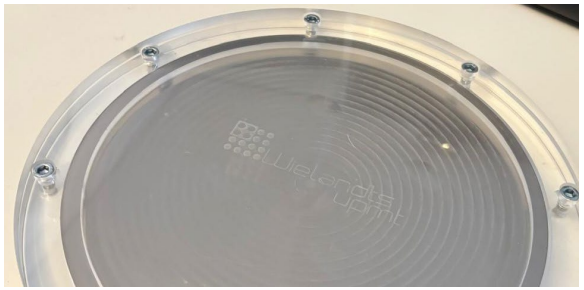


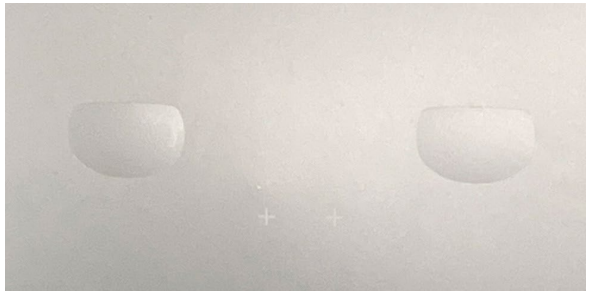
MICRO-OPTICS IS...

Phabulous

ORIGINATION

PRODUCTION

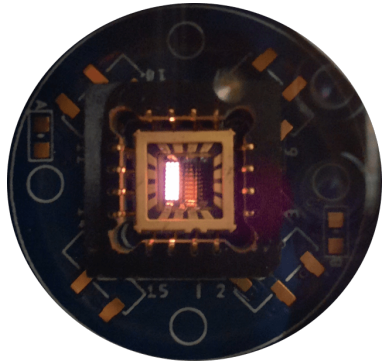


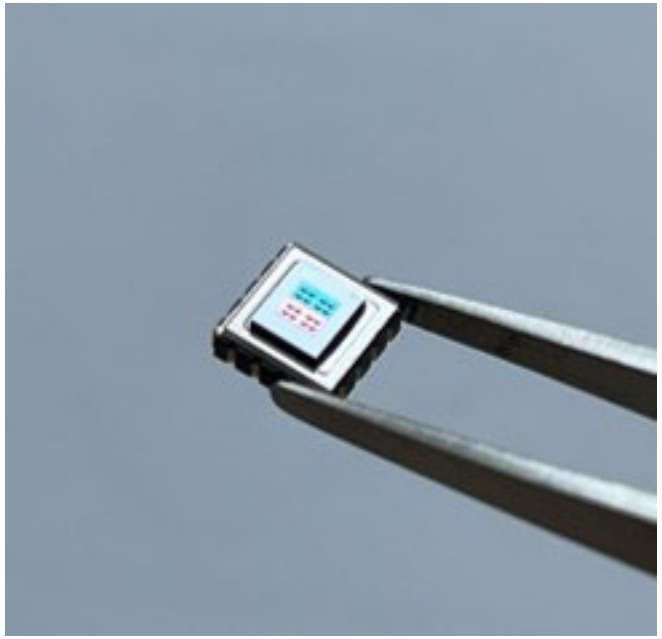


Miniaturized infrared emitter arrays

The freeform micro-optics to ensure the smallest possible formfactor is achieved without any loss in performance.

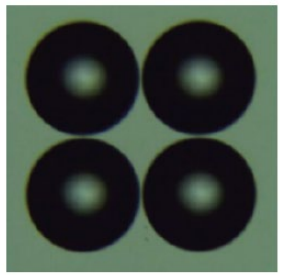
4K-MEMS

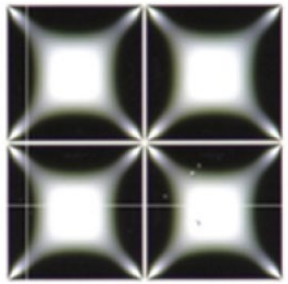


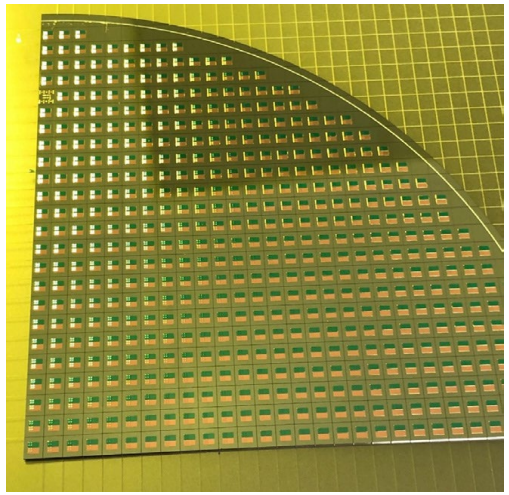


DESIGN

PRODUCTION





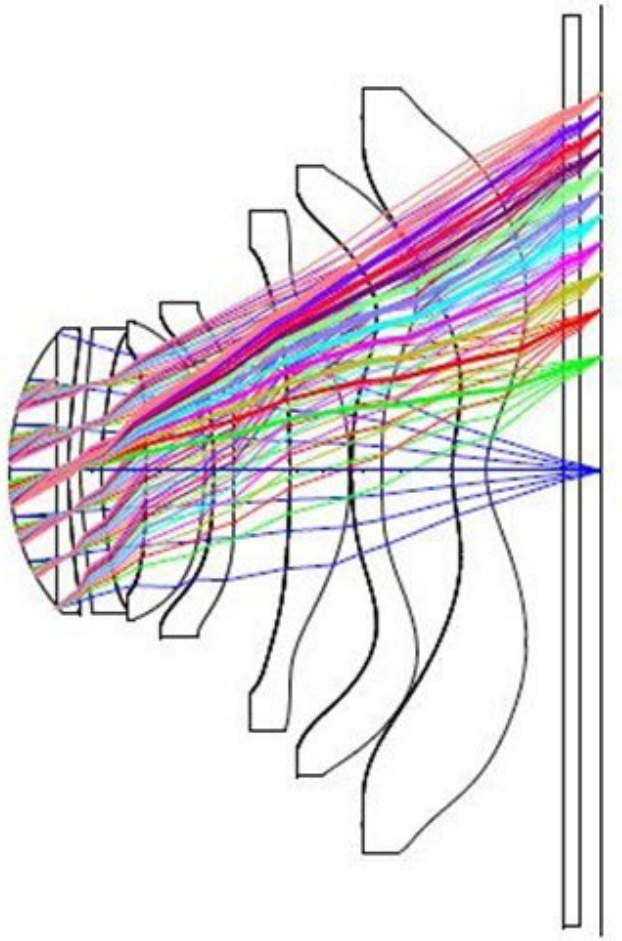


4K-MEMS

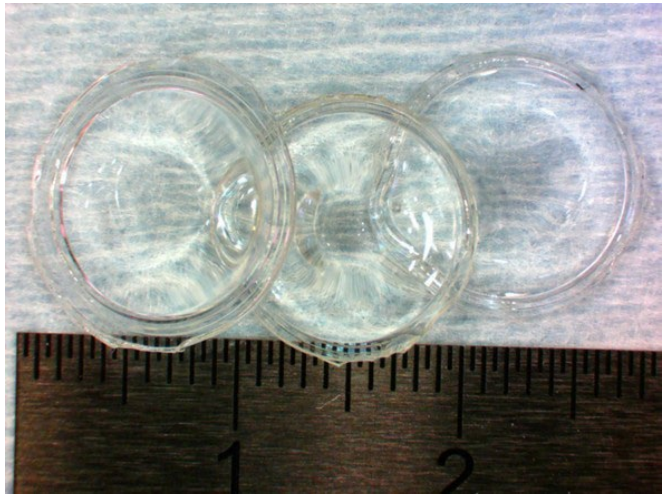
modern camera designs

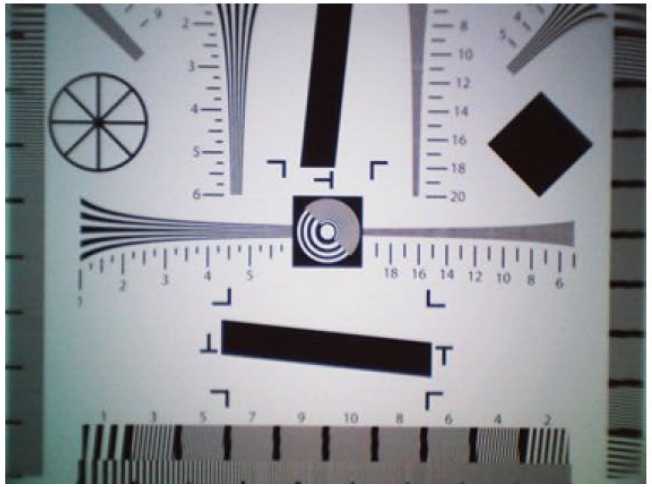
Flexible set-up for miniaturized camera modules

Single modular stack to address high resolution imaging in endoscopy, automotive as well as AR/VR and smartphone applications.



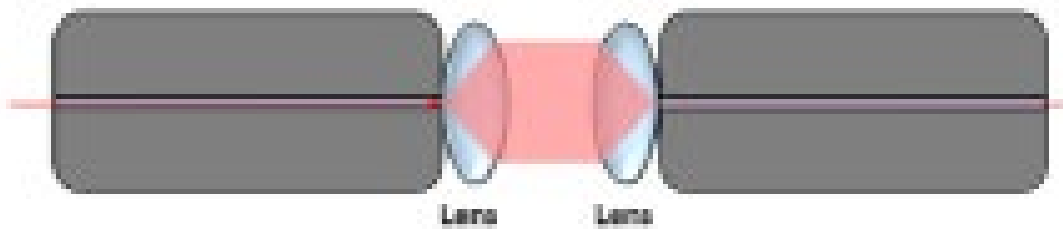
modern camera designs





Expanded beam connector for advanced datacom

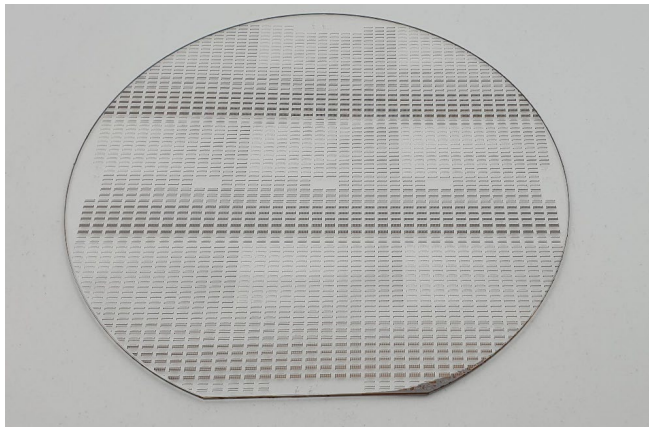
Develop cost efficient connectors with improved performance.

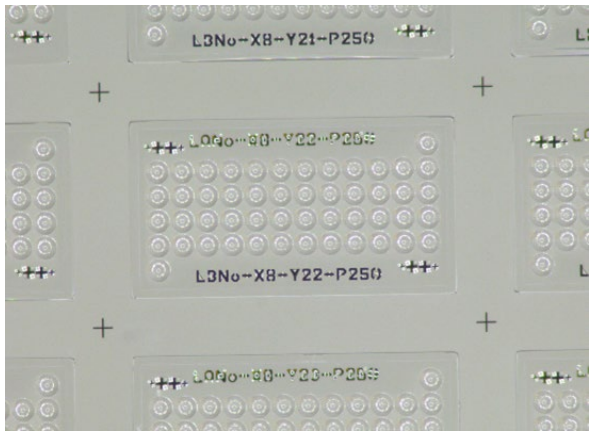


DESIGN

PRODUCTION

BONDING





SFEZ TECHNOLOGIES

MICRO-OPTICS IS...

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Our PHABULOuS partners

leti
ceatech

csem

FOCUSLIGHT
Never stop exploring

Fraunhofer
FEP

JOANNEUM
RESEARCH

LASEA

morphotonics

NANOCOMP

PowerPhotonic

VTT

Wielandts
upmt

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Our PHABULOuS network

csem

BLÖSCH high-end coating solutions

LASEA

SYGLASS

temicon micronano solutions

3D:AG

FEMTOPRINT

ATLANT 3D

Wielandts upmt

microrelleus

PlanOpSim Enlightened Planar Optics

STENSBORG

HETEROMERGE

NANOCOMP

PROFACTOR

Standex

LUXIMPRINT

PHASICS the phase control company

MORPHOTONICS

MICRO OPTICS EUROPE A Healthcare Components Group Company

Fraunhofer IOF

Fraunhofer Institute for Applied Optics and Precision Engineering IOF

photonics precision engineering

imagine optic

nano scribe

TOPPAN TOPPAN PHOTOMASK

alfamation an inTEST Company

EPIC EUROPEAN PHOTONICS INDUSTRY CONSORTIUM

FOCUSLIGHT Never stop exploring

cea

Phabulous

JOY TEAM Optical Systems Design

YALOSYS LASER MICROPROCESSING SOLUTIONS

PowerPhotonic Enhancing Beam Performance

VTT

Fraunhofer FEP

folex

a::etris

JOANNEUM RESEARCH

MATHYM INNOVATIVE NANOMATERIALS

FORVIA HELLA

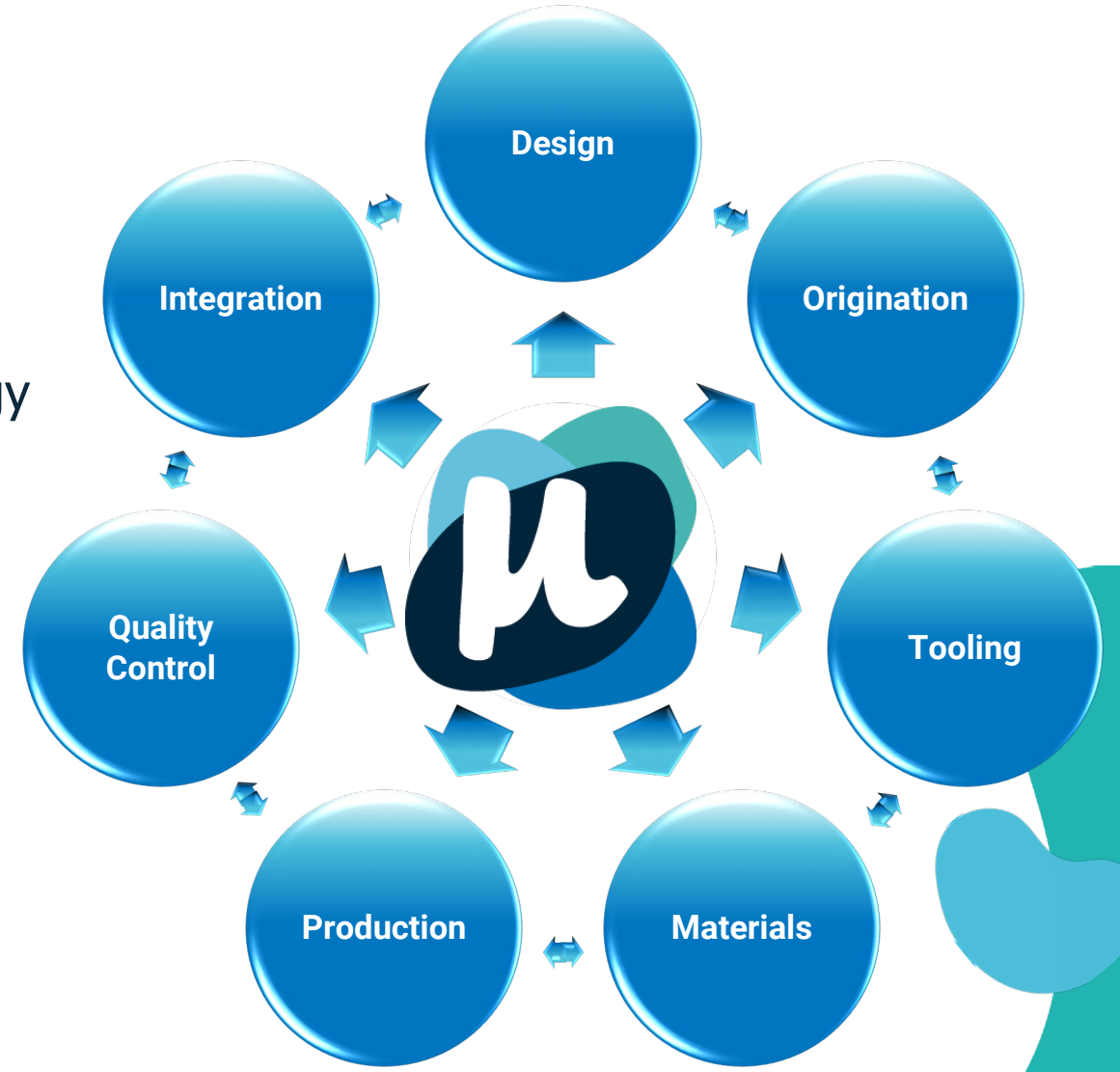
EQUIPMENT · SOFTWARE · PROCESSES esp-engineering

XRnanotech

MICRO-OPTICS IS...
Phabulous

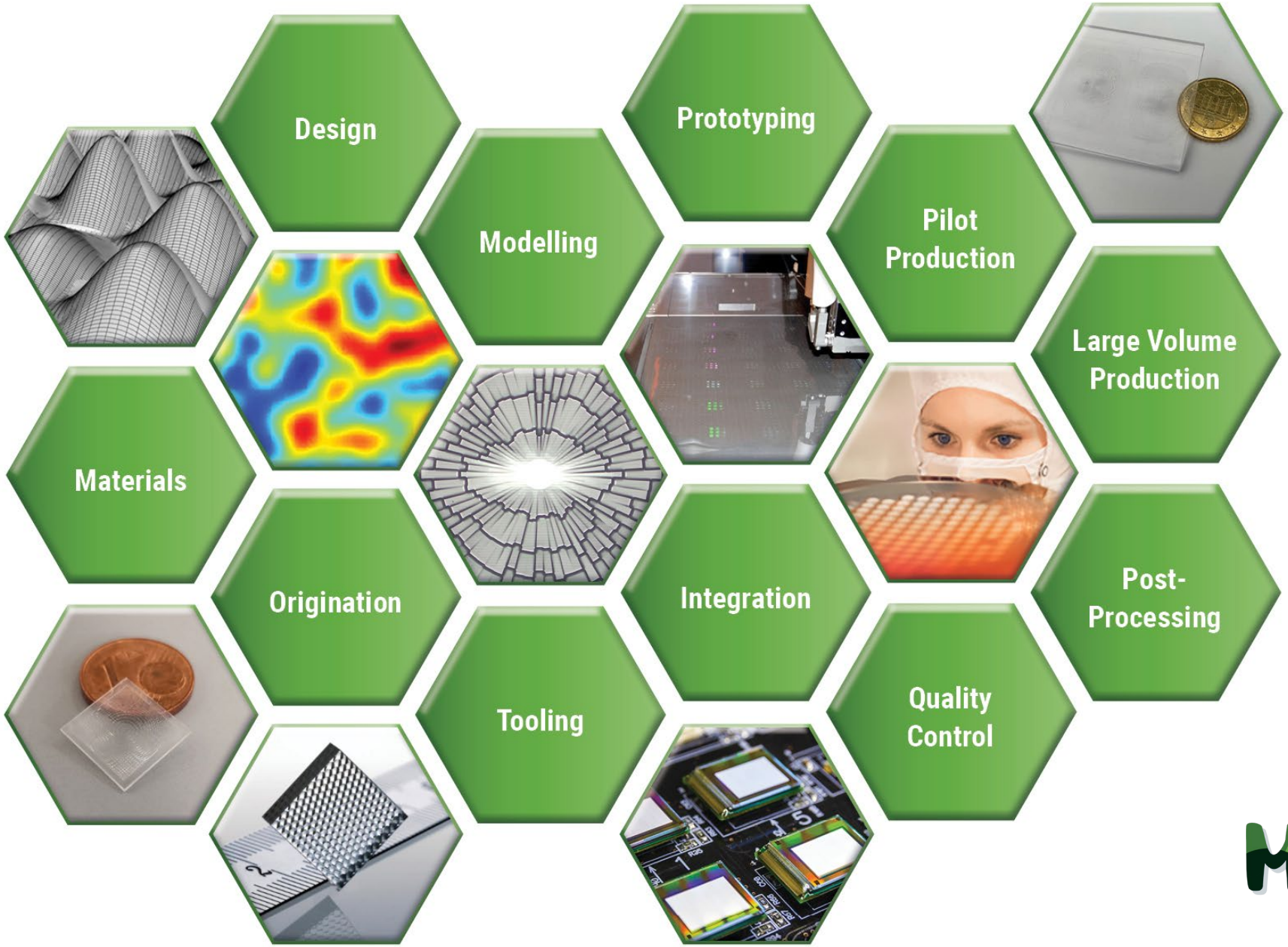
Our mission is...

- to **facilitate collaboration**
- enable **easy access** to cutting edge technology
- and to **accelerate innovation**.



MICRO-OPTICS IS...

Phabulous



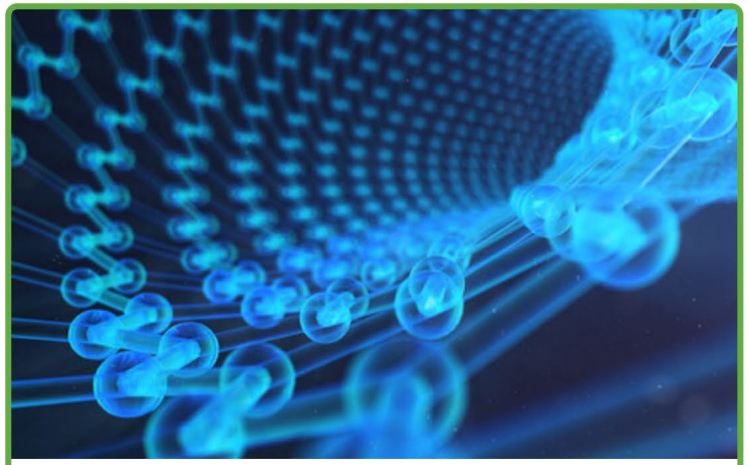
ECOSYSTEM FOR

Micro-optics

ECOSYSTEM FOR
Micro-optics

Website Ecosystem Summit

Technical Marketplace Organisation Registry Community



Technical Marketplace

Catalogue of products, prototypes and technical services

Organisation Registry

Catalogue of ecosystem organisations

Community

Shared information for benefit of PHABULOuS ecosystem

ECOSYSTEM FOR Micro-optics

Organisation registry

ECOSYSTEM FOR Micro-optics

Organisation registry

CEA-Leti

Preferred Supplier

The CEA: a key player in technological research The French Alternative Energies and Atomic Energy Commission (CEA) is a key player in research, development and innovation in four main areas: defence and security, low carbon energies (nuclear and renewable energies), technological research for industry, fundamental research in the physical sciences and life sciences.

Read More

CSEM SA

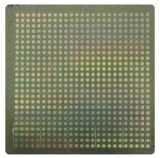
Preferred Supplier

CSEM is a privately held, research and development company established in 1984 in Neuchâtel, Switzerland. CSEM carries out applied research, development, prototyping and small series production in the fields of micro/nanotechnology, microelectronics, system engineering, information and communication technologies. In particular, CSEM has developed strong competences in the design, manufacturing and characterization of micro- and nano-optical components for imaging and non-imaging applications.

Read More

ECOSYSTEM FOR Micro-optics

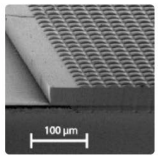
Technical Marketplace



Tooling (step and repeat) Member

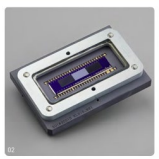
Tooling (electro-forming) Member

Replication by R2P Member

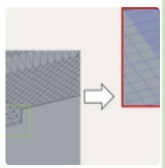


Replication at Wafer-scale Member

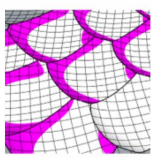
Origination Member



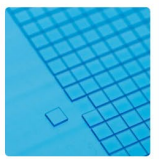
Micro-lenses And Micro-lens Arrays Member



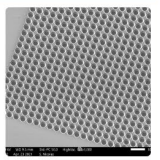
Characterization And Quality control Member



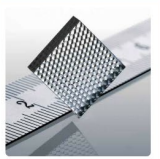
Design And Design for Manufacturing Member



Laser Dicing of glass based wafer level manufactured products



Origination – MicroLens Array Member

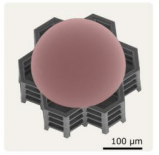


Microimprint on Wafer Level Member

Large area vacuum coating via sheet-to-sheet processes Member

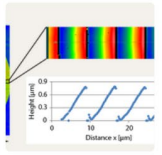
Advanced Laser Ablation Member

Step and Repeat Member



High-resolution multi-material micro-optics

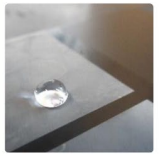
Headlamps with Micro-optics User



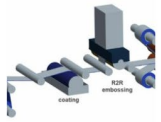
Micro Fresnel lenslets

R2R assembly pilot line

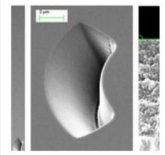
Roller-based NanoImprinter



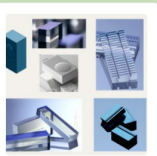
Micro- and Nano Laser structuring



Roll-to-Roll UV Imprint Replication Member

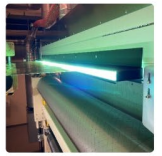


Origination – Grayscale Direct Write Laser Lithography Member



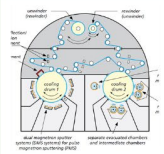
Aspherical microlens and MLA on silicon and glass wafer

R2R pilot converting line

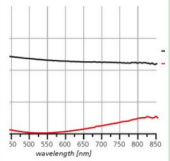


R2R UV-Imprint Manufacturing

Optical grade polymers on wafer-level

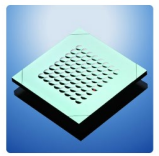


Vacuum Roll-to-roll Coating Member

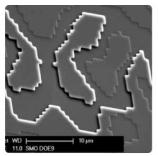


Nanostructuring via plasma processes Member

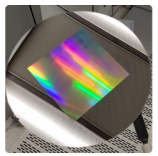
Material Characterization Member



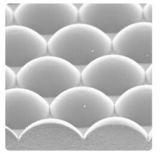
Etched Microlenses Member



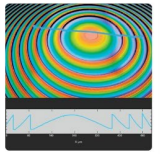
Diffractive Optics (DOEs) Member



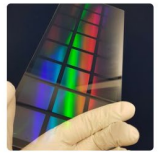
NanoImprint at wafer-scale Member



Microlens Array Films Member



Fresnel Lens Films Member



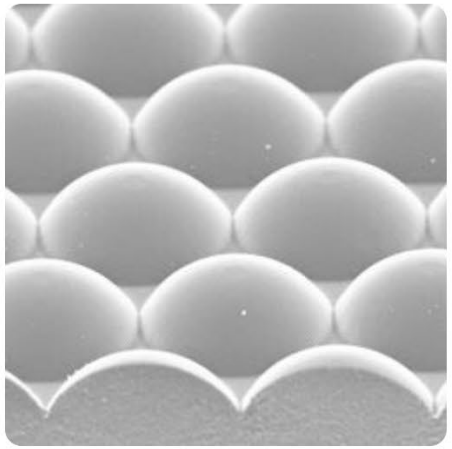
Nanoimprint (replication of nano/micron textures) Member

FEMTOSECOND LASER MICROSTRUCTURING SERVICES IN 5 AXIS

View All

ECOSYSTEM FOR Micro-optics

Technical Marketplace



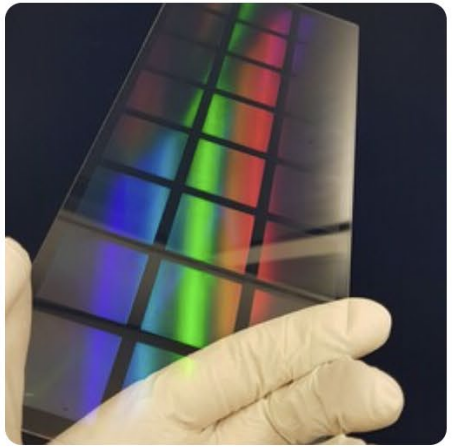
Microlens Array Films

Preferred Supplier

Nanocomp Oy Ltd manufactures customizable microlens array (MLA) films using UV roll-to-roll imprinting, offering high precision and cost-efficient mass production. These ultra-thin, flexible films are ideal for applications in displays, sensors, fiber couplers, and 3D imaging, providing excellent optical performance and customizable shapes.

View Offering

NANOCOMP



Nanoimprint (replication of nano/micron textures)

Preferred Supplier

Morphotonics B.V. offers UV-Nanoimprint Lithography (UV-NIL) replication for large substrates (up to 1.1m). This cost-effective technology enables mass production of precise micro/nanostructures for applications in displays, lighting, sensors, and solar panels, with textures ranging from 50 nm to 500 µm.

View Offering

MORPHOTONICS

ECOSYSTEM FOR Micro-optics

Community

Publications

Illuminating design with freeform optics

How optical designers can realise the benefits of us
designing for illumination applications

Publications

Advancing lighting innovation: free-form optics' promising future in mobility interi

PHABULOuS aims to revolutionise the development opportunities for lighting techniques.

Publications

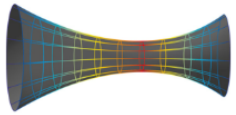
More passenger comfort

Freeform micro-optics opening up new possibilties i

News

PowerPhotonic Inc appoints Mark McElhinney to spear head the founding of US manufacturing.

PowerPhotonic has appointed Mark McElhinney as CEO of PowerPhotonic Inc. Mark's initial focus will be quickly establishing US engineering & manufact



News

The Light Tunnel Generator by PowerPhoton

Launch of a game-changing new class of optical Beam S
The Light Tunnel Generator

News

Enhanced LightForge rapid prototyping servi

PowerPhotonic has enhanced its rapid prototyping servic

Videos

Free-form micro-optics for fibre coupling

Learn about a patented solution that enables "plug-and-play" fibre coupling using fr

Videos

Free-form micro-optics in Automotive

Harald Pier from SUSS MicroOptics talks about innovation in free-form micro-optics safety, light carpets and headlights.

Videos

MicroOptics for Automotive Lighting

Micro-optics allows for small and compact lighting solutions and are increasingly us applications.

Micro-Optics Summit & Expo

- Main event to **connect the value chain** in micro-optics to **potential customers**
- Next edition planned on **25-26 June 2026** in Rotterdam

Services for (end) users

- Easy access to relevant information
- Manufacturing services
- Prototyping → piloting → large volume production
- Funding opportunities

Services for technology providers

- Integration into the value chain for micro-optics
- Organization registry → Marketplace → Community
- Lead generation

PHABULOuS recap

- Collaboration of leading European companies in the field of (free-form) micro-optics
- Full value chain from design to integration for smooth upscaling
- For a wide range of applications
- Funding for companies looking to implement free-form micro-optical components

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Let's Connect

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CEO / Chairman

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LinkedIn