

# Laser-based 3D Printing for Advanced Glass Micro-devices

Dr. Rolando Ferrini

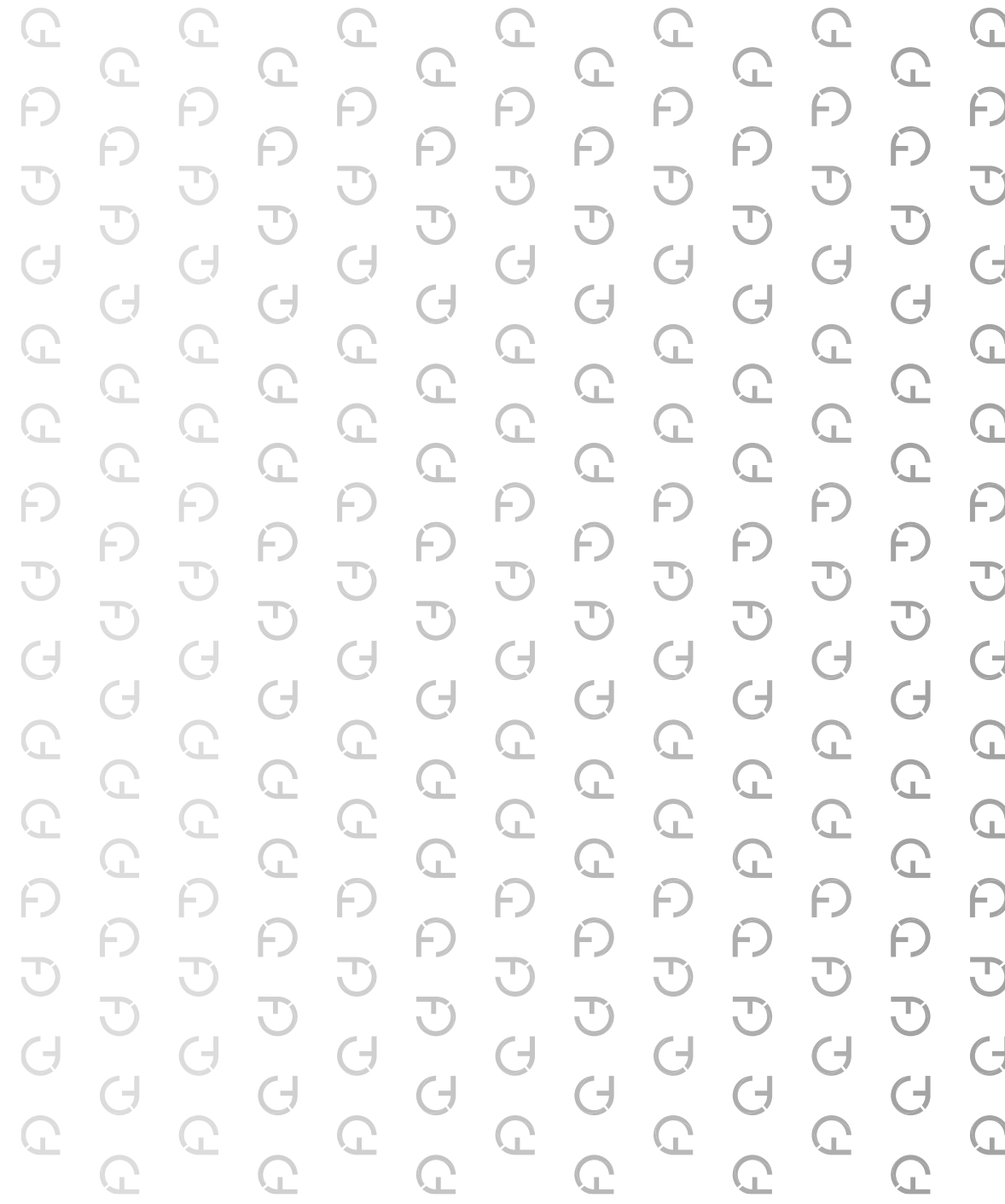
EPIC Meeting on Laser-based Advanced & Additive Manufacturing

*Laser World of Photonics*

*Munich, April 27<sup>th</sup>, 2022*



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# FEMTOprint IN A NUTSHELL

FEMTOprint is a Swiss high-tech Contract Development and Manufacturing Organization (CDMO) specialized in **high-precision 3D microfabrication in glass**.

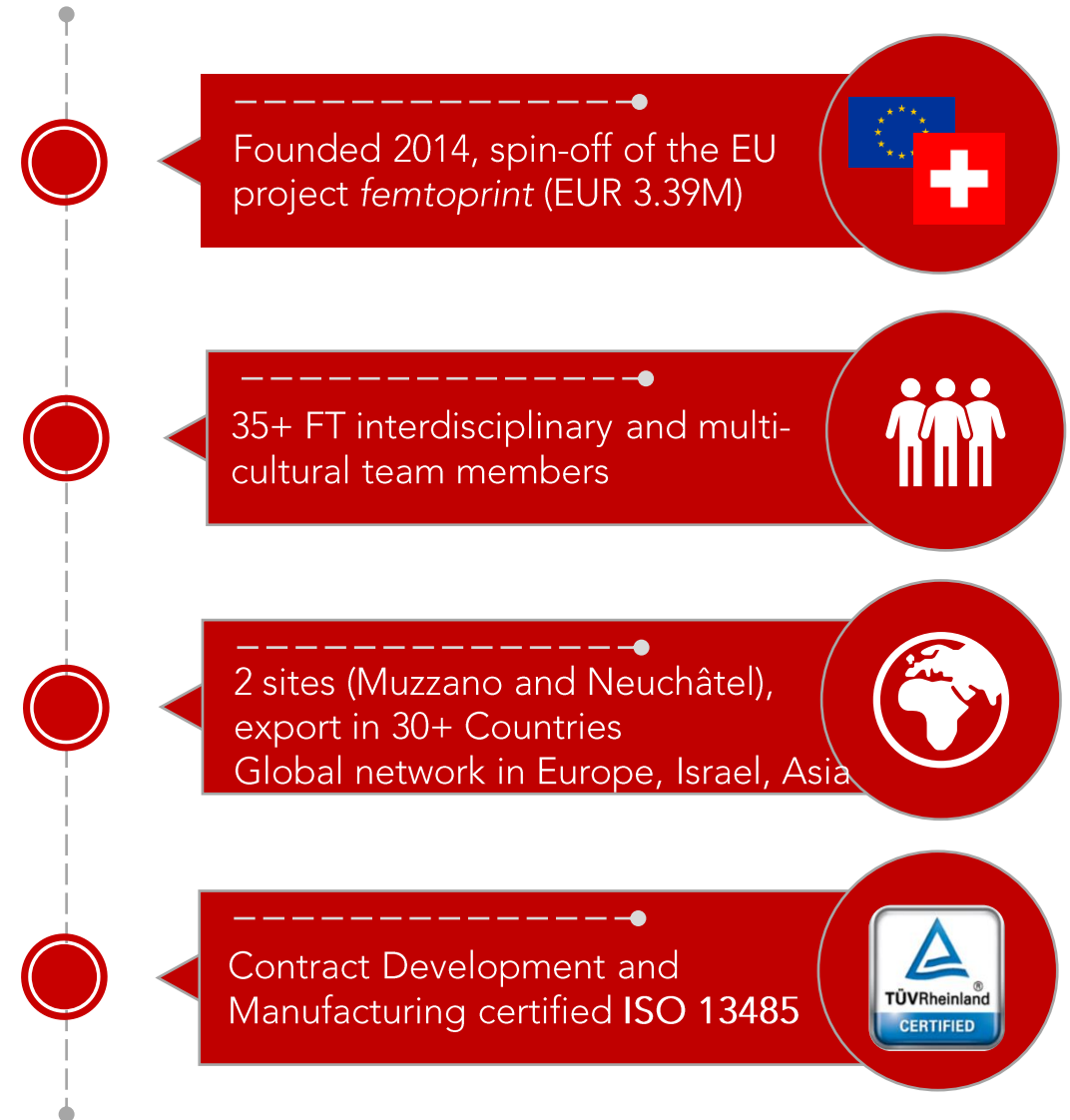
With the groundbreaking FEMTOPRINT® microfabrication platform we serve leading industrial Customers with **feasibility, rapid prototyping, pilot- and industrial series manufacturing at wafer-level**.

## APPLICATIONS

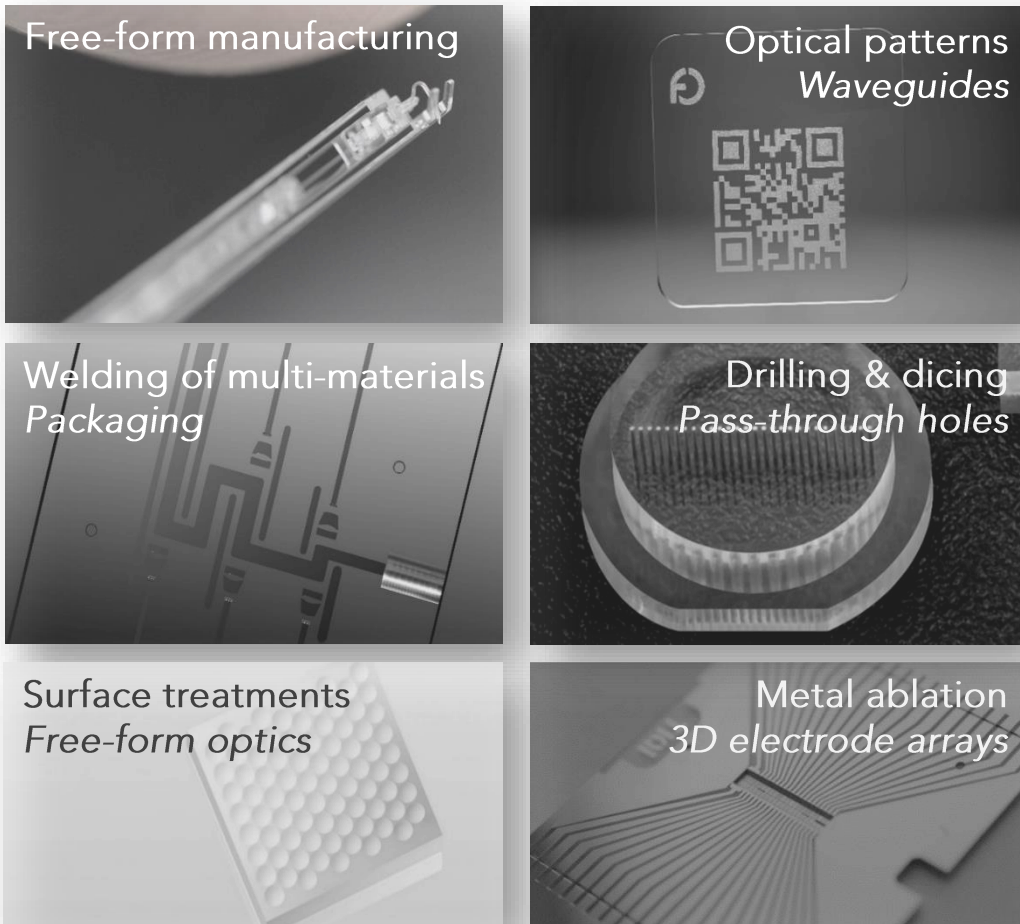
*Microfluidics | Microoptics | Photonics | Microelectronics |  
Micromechanics | MEMS | Packaging | Mastering*

## INDUSTRIES

Life Sciences & Diagnostics | Medical | Watchmaking  
Aerospace & Defense | Automotive | Industrial Machinery  
Precision Mechanics | Semiconductors | VR & AR | Sciences



## CAPABILITIES

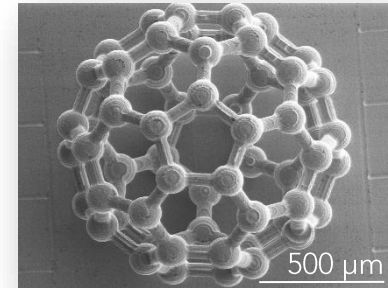


## PERFORMANCES\*

\*in SiO<sub>2</sub>

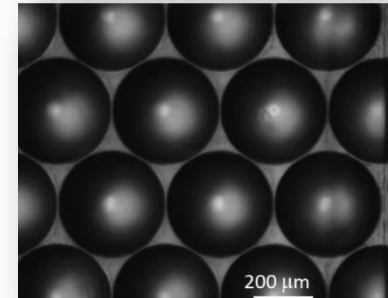
### RESOLUTION AND TOLERANCES

- Process resolution  $\sim 1 \mu\text{m}$
- XY tolerances  $\pm 1 \mu\text{m}$
- Z tolerance  $\pm 2 \mu\text{m}$



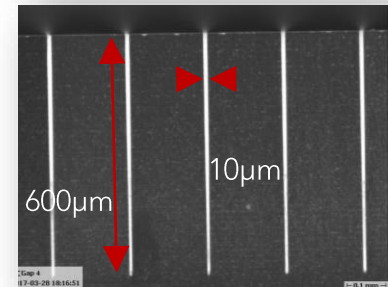
### SURFACE QUALITY

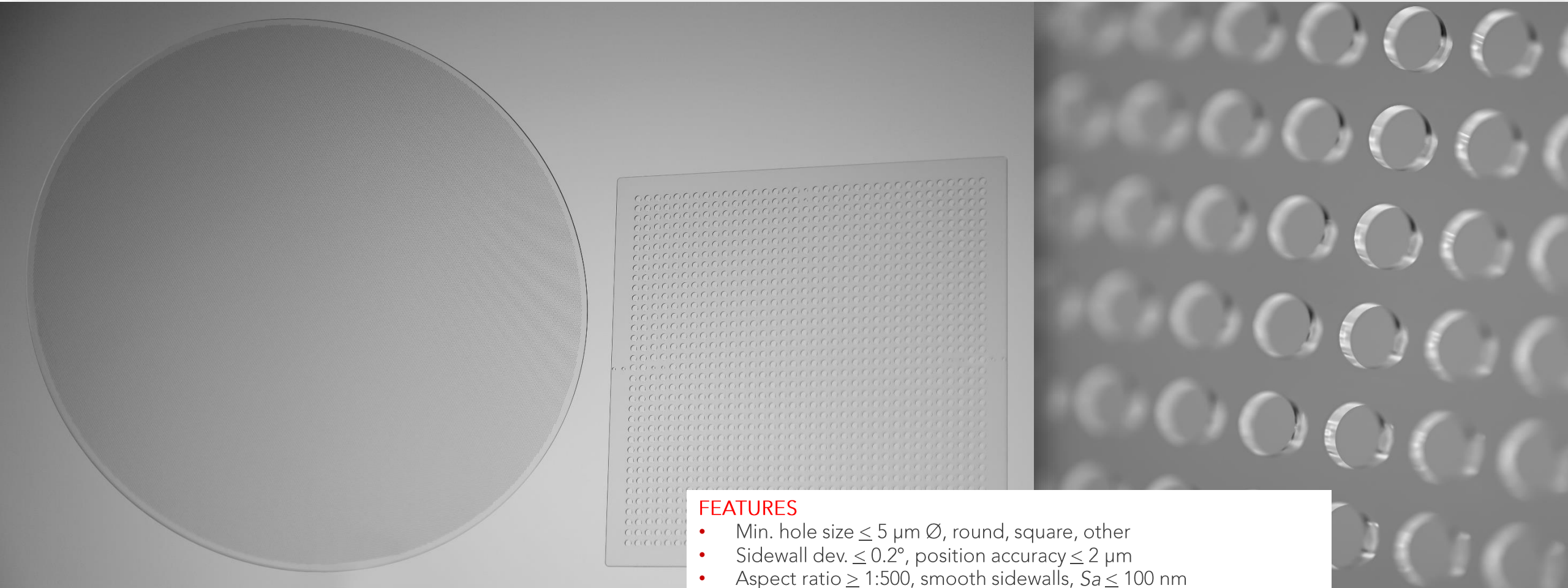
- Patterned surface  $S_a \leq 100 \text{ nm}$
- Surface treatment  $S_a \leq 10 \text{ nm}$



### ASPECT RATIO

- Channel aspect ratio  $\geq 1:500$
- Bulk height up to 30 mm
- Working area up to 300 mm Ø

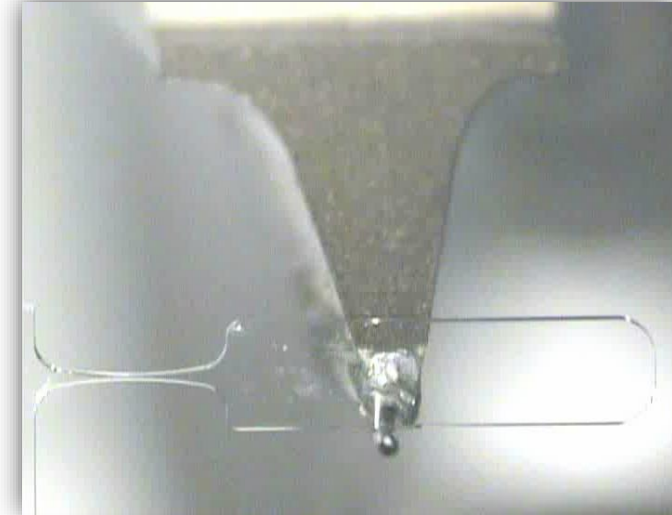




## FEATURES

- Min. hole size  $\leq 5 \mu\text{m } \varnothing$ , round, square, other
- Sidewall dev.  $\leq 0.2^\circ$ , position accuracy  $\leq 2 \mu\text{m}$
- Aspect ratio  $\geq 1:500$ , smooth sidewalls,  $S_a \leq 100 \text{ nm}$
- Sharp or tapered edge, no sagging and chipping

- 01 TRANSPARENT AND ISOTROPIC
- 02 STABLE AND ELECTRICALLY INSULATING
- 03 BIOCOMPATIBLE
- 04 ELEVATED THERMAL PROPERTIES
- 05 HIGHLY ELASTIC
- 06 RESISTANT TO CORROSION, ABRASION AND SCRATCHES
- 07 NEUTRAL TO MAGNETIC FIELDS





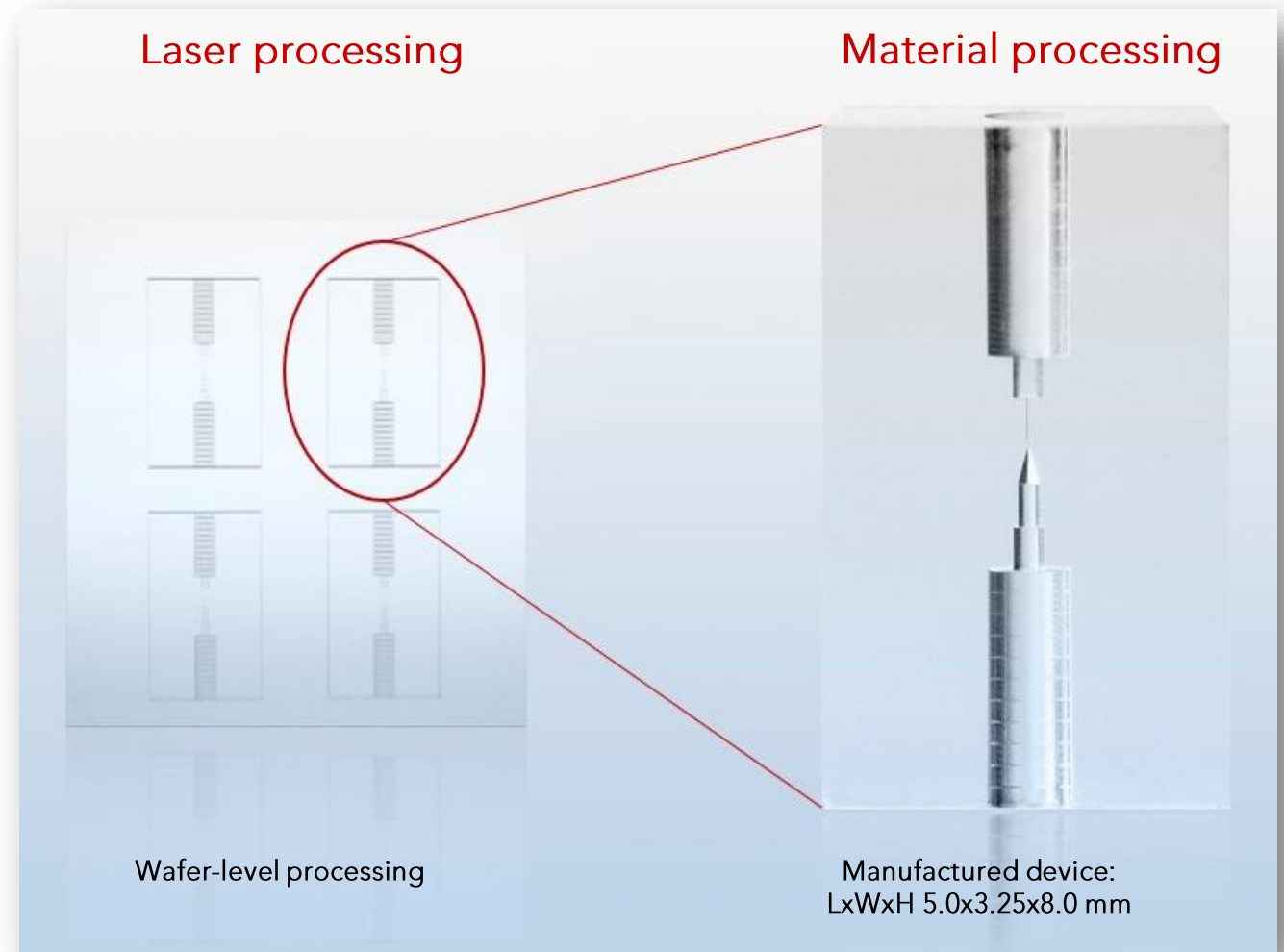


## LASER 3D MICROFABRICATION

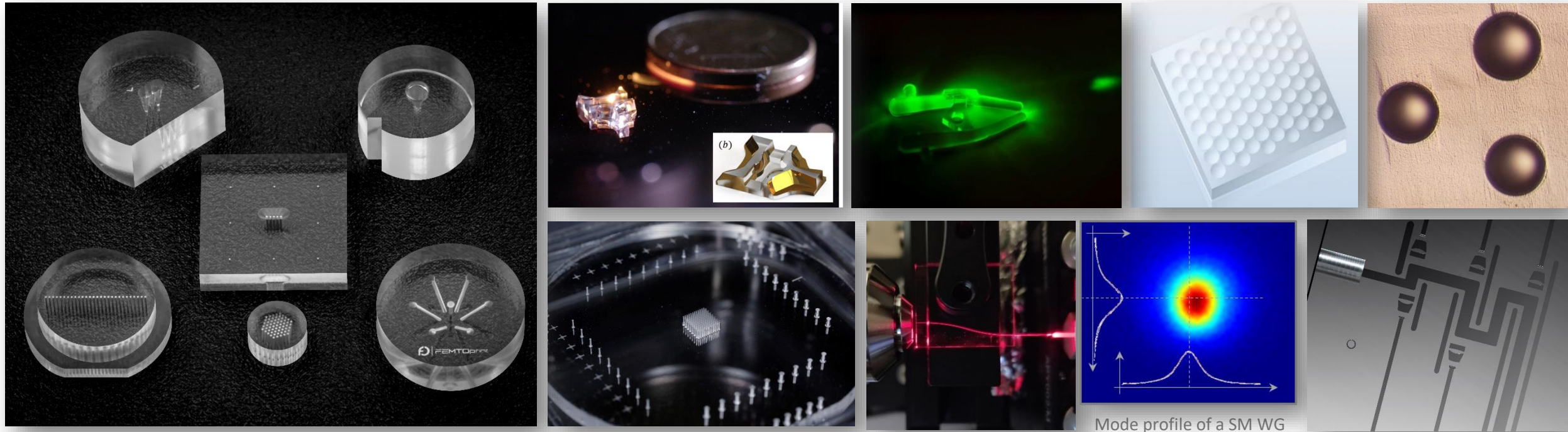
- laser-based microstructuring & material processing
- free-form 2D/3D microprocessing in glass materials

## WHY WORKING WITH US

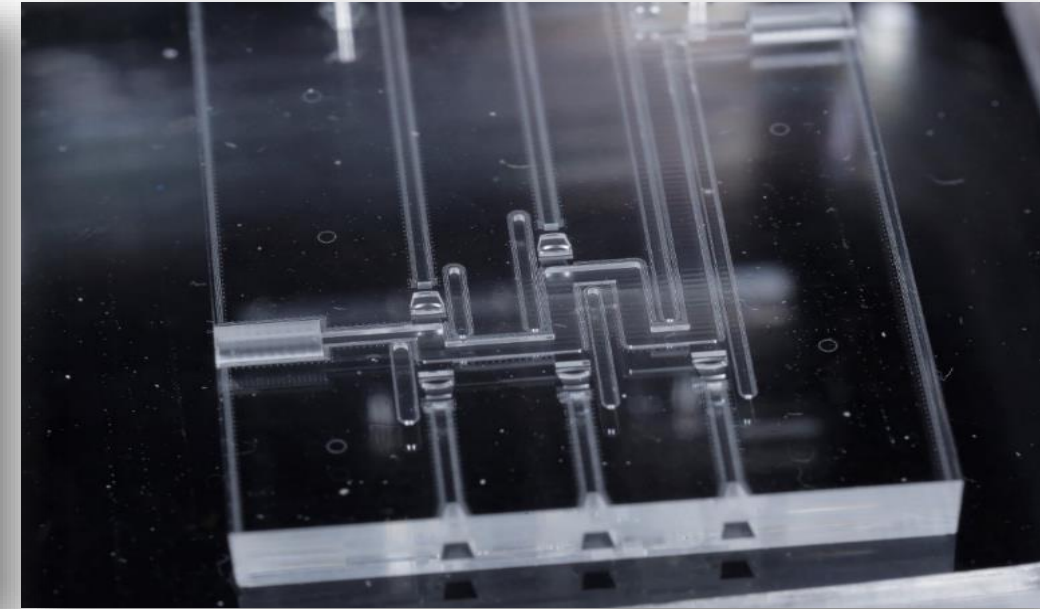
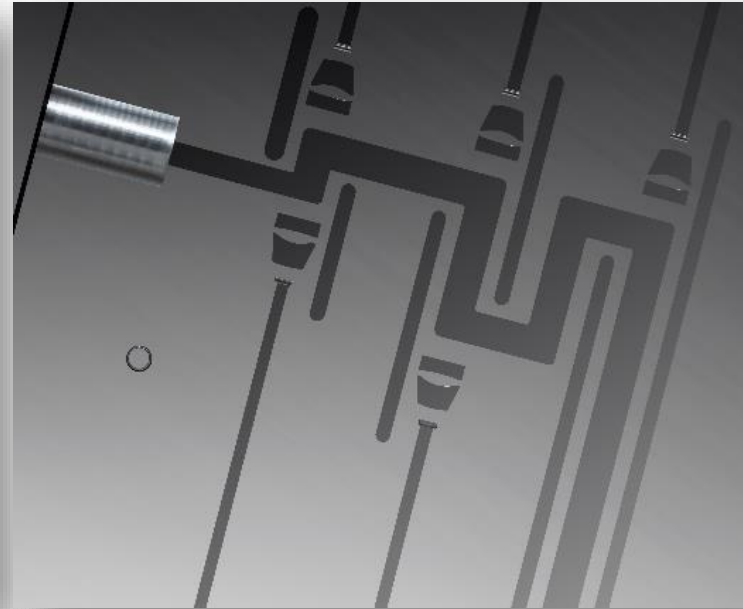
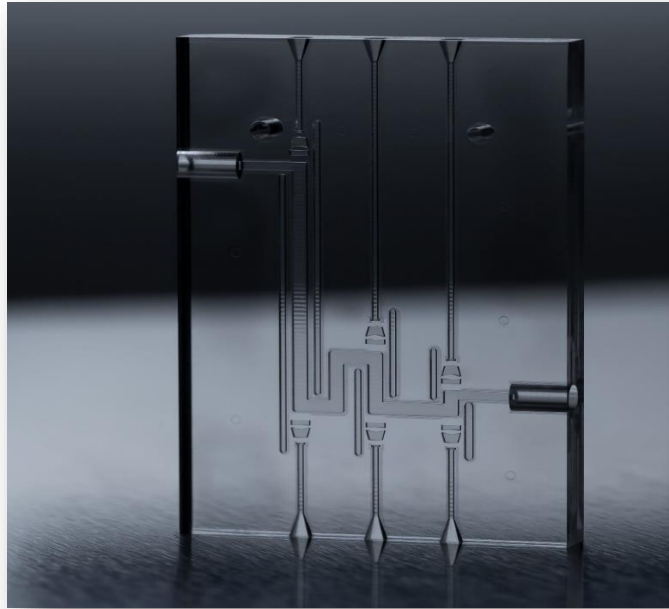
- In-house unique know-how and capabilities of glass micro-processing, from proof-of-concept, to pilot and series manufacturing;
- Vertically integrated, one-stop shop manufacturing foundry, delivering from single units up to volumes on wafer-level;
- Control over the entire value chain and fast turnaround cycles in prototyping;
- ISO 13485:2016 certified for medical devices;
- Suitable for numerous glass types: fused silica, fused quartz, borosilicate, aluminosilicate, alkali-free, etc.



- Opto-mechanical aligners & positioners
- Interconnectors
- Photonic packaging
- Birefringent nanogratings
- Integrated opto-mechanical sensing & opto-fluidic devices
- Diffractive elements
- Microlenses
- Free-form lenses
- Microlens arrays
- Fiber couplers
- 3D v-grooves
- Bulk alignment marks
- Masters for replica
- Waveguides
- Lab-on-fibers
- Prisms & mirrors







## APPLICATION

- Optofluidic Photonic Lab-on-a-Chip
- Monolithically integrated micro-optical system for the optical spectroscopy in a microfluidic structure

## USPs

- Combination of functionalities
- Monolithic integration

CEA, DEN, DMRC, University of Montpellier, Marcoule, France.

Elodie Mattio et al. Photonic Lab-on-a-Chip analytical systems for nuclear applications: optical performance and UV-Vis-IR material characterization after chemical exposure and gamma irradiation.  
*Journal of Radioanalytical and Nuclear Chemistry* (2020) 323:965–973.

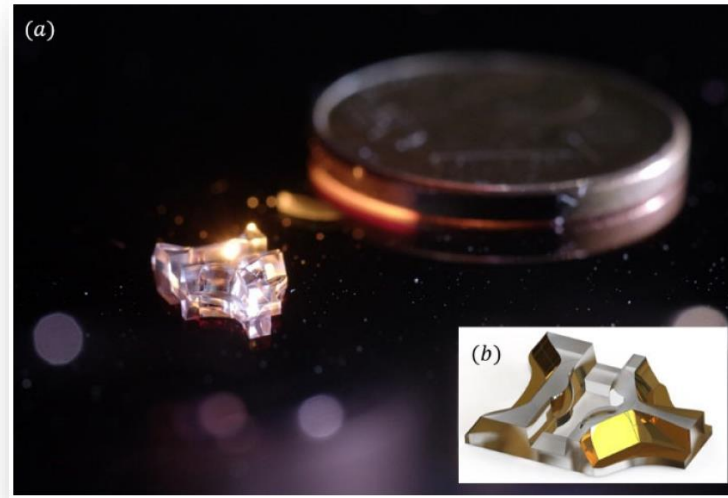
# MINIATURIZED FREE-FORM OPTICAL SYSTEM

## APPLICATION

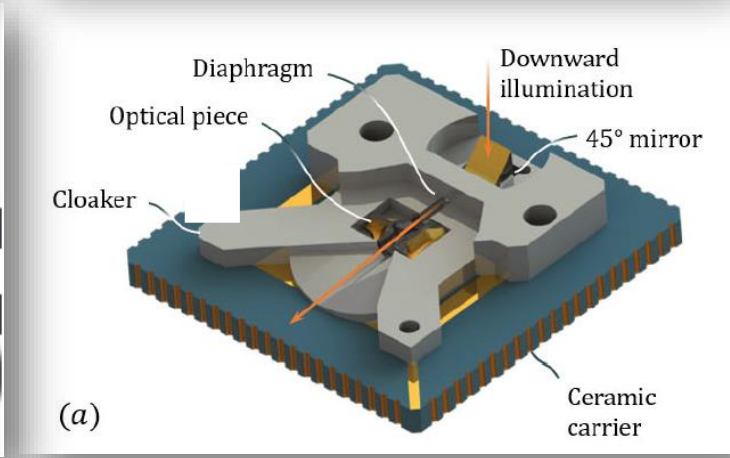
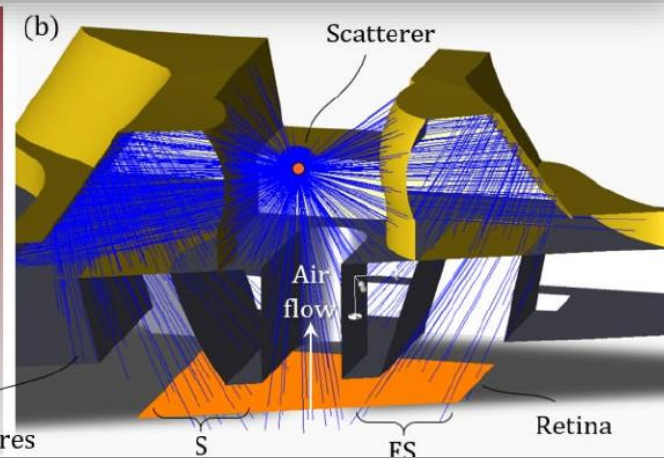
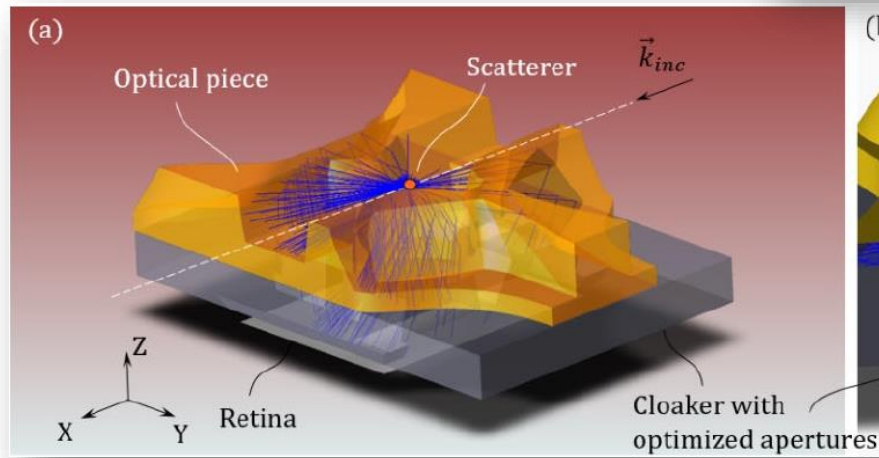
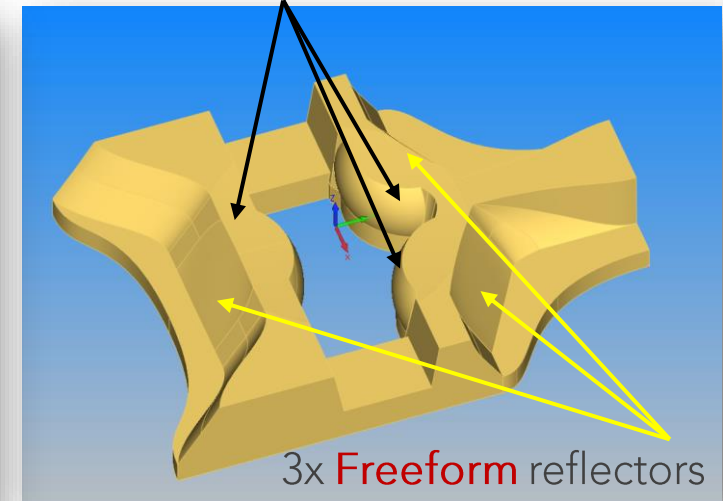
- Air quality monitoring
- Improved sensitivity by the integration of a miniaturized refractive/reflective optical system

## USPs

- Integration of functionalities
- Free-form fabrication

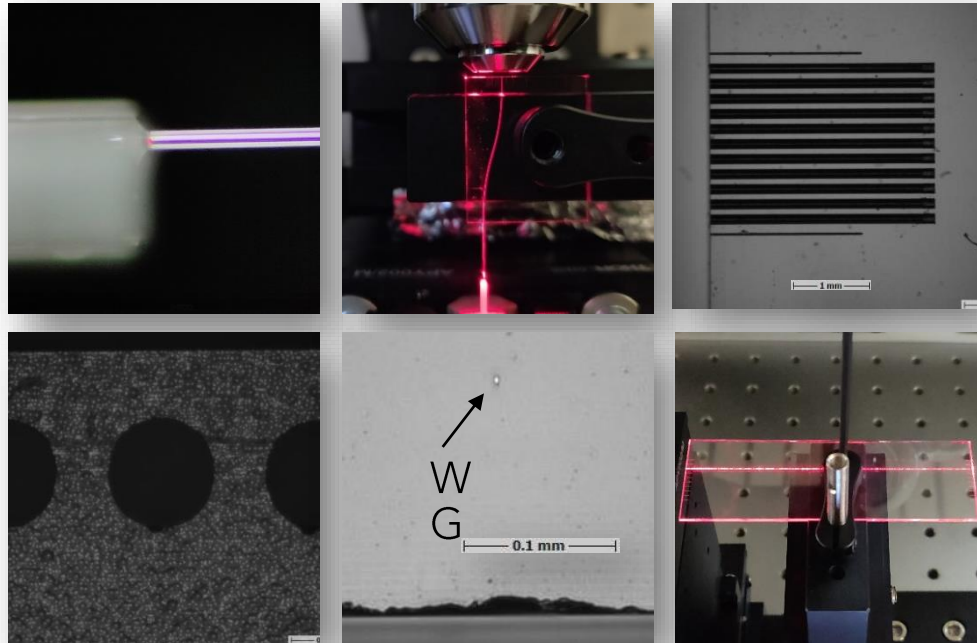


3x **Vertical** spherical lenses



CEA-LETI Minatéc & Institut des Nanotechnologies de Lyon.

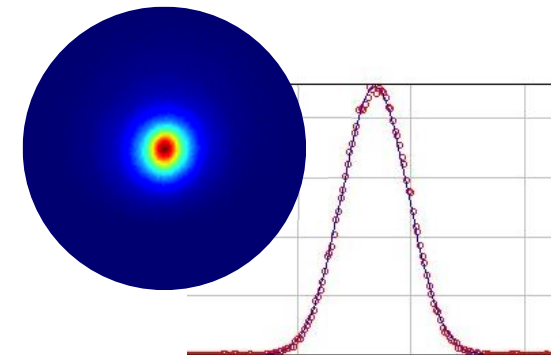
Jobert G. et al. Miniature Optical Particle Counter and Analyzer Involving a Fluidic-Optronic CMOS Chip Coupled with a Millimeter-Sized Glass Optical System. Sensors 2021, 21, 3181.



Materials	FS, BF33, EXG
Working $\lambda$ [nm]	630, 980, 1310, 1550
MFD SM [ $\mu\text{m}$ ]	3 @ 630nm, 7 @ 980nm
Min. Curvature Radius	approx. 30mm
Propagation Loss	< 1 dB/cm
$\Delta n$	$10^{-2} - 10^{-3}$

## ADDITIONAL FEATURES

- Alignment markers and grooves can be conveniently added
- Facet polishing for rapid prototyping and characterization



## WHAT CAN WE DO FOR YOU?

- Laser-based 3D printing of advanced glass micro-devices
- From 3D waveguides to free-form 2.5D micro-optical structures & 3D miniaturized optical systems
- Monolithically integrated photonic systems
- Fiber-to-chip & packaged coupling solutions for photonic integrated circuits
- Origination of micro-structured masters for replication technologies: UV imprint, hot embossing, injection molding

## WHAT CAN YOU DO FOR US?

- Reliable fs laser sources with increased life-time
- Advanced predictive maintenance solutions based on AI/ML for laser systems
- Reliable optical components for laser systems (focusing optics, beam-splitters, etc.)
- Collaboration on the development of application specific photonic systems and optical components
- Collaboration on use cases, where several optical and non-optical functionalities are combined in glass micro-devices



*Thank  
you!*



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