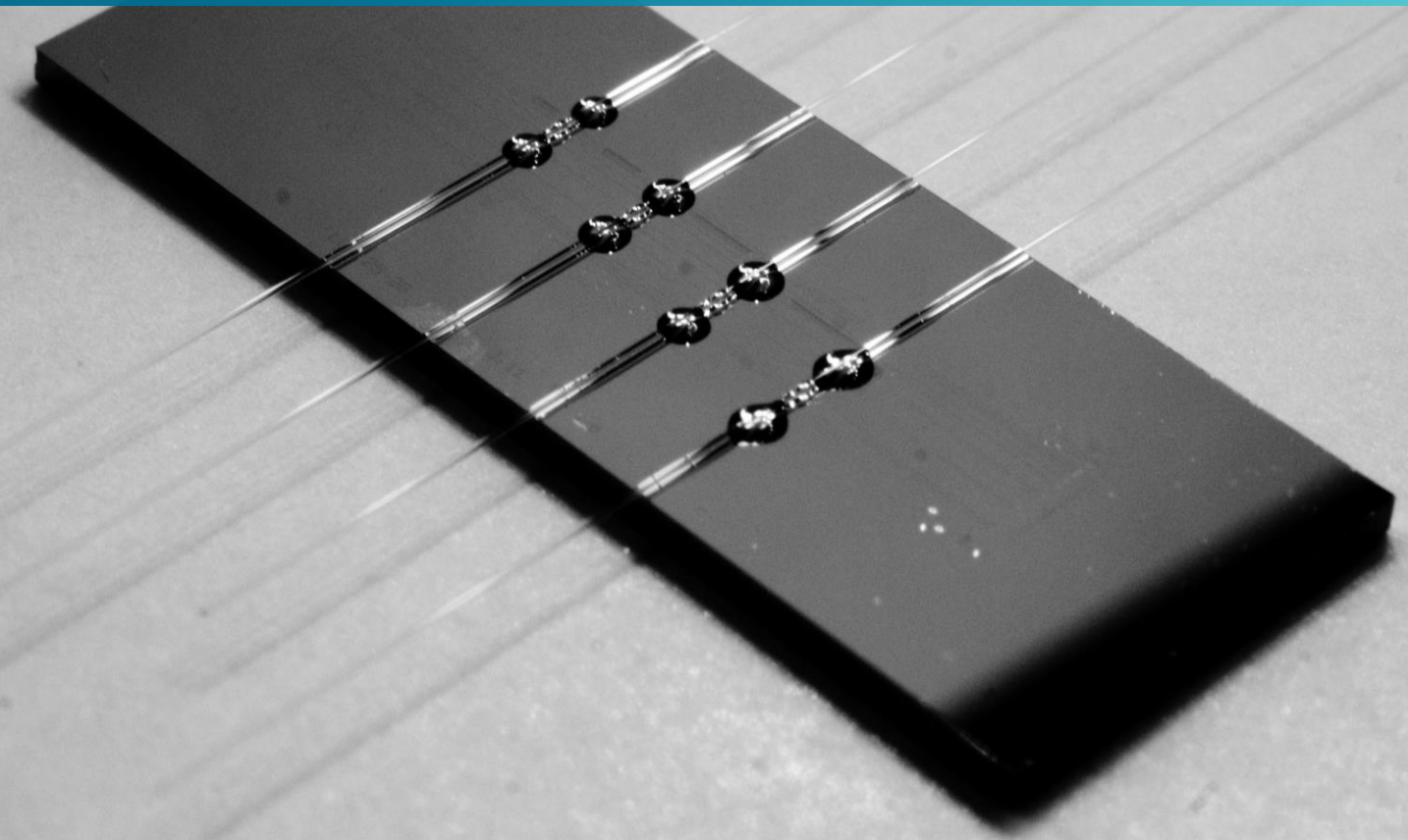
Scalable Assembly Processes for Packaged Photonic Biosensors

Dr. Zamora, Senior Scientist/Team leader at IZM

EPIC Technology Meeting on Photonics for Bio and life science | 27 September 2023



Fraunhofer IZM

Fraunhofer Institute for Reliability and Microintegration IZM

Fraunhofer IZM at a Glance

30 years of experience

430 employees (including students and trainees)

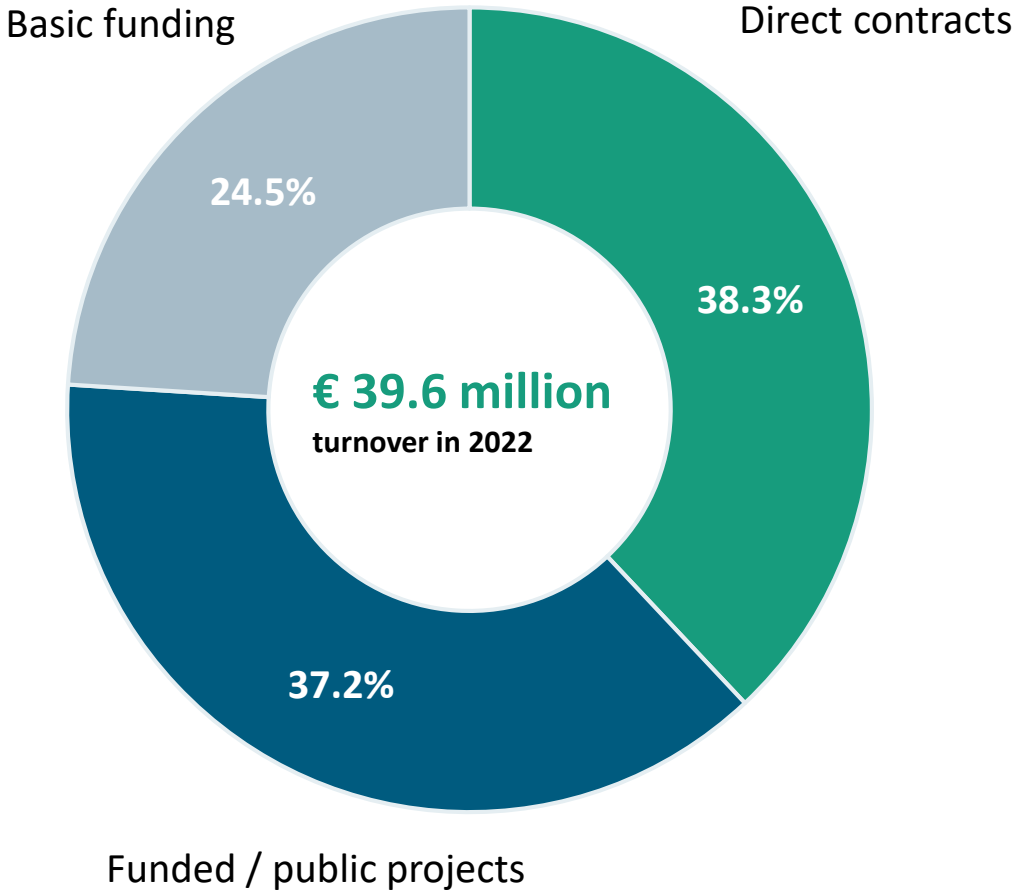
- 121 interns, bachelor students, master students and student assistants have been supervised at Fraunhofer IZM
- 8 trainees

5,374 m² laboratory space

69 labs and measurement spaces

Long-term contracts with

- Technical University of Berlin
- Technical University of Dresden
- Brandenburg University of Technology



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Fraunhofer IZM

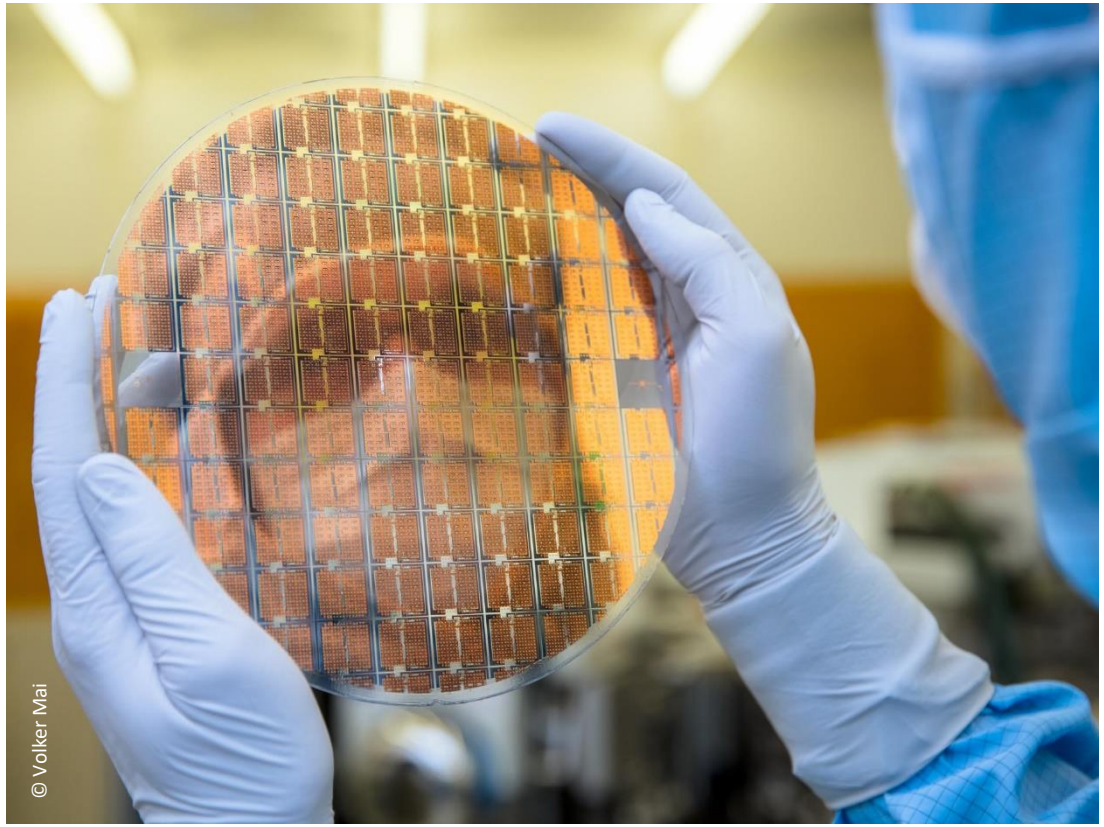
Fraunhofer IZM - Crossing Frontiers in Microelectronics

Three facts about our institute

1. We are one of the world's leading institutes for applied research as well as the development and system integration of robust and reliable electronics.

2. We have over 30 years of experience with novel technological solutions developed in collaboration with partners from industry and academia.

3. We are the only fully integrated packaging institute covering everything from design, technology, reliability, and eco assessments.



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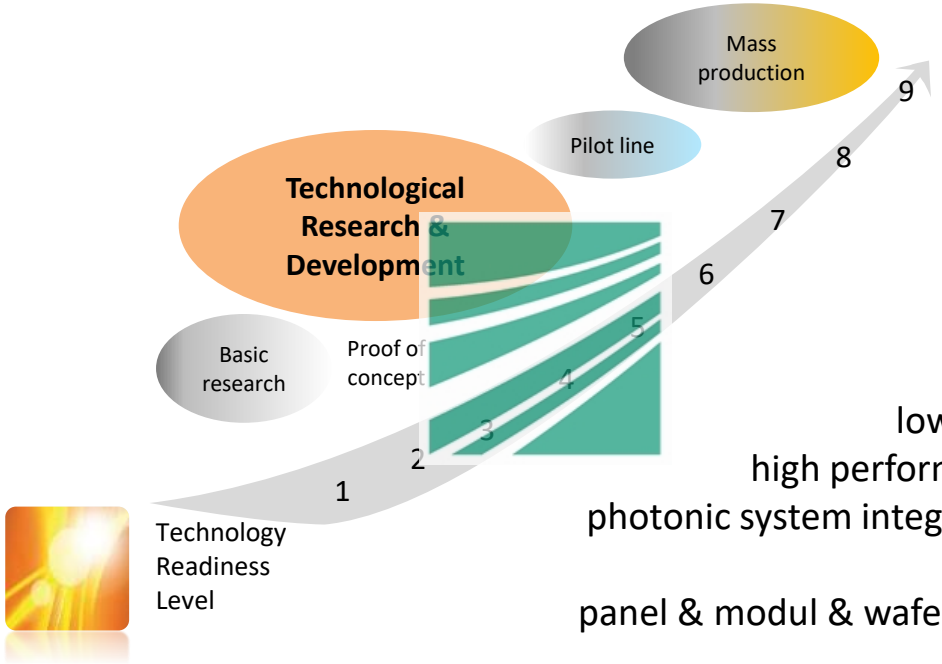
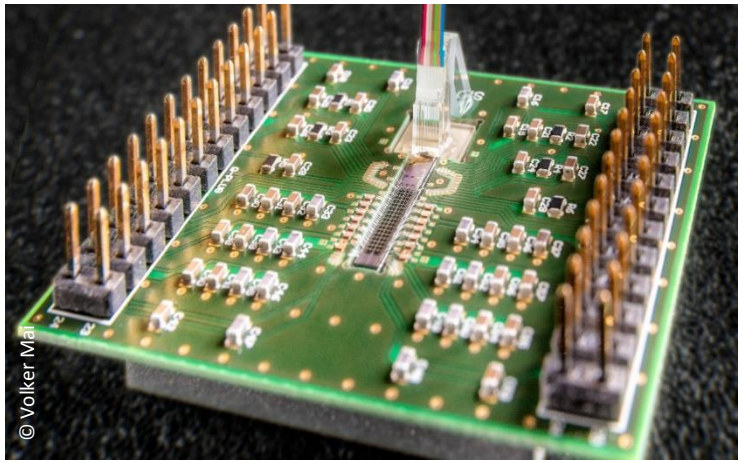
Fraunhofer IZM: Bringing photonics into application



Communication
Medical
Quantumtechnology
Lighting
Sensing
Material Processing

low cost,
high performance
photonic system integration
in
panel & modul & wafer level



- Optical fiber and planar waveguide coupling
- Assembly and interconnection technologies for photonic components and systems

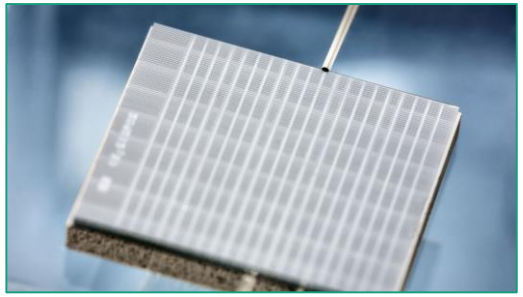
Miniaturization of biosensors through integrated photonics has a challenge…

Photonic chips need microfluidic integration and external interfaces

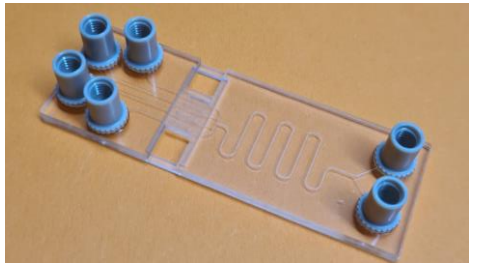
Standard ELISA assay

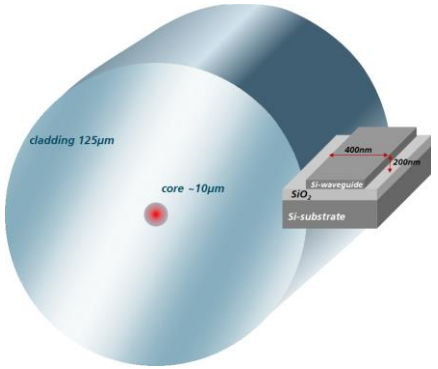
https://www.thermofisher.com/de/de/home/life-science/antibodies/immunoassays/elisa-kits/elisa-instruments-equipment.html

Potential photonics platform



Integration challenge

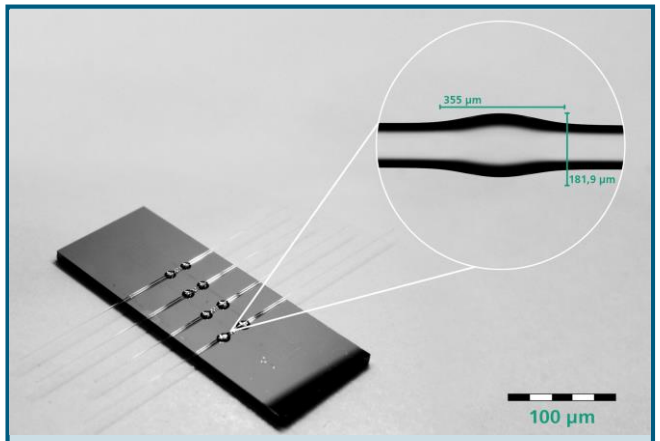




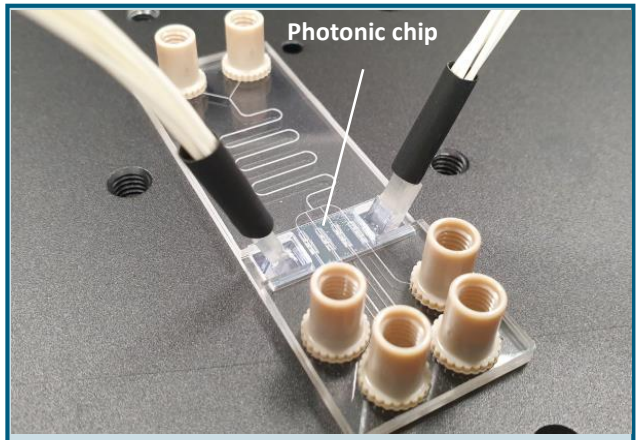
On-chip 3D microresonators for biorecognition

Project overview

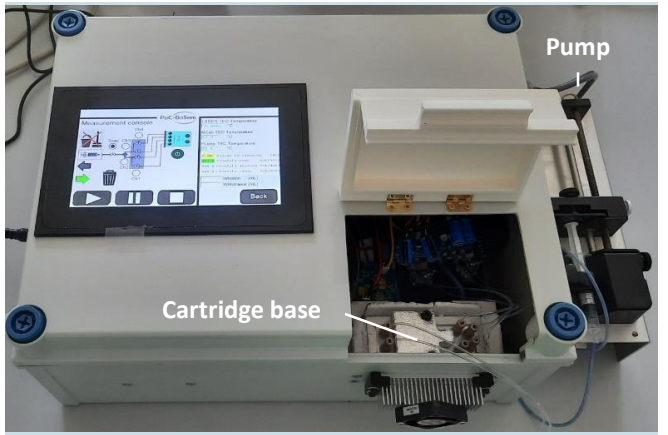
Optofluidic cartridge based on four glass microbottles and its readout system prototype



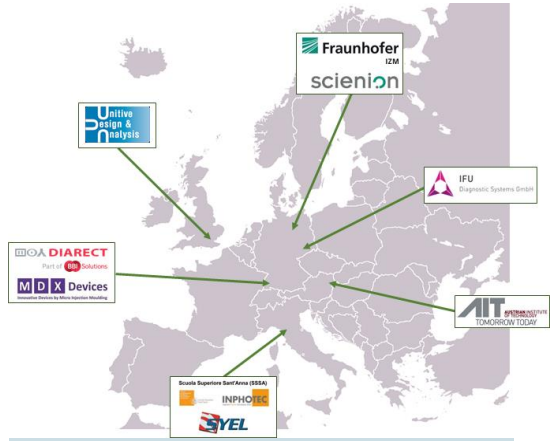
Photonic chip with four microbottles (Size: 16.6mm x 8mm)



Optofluidic cartridge incl. interfaces (Size: 75.5mm x 12.75mm) © SSSA



Readout system incl. Pump © IfU



Consortium

Coordinator: Dr. Zamora

www.poc-bosens.researchproject.at

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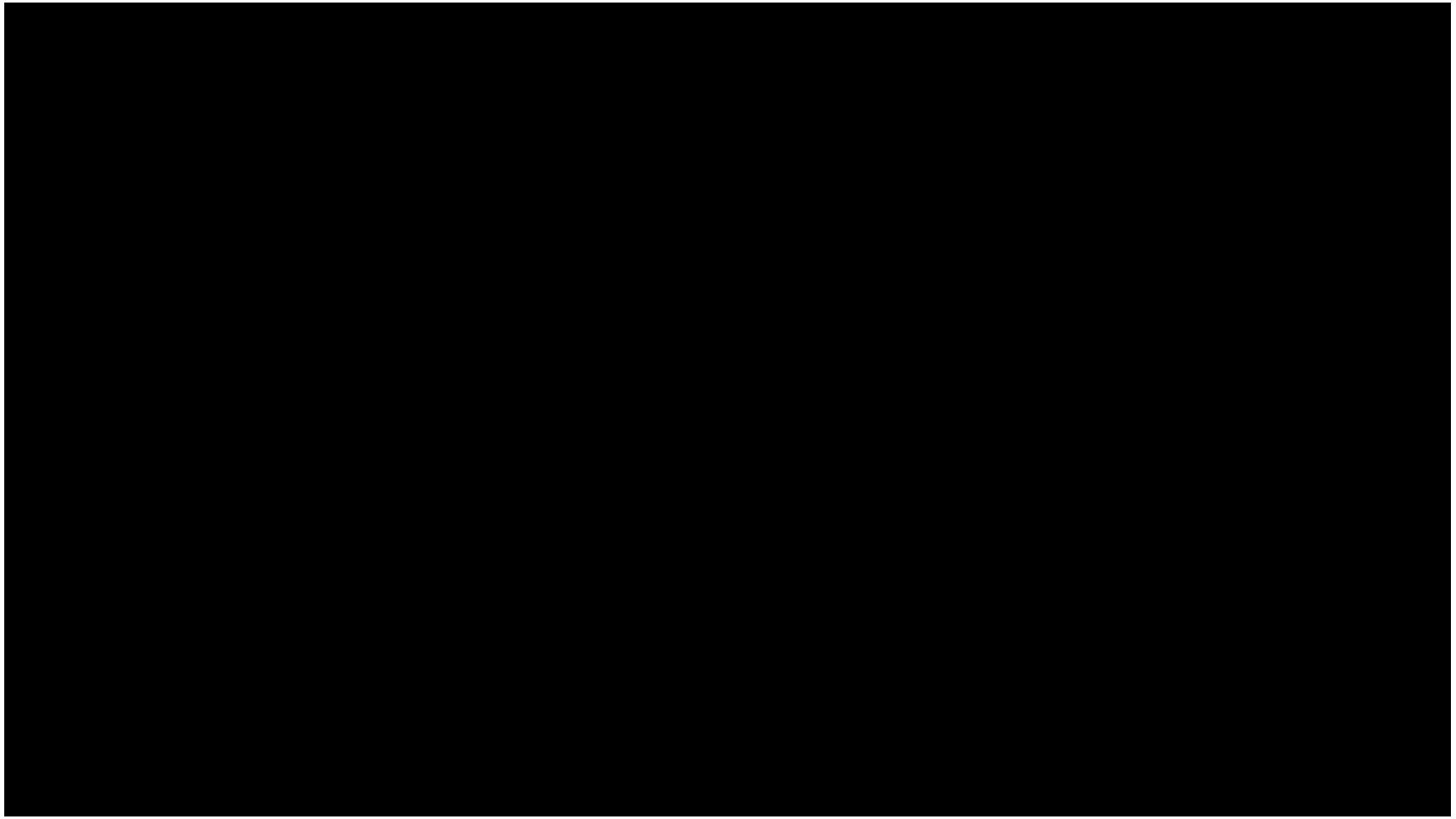
PoC-BoSens PHOTONIC SENSING Fraunhofer IZM

Assembly of 3D microresonators and microfluidic bonding

Overview of the assembly process



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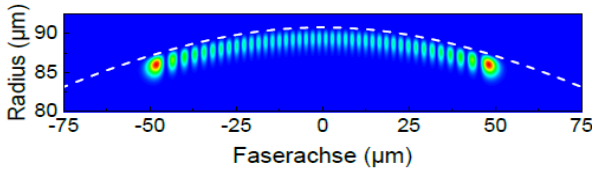
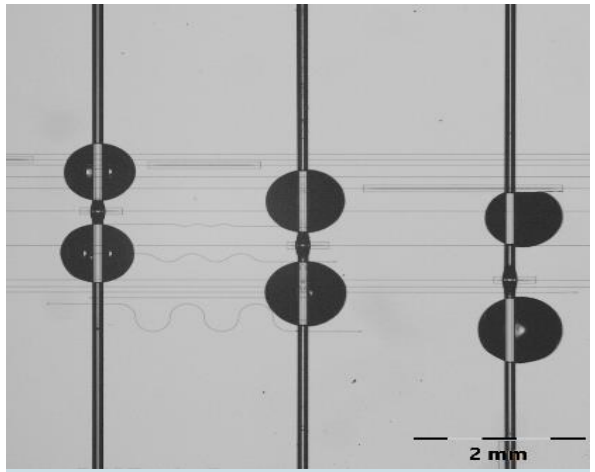
On-chip 3D microresonators for biorecognition

From design to assembly

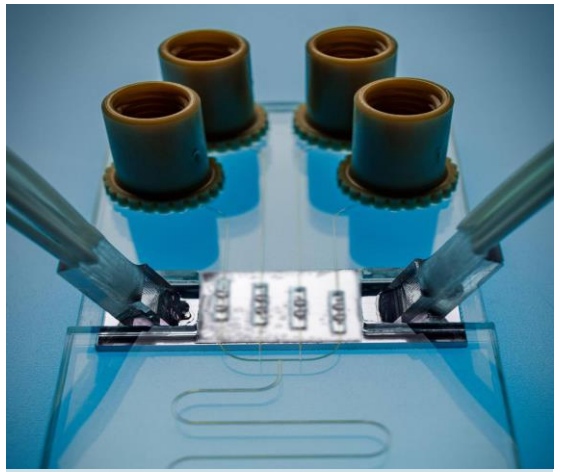
Production of the optofluidic chip cartridge based on 3D glass microbottles



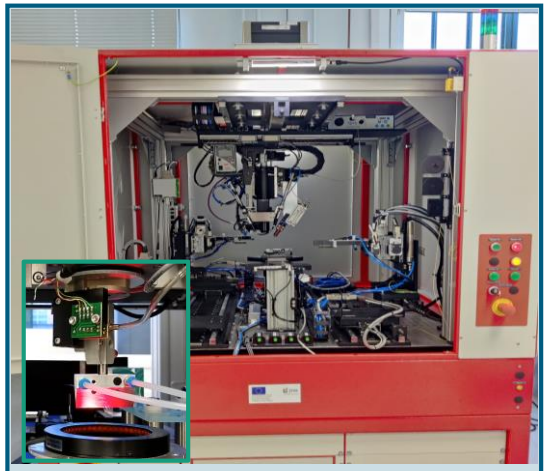
Design and easy manufacturing of glass microbottles



Semi-automatic assembly (active/passive) of microbottles on waveguides



Hybrid integration through double-sided laser-structured tapes



Scalable production

- Microbottles
- Glass waveguides
- Assembly and bonding
- Interfaces based on printed micro-optics

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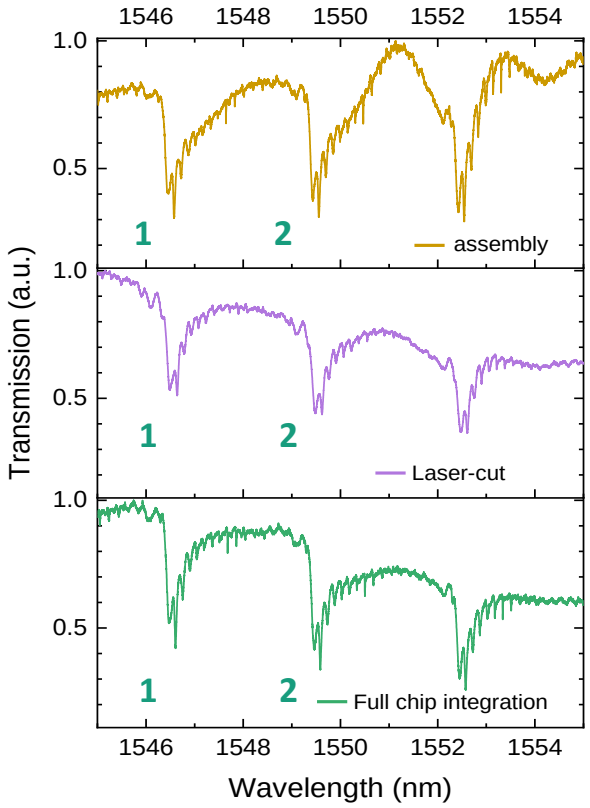
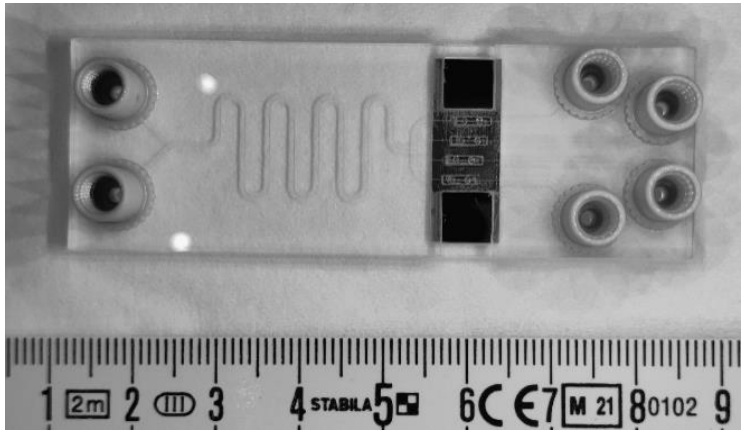
Optical measurements of an optofluidic cartridge

Full integration approach capable of preserving optical properties



	Step	λ_c/nm	FWHM/nm	Q/10^4	A/a.u.
Drop 1	assembly	1546.579	0.055	2.8	0.225
	laser-cutting	1546.64	0.10	1.5	0.206
	chip integration	1546.607	0.059	2.6	0.279
Drop 2	assembly	1550.470	0.009	17	0.104
	laser-cutting	1550.55	0.02	7.8	0.026
	chip integration	1550.504	0.008	19	0.076

No significant changes in resonances



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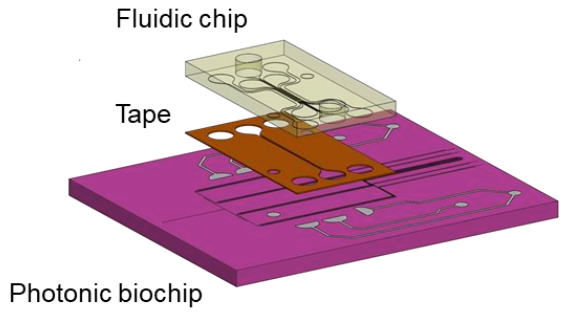
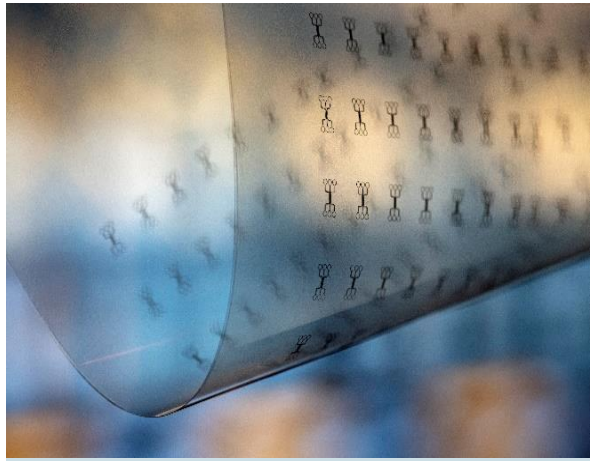
Chip integration to develop a low-cost point-of-care photonic device

From design to assembly

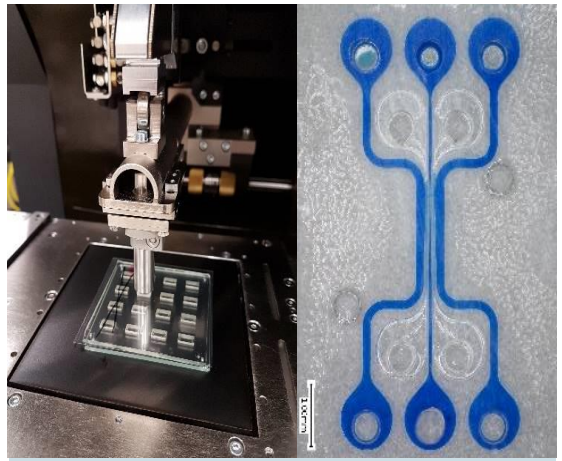
Biocompatibility, free-damage of biomaterial, cost-effective & scalable assembly processes are required



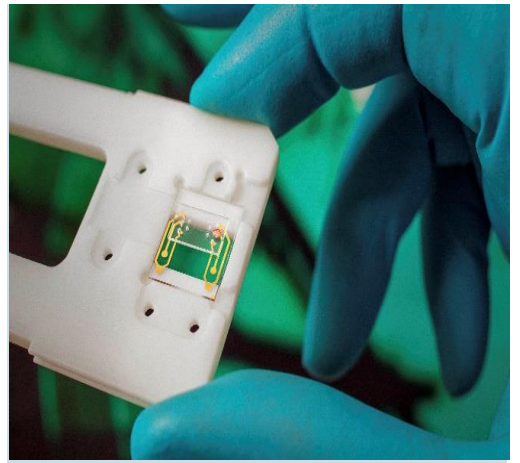
Integration design incl. all interfaces



Laser structuring (50 µm wide channels patterned to the tape)



Room temperature bonding via double-sided laser-structured tapes



Optofluidic chip cartridge for early detection of CVD biomarkers

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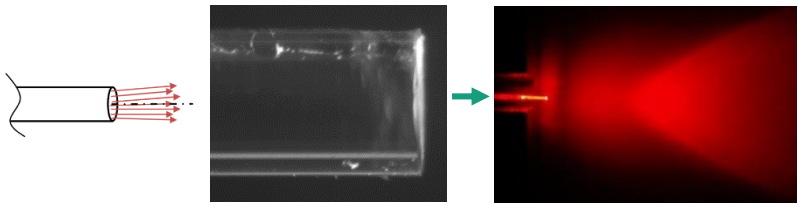
Laser structuring and laser welding of glass fibers for medical applications

Structuring of fiber tips for radial emission and hermetic sealing of glass capillary caps

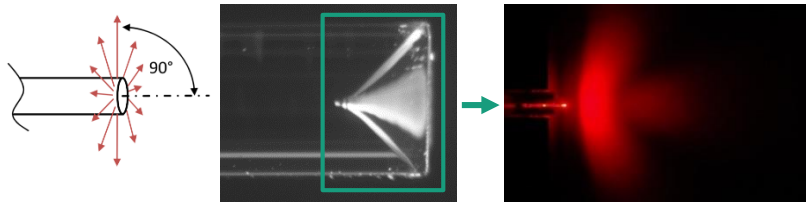
Approach

- Laser-induced ablation of a conical volume at the fiber end
  - Angle of (inverse) cone can be adjusted
- Adhesive-free direct capping by laser welding
  - Design and construction of a corresponding setup

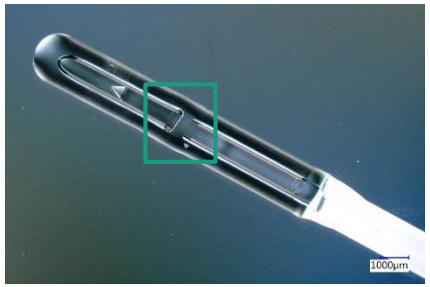
Normal fiber cleave radiation



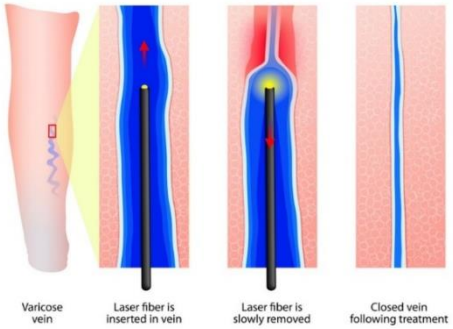
Inverse cone radiation

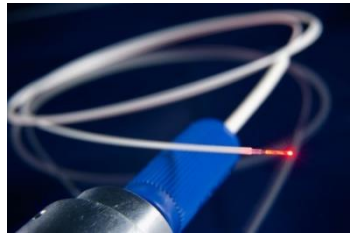


Glass cap welded to the fiber end



Endovenous laser treatment





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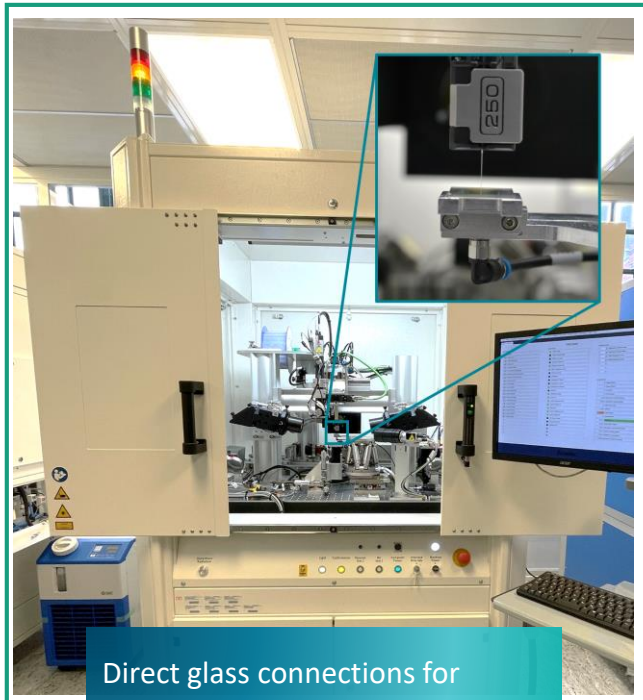
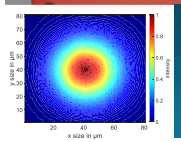
New equipment at IZM for scalable assembly solutions…

3D polymer nanoprinting for photonic wire bonding and lensed fiber tips will be available at IZM soon

Fiber/fluidic interfaces

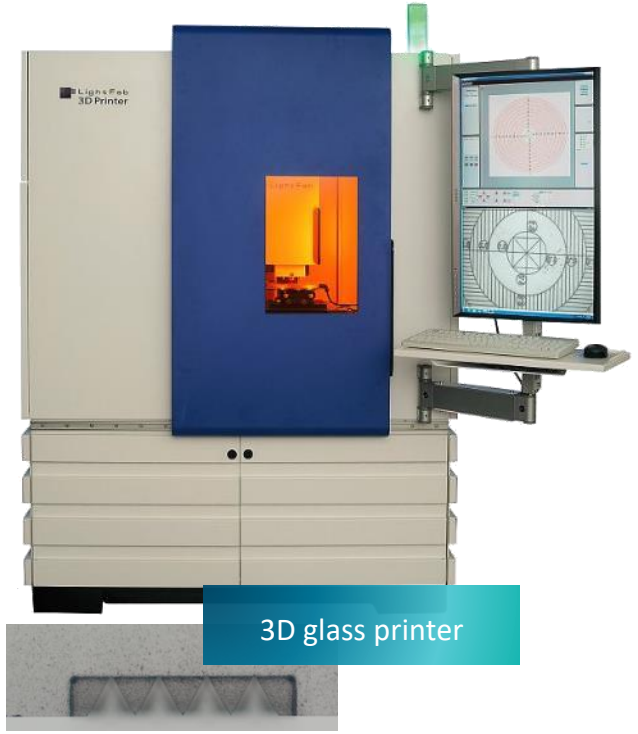


Direct glass connections for micro-optics and capillaries



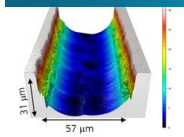
Automatic alignment and standard attachment of fibers

Glass structuring



3D glass printer

Molten salt glass etching/polishing



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IZM is looking for synergies

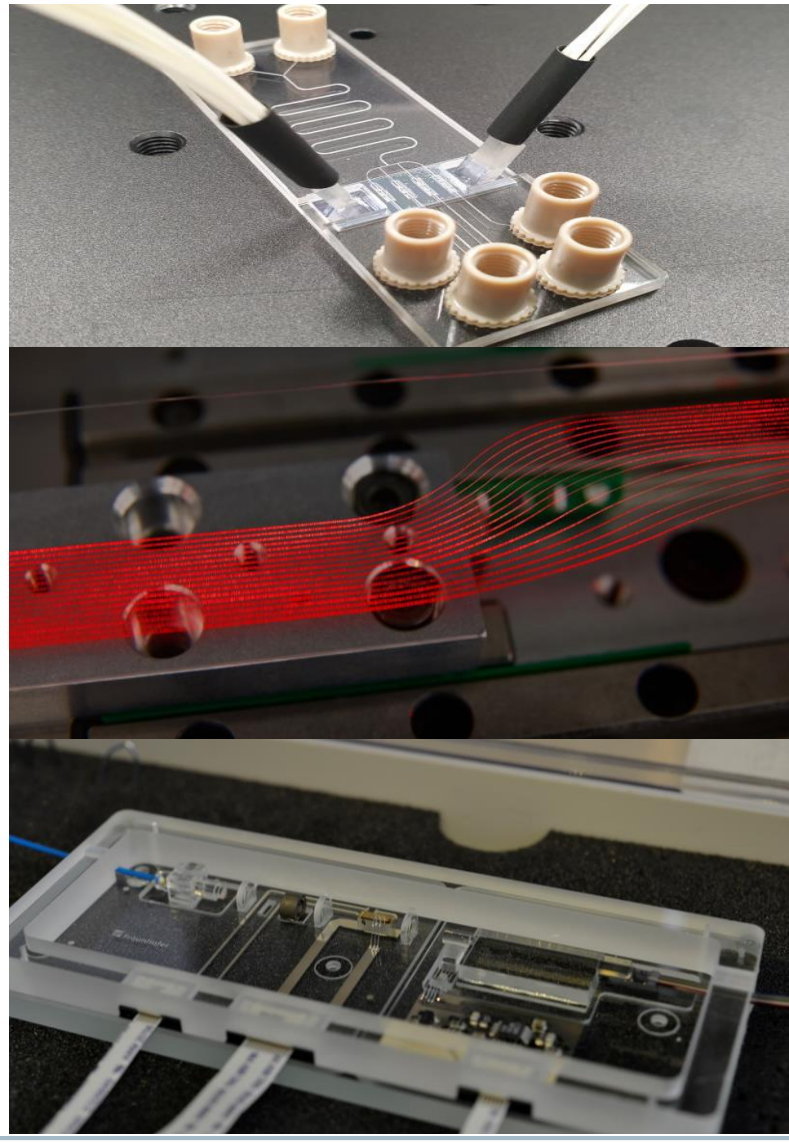
Focus mainly on industrial and R&I projects

What can I do for the others?

- Chip and micro-optics integration
- Reliable and hybrid microfluidic packaging
  - Hermetic sealing
- Custom solutions for optical, fluidic and electrical interfaces
- *Components*: 3D optical resonators and integrated glassy waveguide platforms for biosensing
  - Glass microfluidics
- *System*: Portable optical readout incl. FPGA programing

What can do the others for me?

- Define a specific bio- and life science application where miniaturization is relevant
- Biofunctionalization
- Electronics integration for portable readout system



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