

SPIO
SYSTEMS

Miniaturised optical devices and systems

Quantum sensors via SPIO technology?

Henrik Madsen, CEO

CONFIDENTIAL

About SPIO Systems

SPIO Systems is a deep-tech company.

Development and production of **miniaturised optical devices** – an optical chip solution for customers.

Technology based on **new manufacturing platform** for optical devices

SPIO technology enables **miniaturisation** of existing optical devices by at least an order of magnitude **and** allows **scalable** production for high-volume manufacturing

10 employees

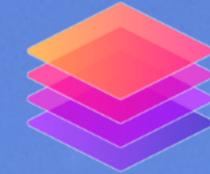
Private company, backed by large industrial investors



Founded in
September 2020



Farum, Denmark



SPIO
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SPIO stands for
Stacked
Planar
Integrated
Optics

What is SPIO?

SPIO IS...

A technology platform that enables the guiding and processing of light in advanced, complex optical devices.

- Optical elements integrated into a single component – free space optics.
- Closed packed design: Frameless - no mechanics.
- “Cubic” design: Optical light paths in 3 dimensions – within 2D planar layers and between layers as well

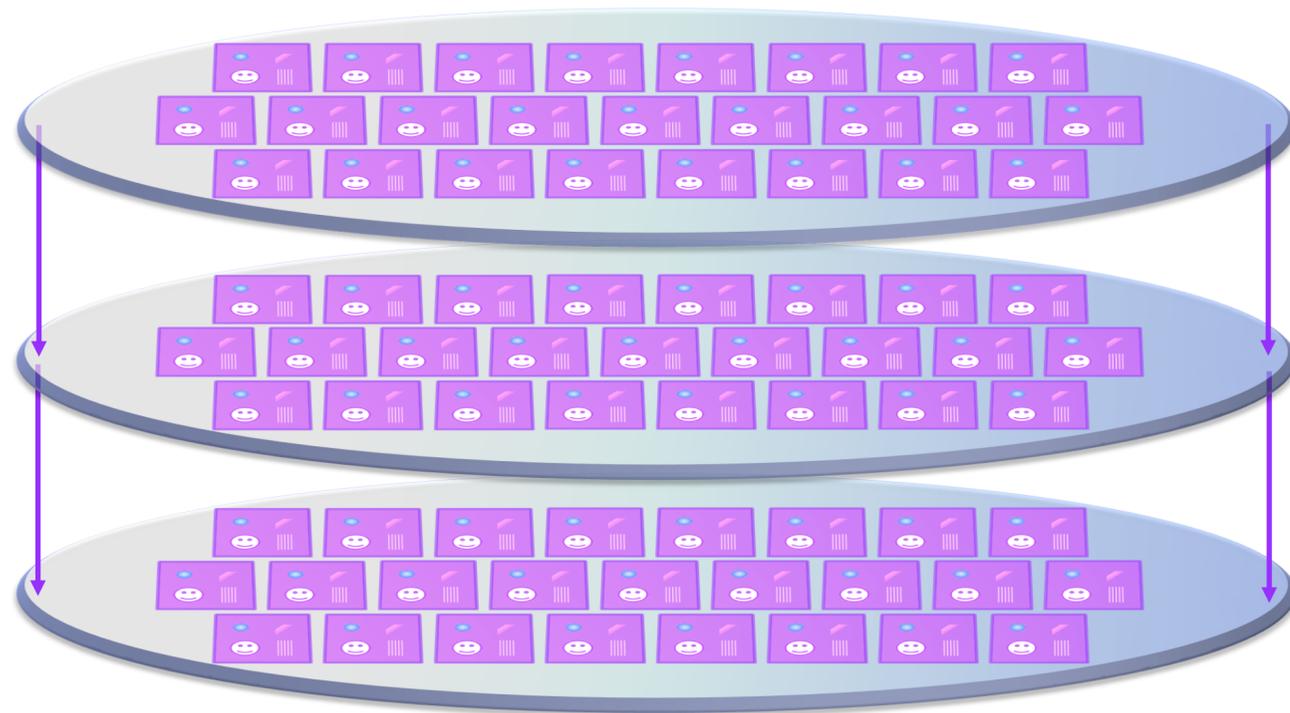


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Wafer platform approach for manufacturing optical devices

Wafer stacking



Singulation

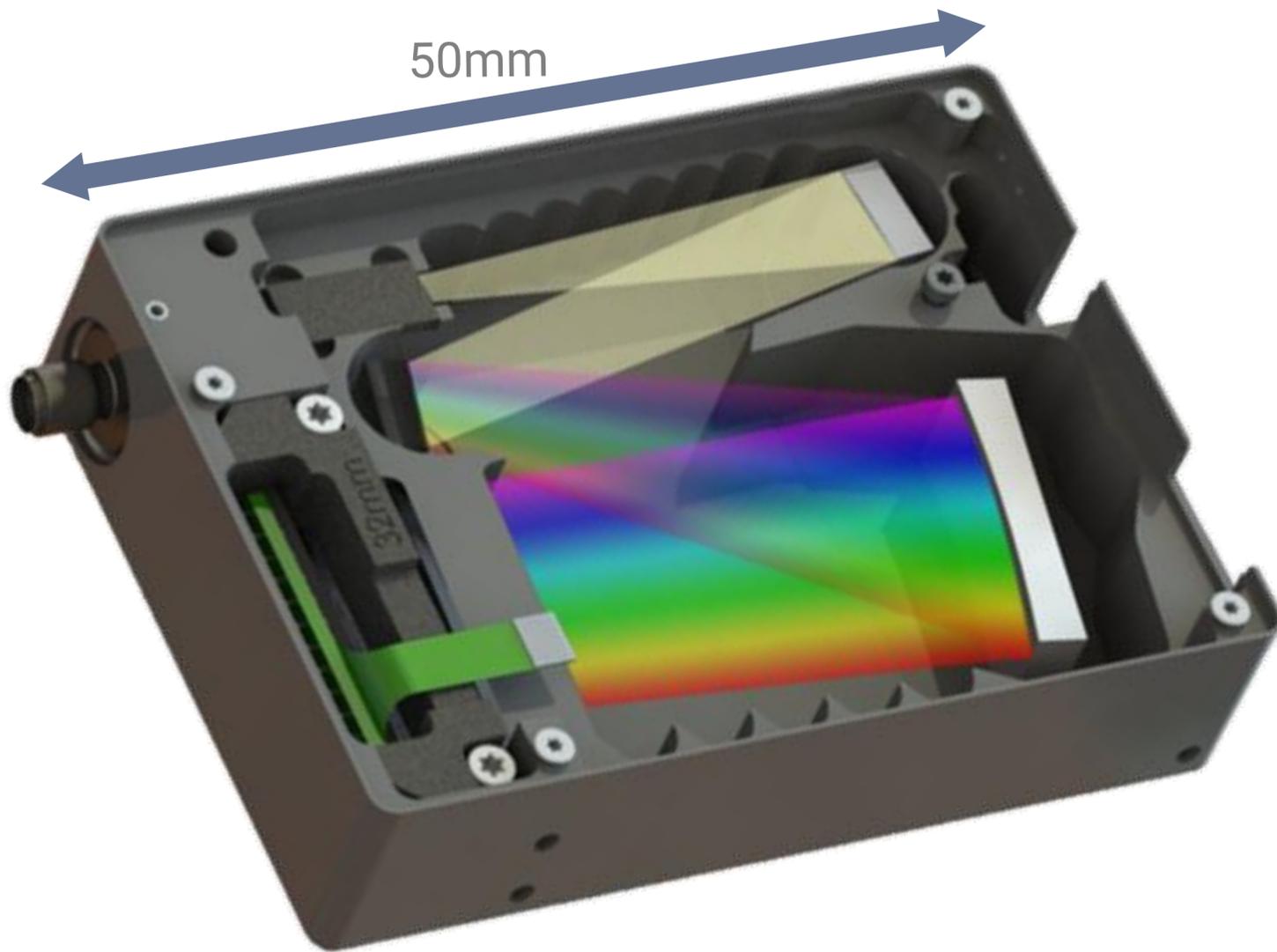


SPIO versus conventional device



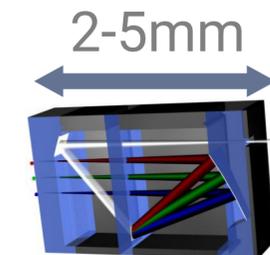
CONVENTIONAL DEVICE: €€€€€€

Discrete optical elements
Manual assembly and alignment



SPIO DEVICE: €

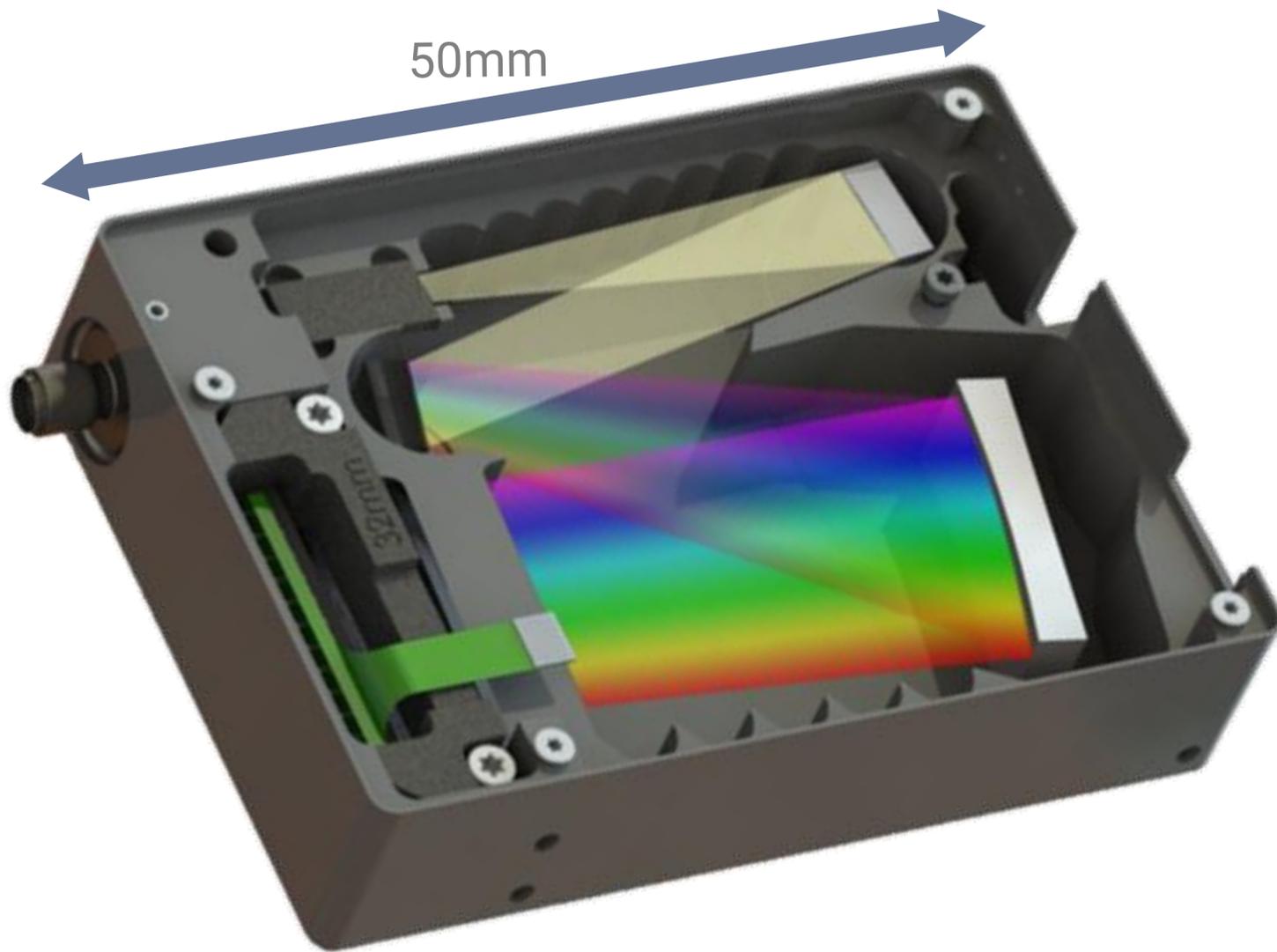
Integrated optical components in multiple planar layers on wafers
Automated assembly and alignment



SPIO versus conventional device

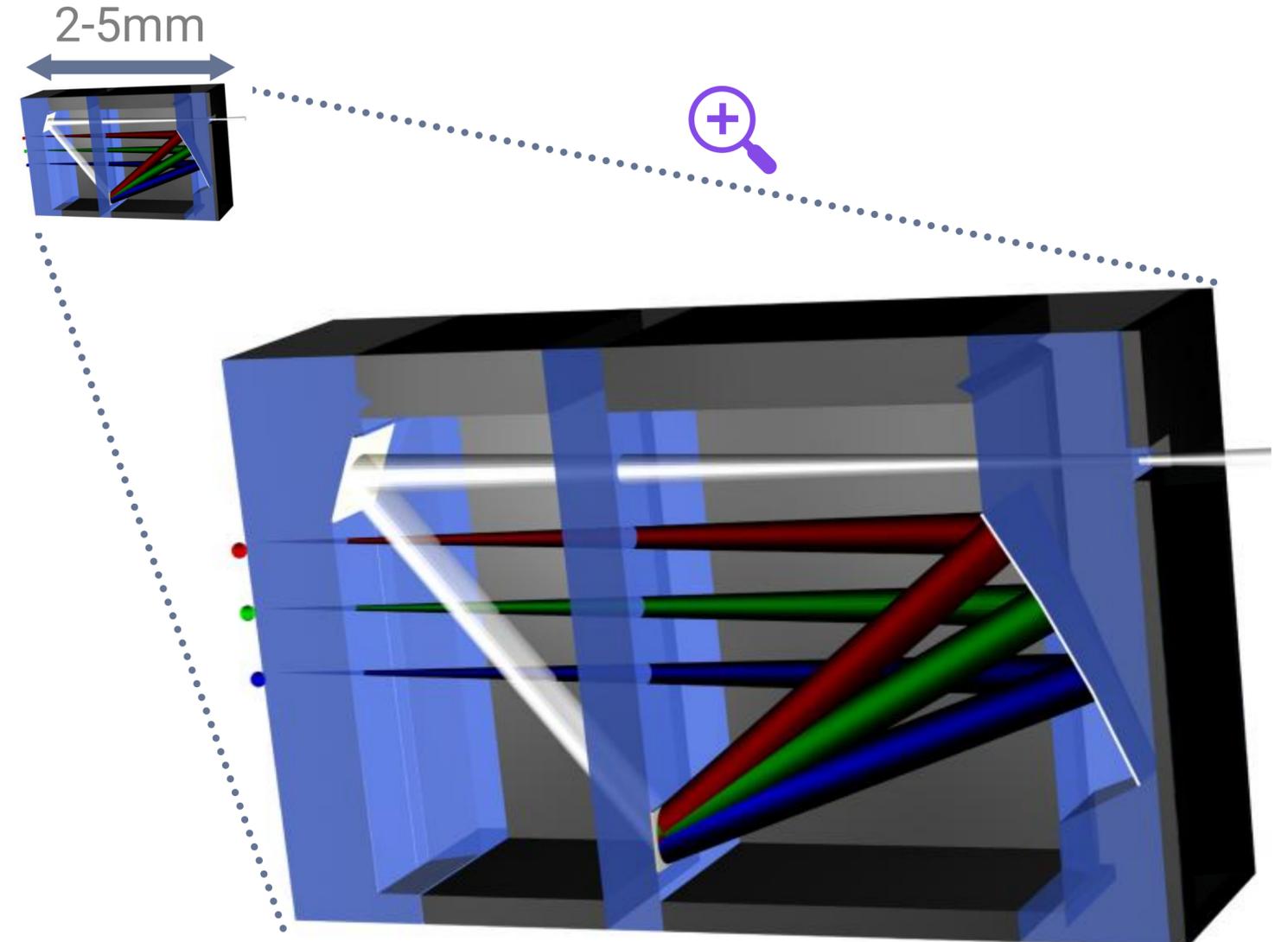
CONVENTIONAL DEVICE: €€€€€€

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SPIO DEVICE: €

Integrated optical components in multiple planar layers on wafers
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SPIO technology and process

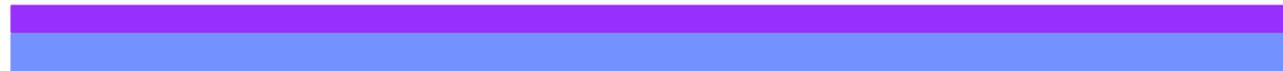
SPIO Unit Assembly Process



Master for replication



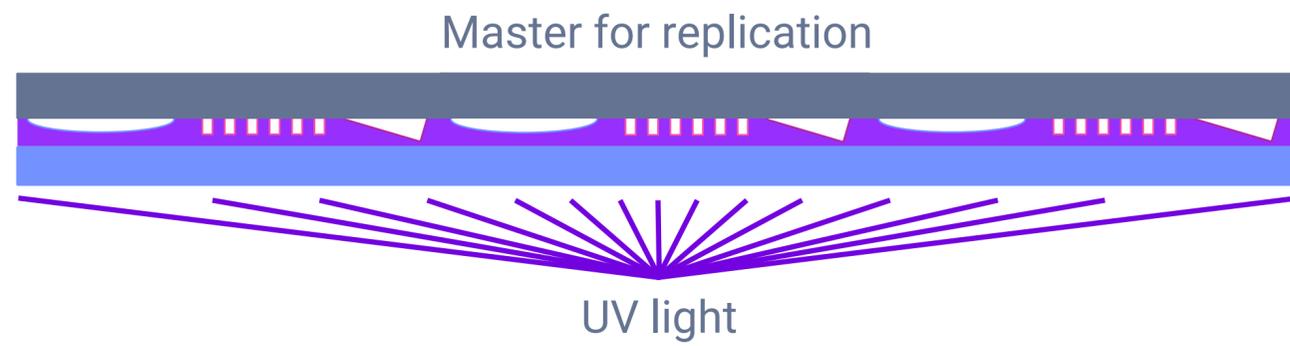
Polymer on glass wafer



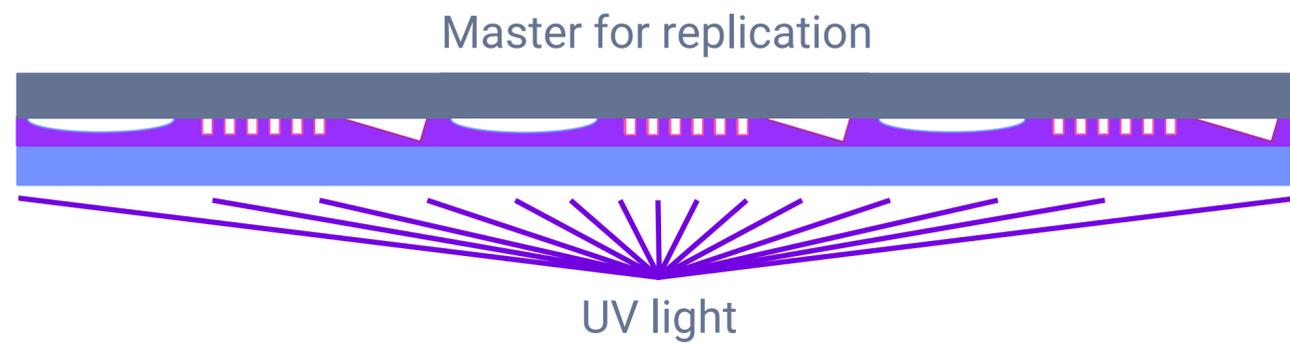
SPIO Unit Assembly Process



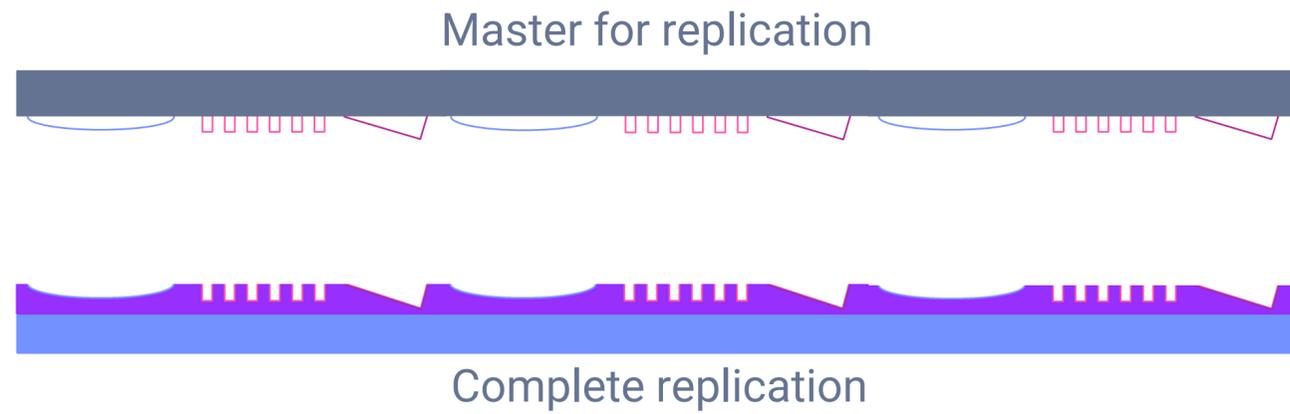
SPIO Unit Assembly Process



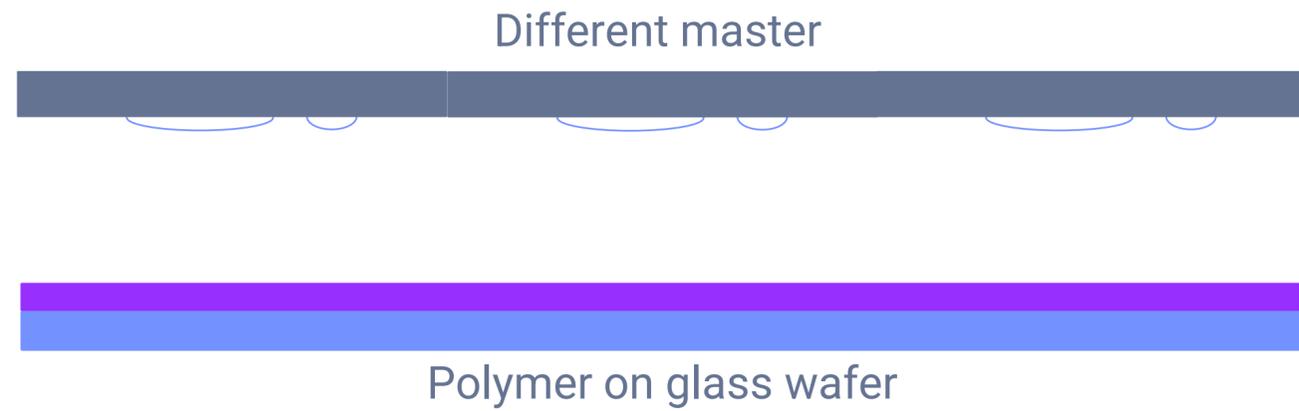
SPIO Unit Assembly Process



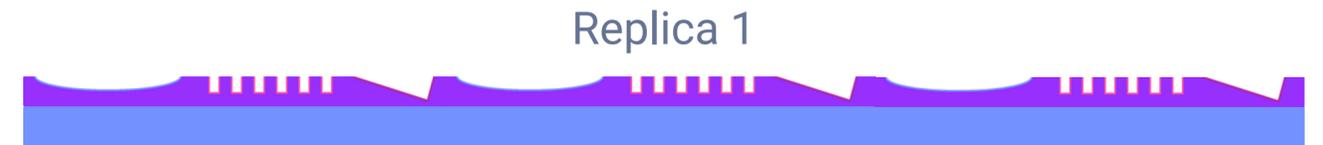
SPIO Unit Assembly Process



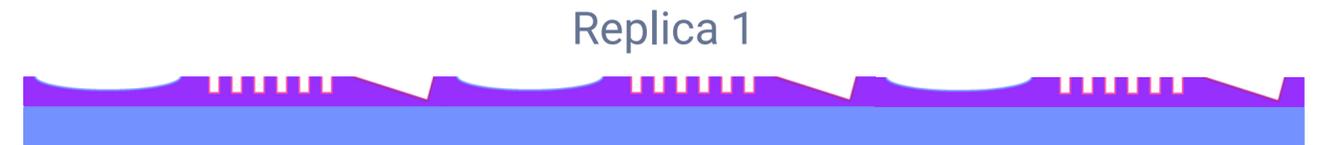
SPIO Unit Assembly Process



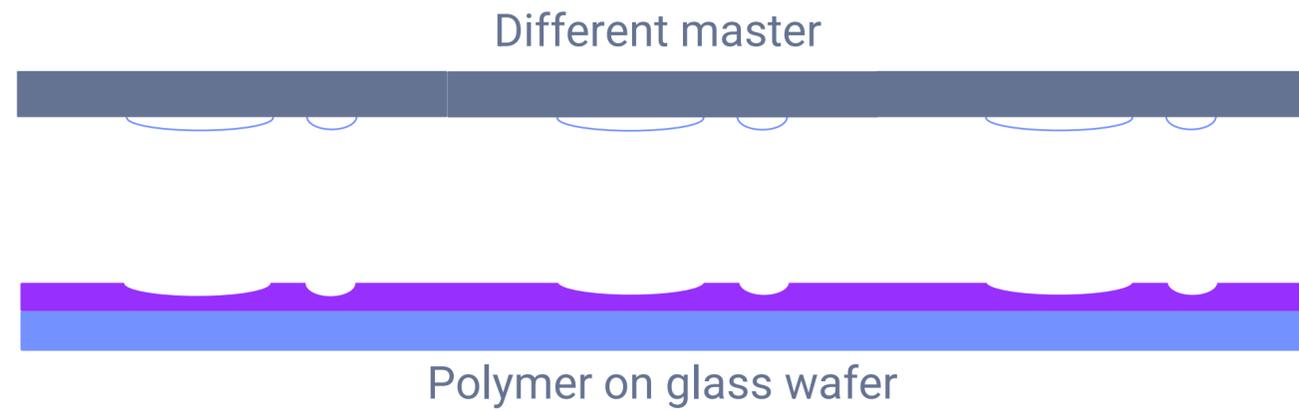
SPIO Unit Assembly Process



SPIO Unit Assembly Process



SPIO Unit Assembly Process



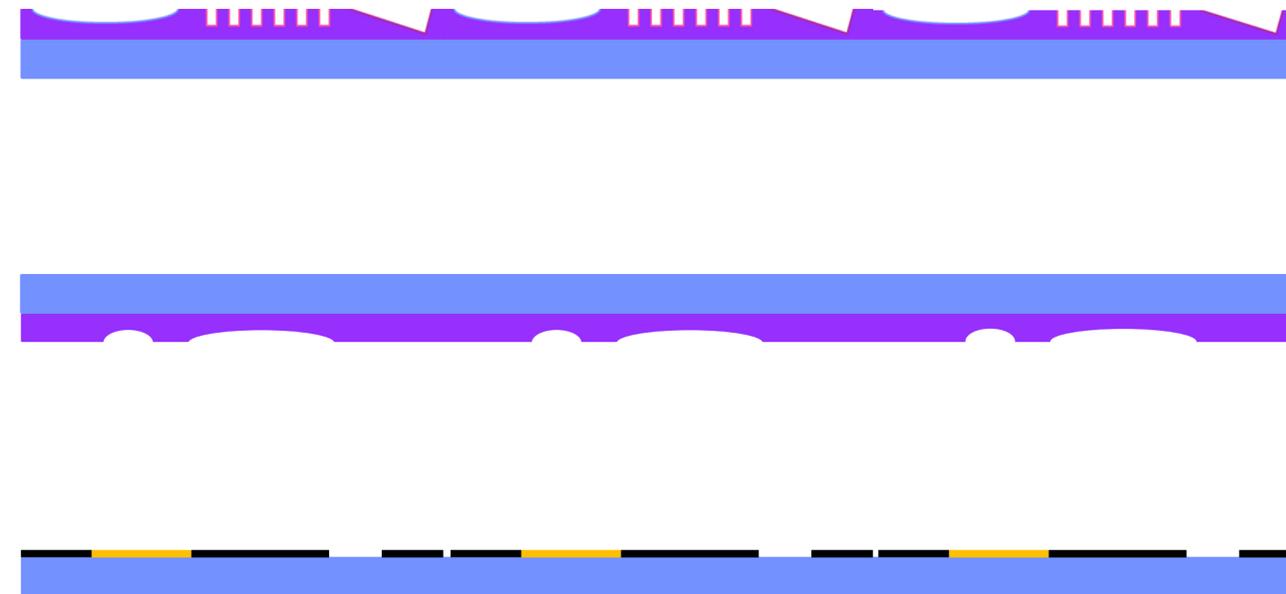
SPIO Unit Assembly Process



SPIO Unit Assembly Process



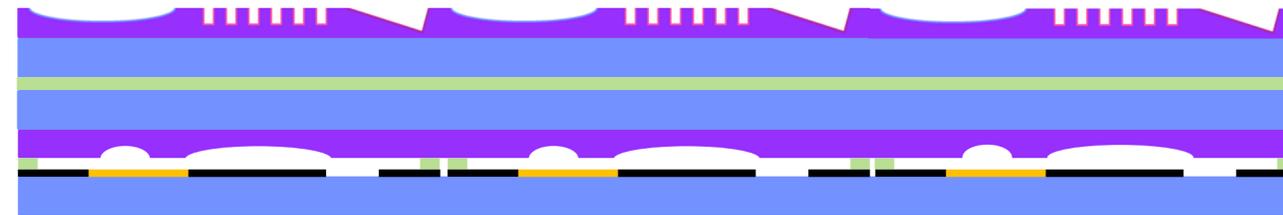
SPIO Unit Assembly Process



SPIO Unit Assembly Process



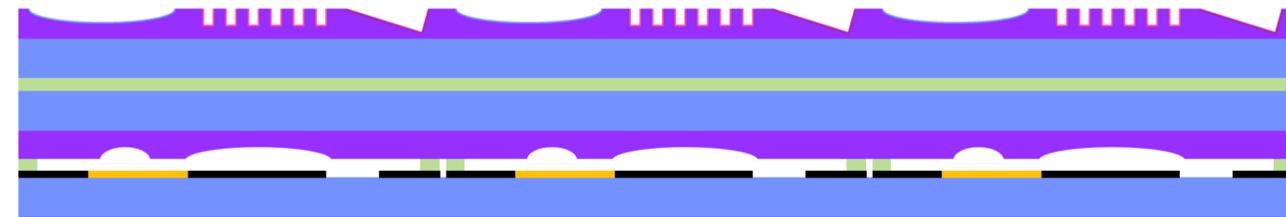
Stacking and gluing of wafers



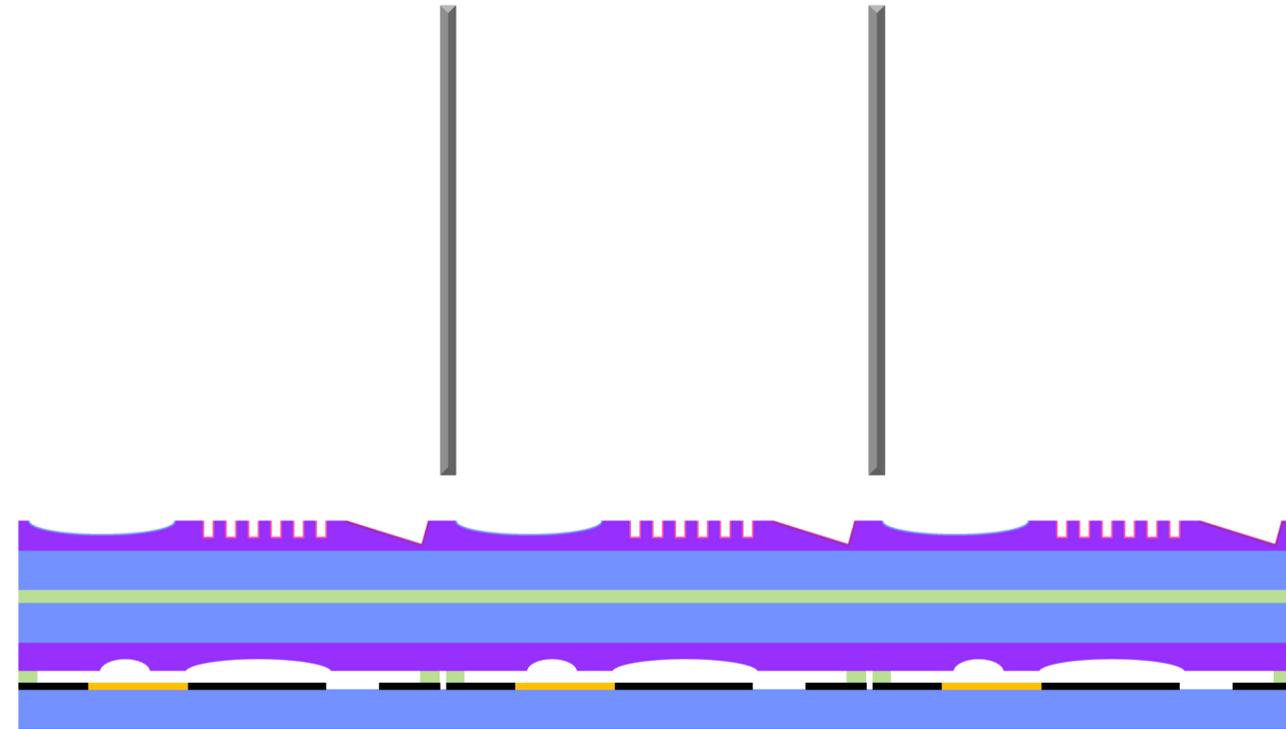
SPIO Unit Assembly Process



Stacking and gluing of wafers



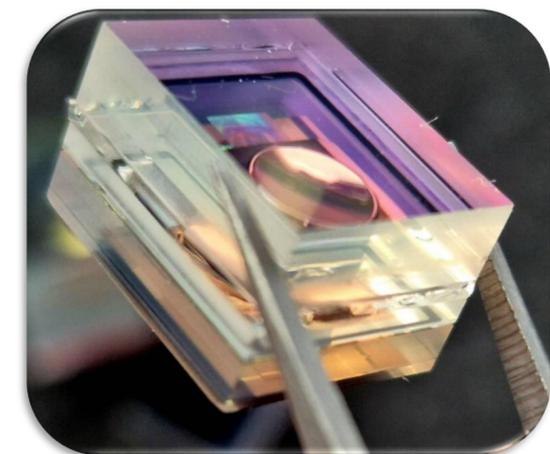
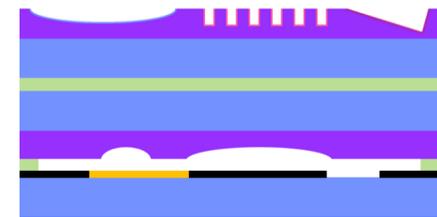
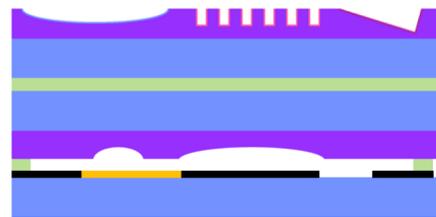
SPIO Unit Assembly Process



SPIO Unit Assembly Process



Diced and complete SPIO units ready for integration



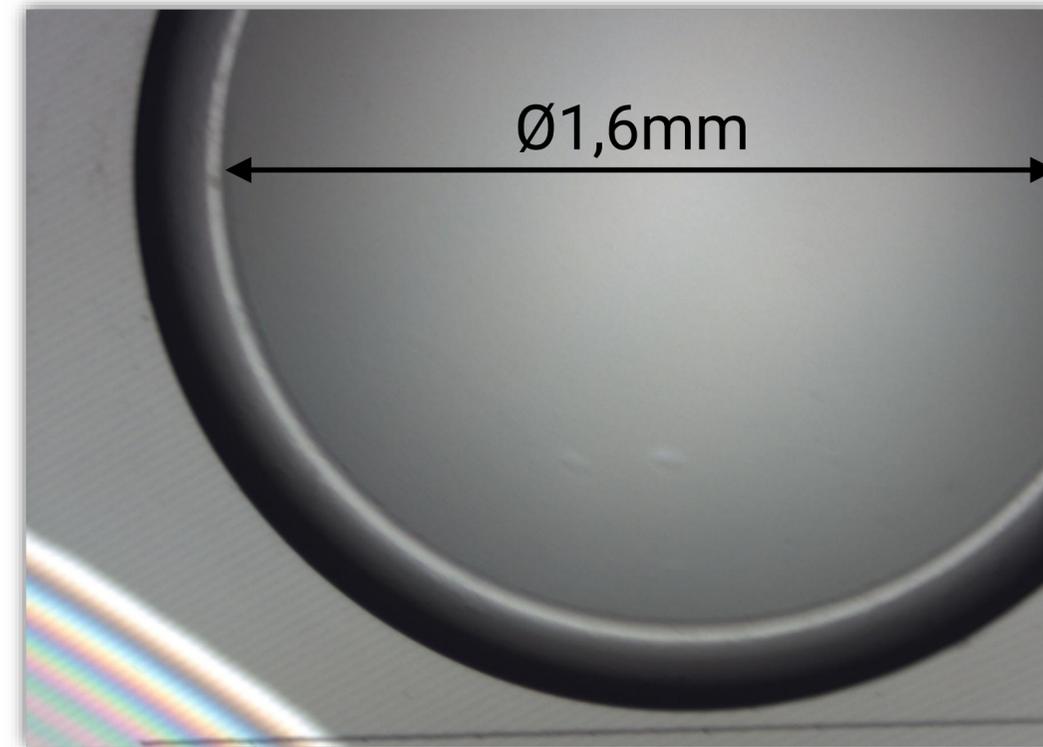
What is in our SPIO toolbox?

...for now

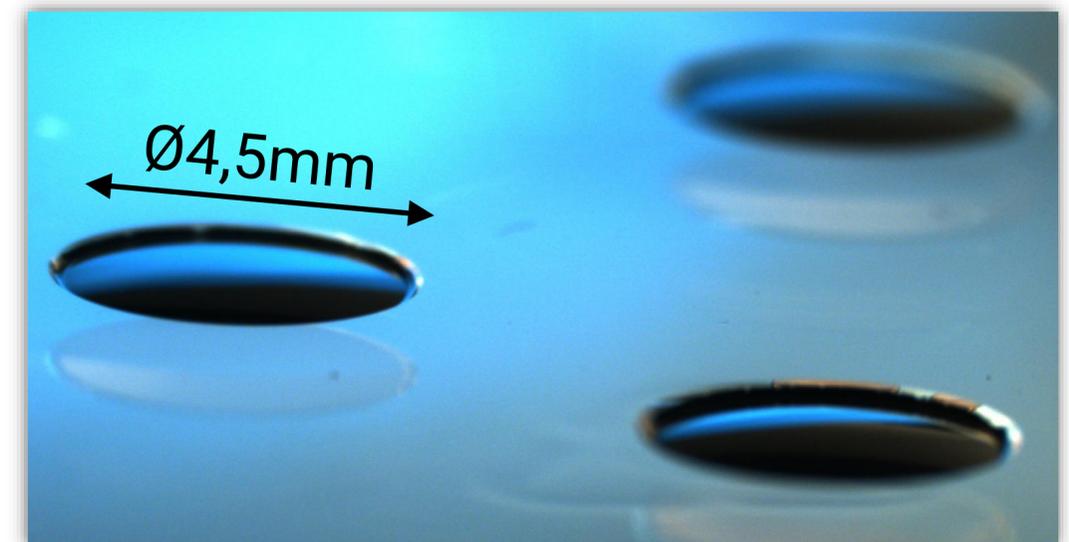
Lenses

- Both transmissive and reflective lenses possible via metal coating
- Small, Medium and Large diameters/SAG
- Aspherical and non-circular lenses
 - One-time fabrication is huge advantage vs conventional lenses
- Good form accuracy due to low shrinkage polymers
 - $<50\mu\text{m}$ error on radius of curvature after compensation

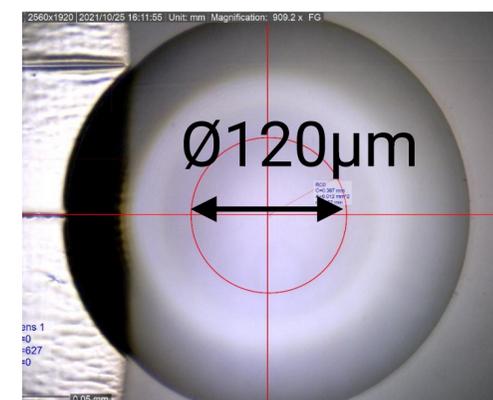
Tilted parabolic lens



Large spherical mirrors



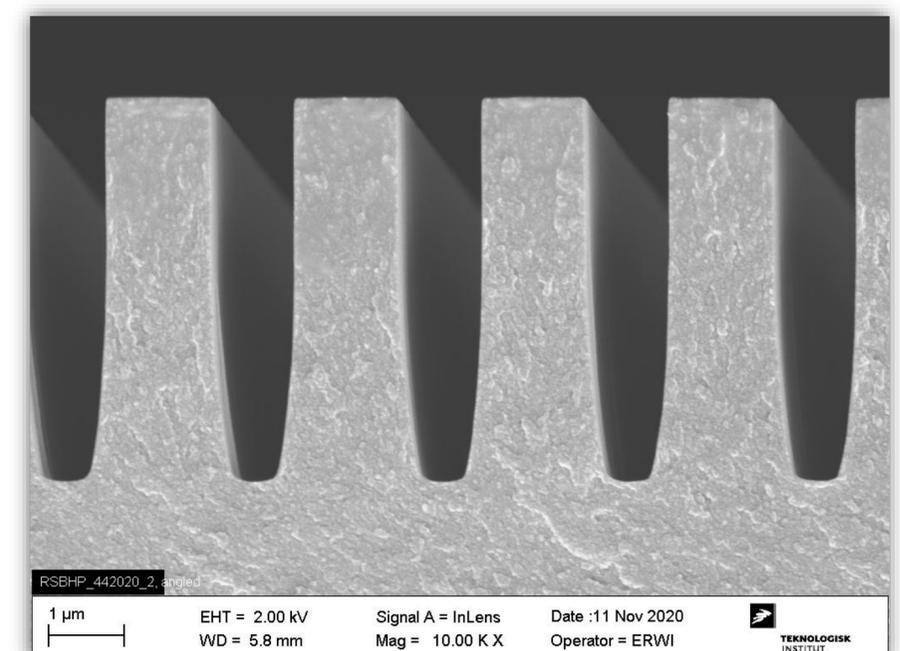
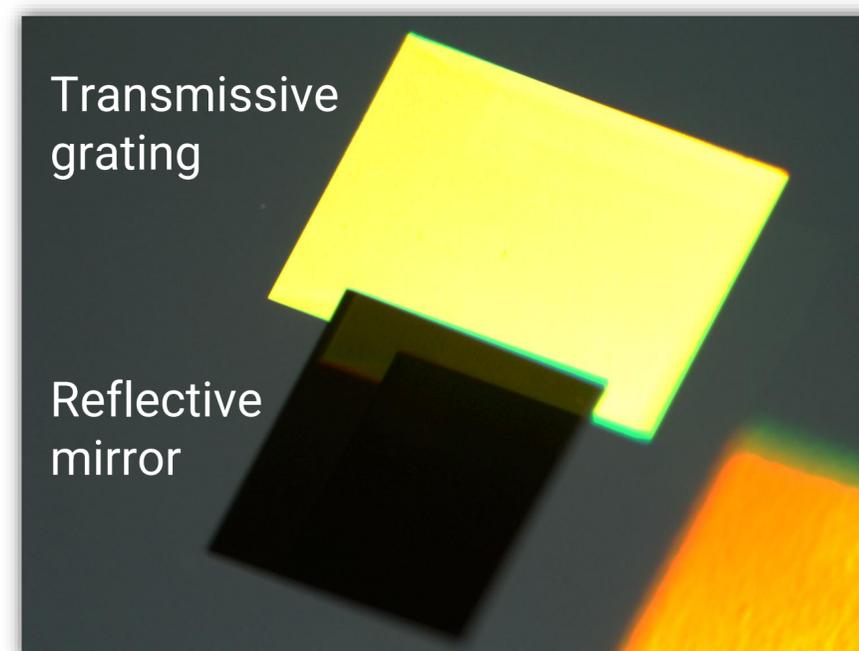
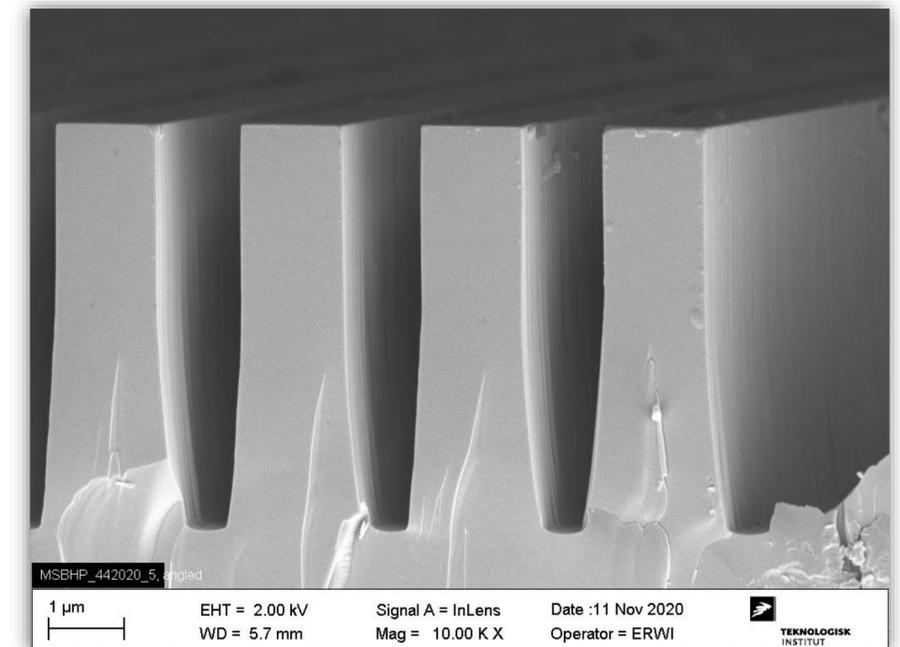
Small spherical lens



Diffraction gratings and DOE's

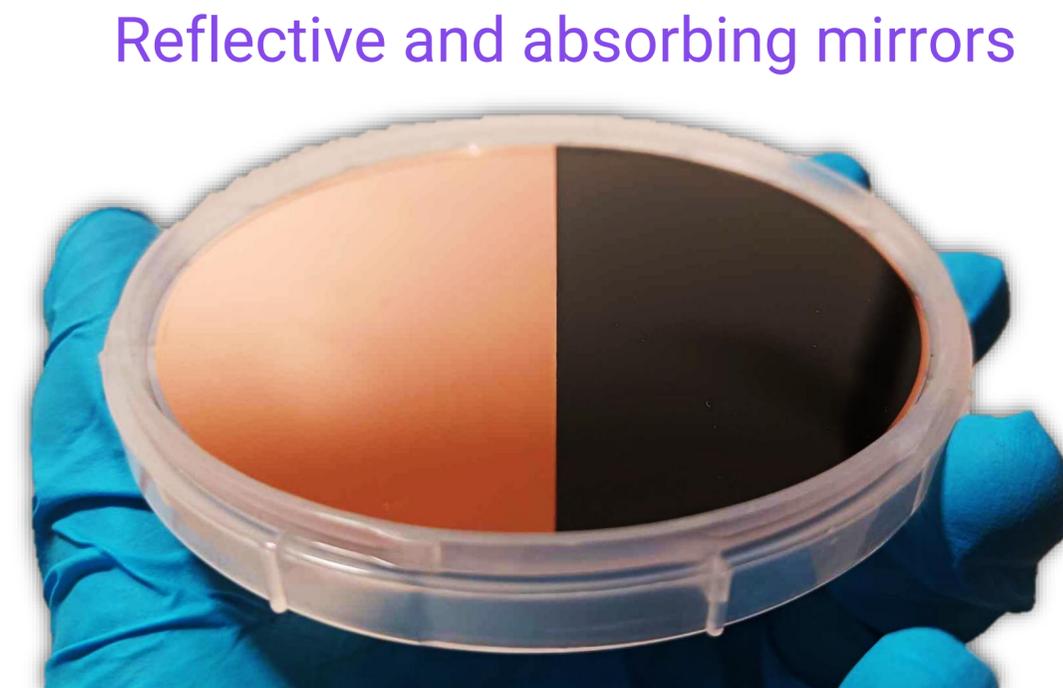
- High aspect ratio (>3) gratings possible with R2P imprinting and tight parameter window
- Variable refractive index via resin and glue selection
- High-precision alignment to lithographic structures on the wafer, e.g. mirrors

Grating master vs replication

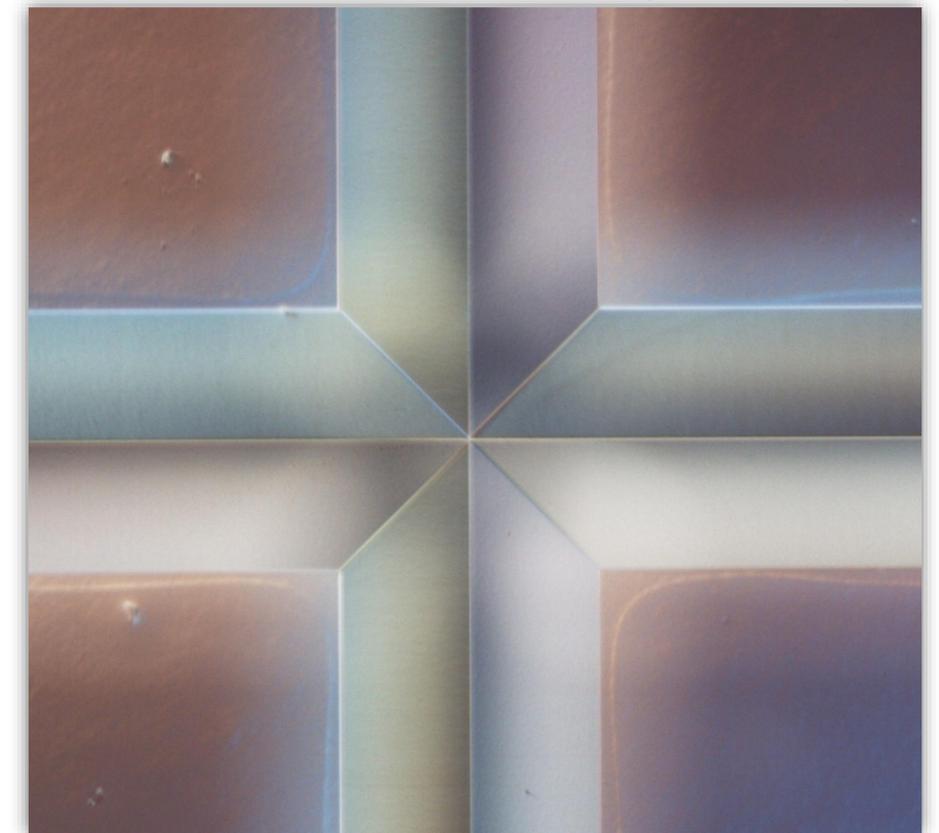


Coatings and prisms/mirrors

- High accuracy lithographic processes
- Reflective metal coatings
- Thin-film deposition
 - Reflective metals
 - AR coatings
 - Absorbing mirrors
 - Polarizers
 - Optical filters
- Ruled prisms => mirrors



Replicated V-grooves (prisms)



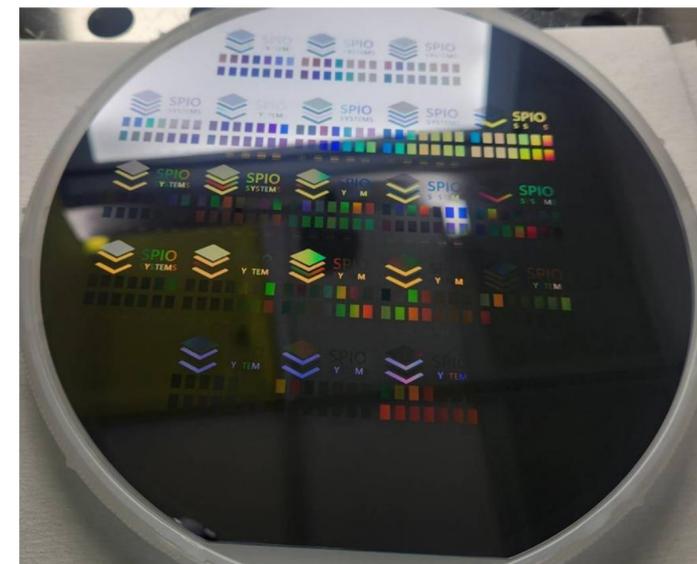
Mastering:

- Lithography/Etching into Si wafer
- Diamond machining in soft metals
 - Cupper, Nickel Phosphorous
- Optics and fiducials in on operation
- Test masters with shrinkage compensation
 - Proof of concept, Prototypes
 - False light suppression and system debug
 - Short iteration loop

Tilted parabolic lens test master



Si wafer with gratings



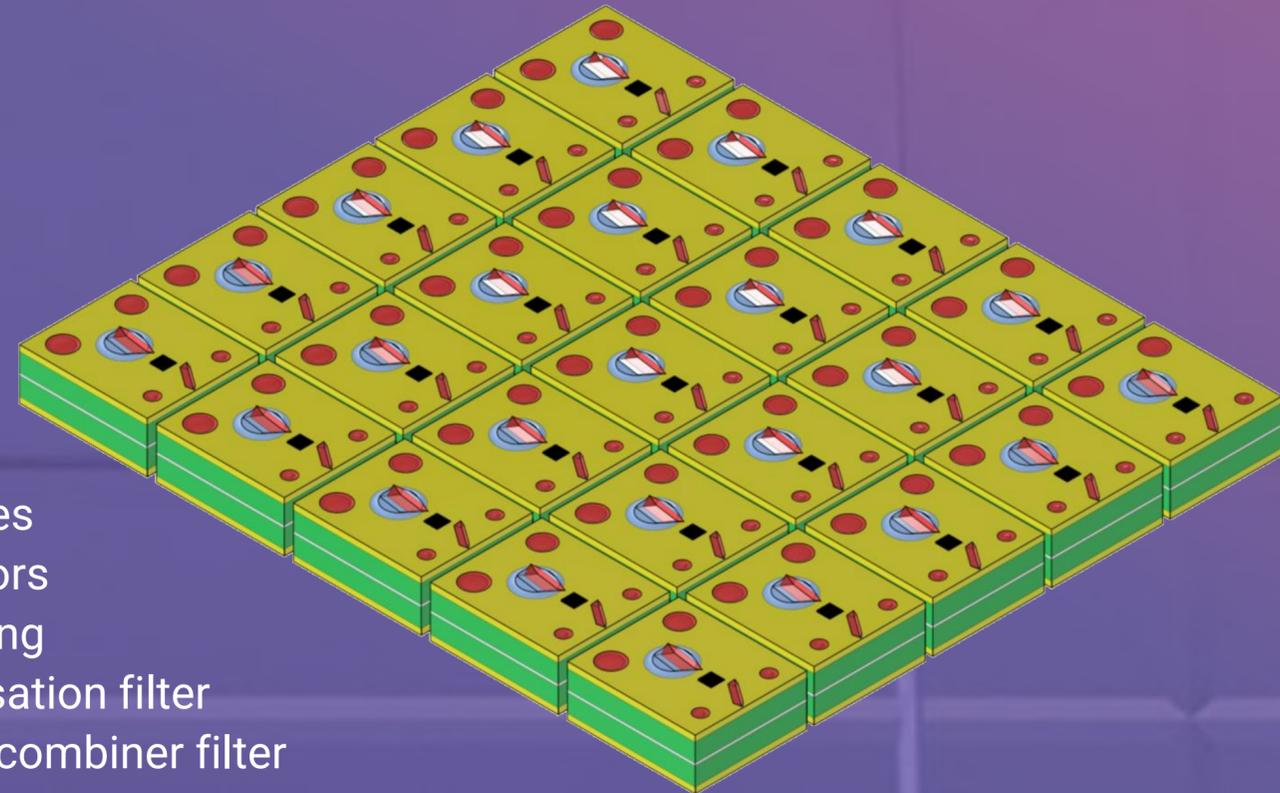
V-groove test master



User case examples

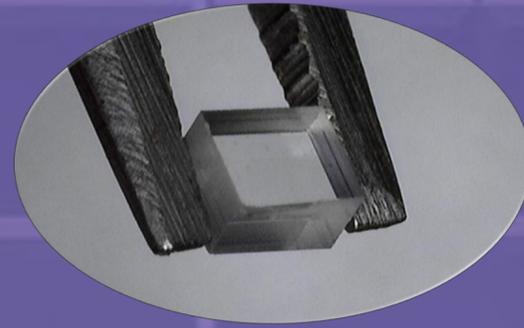
User cases

Quasi-coherent tele-/datacom receiver



Conventional

SPIO



Tactile robot grabber sensors

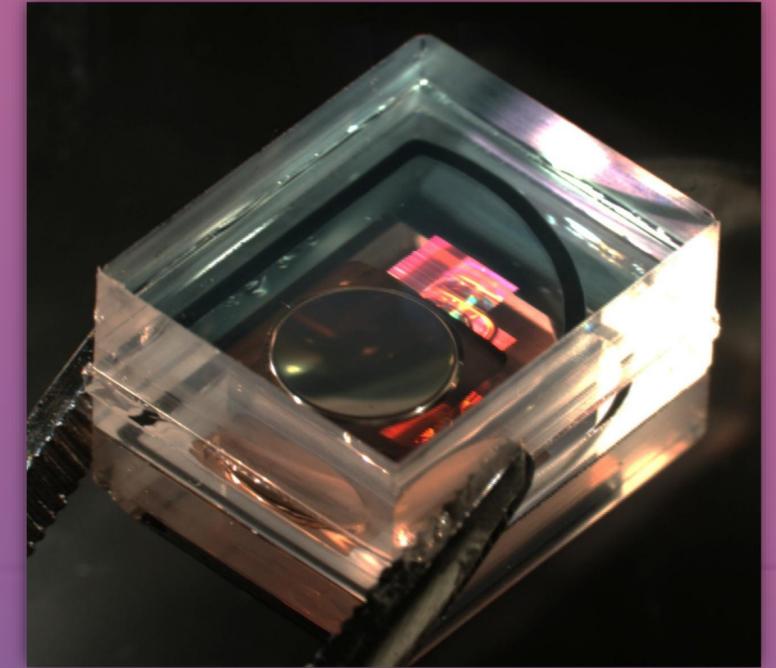
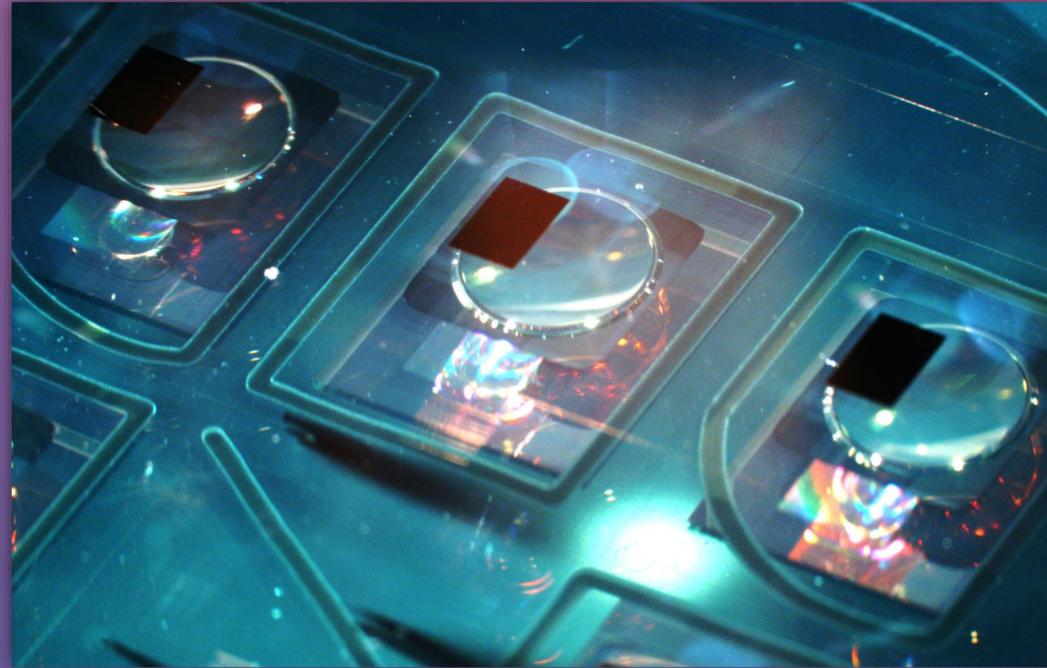
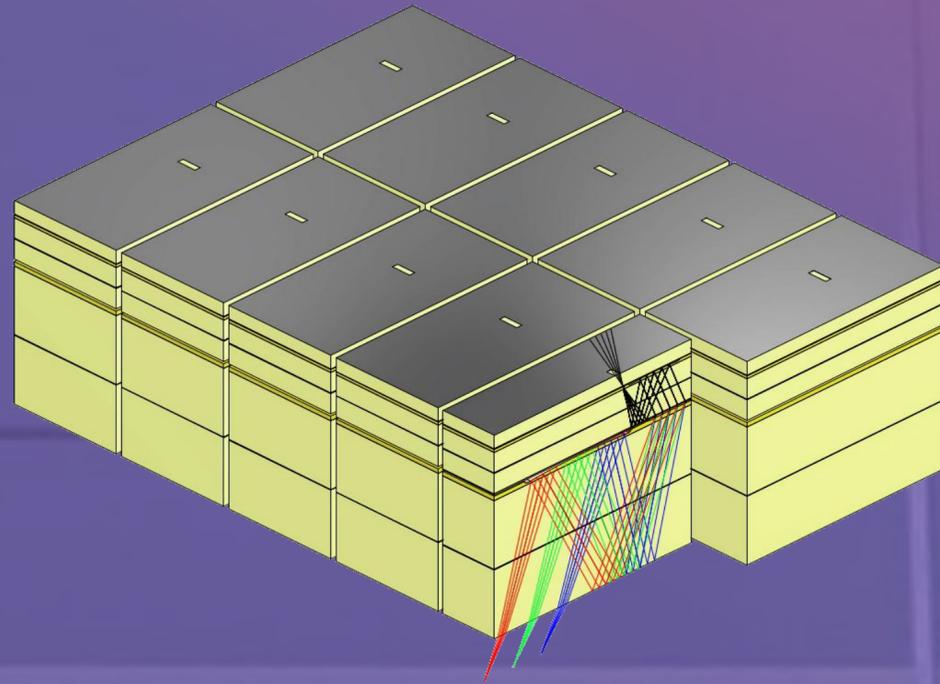
Proximity: Measure distance to an object

Touch force: Handle delicate objects like tomatoes and glass

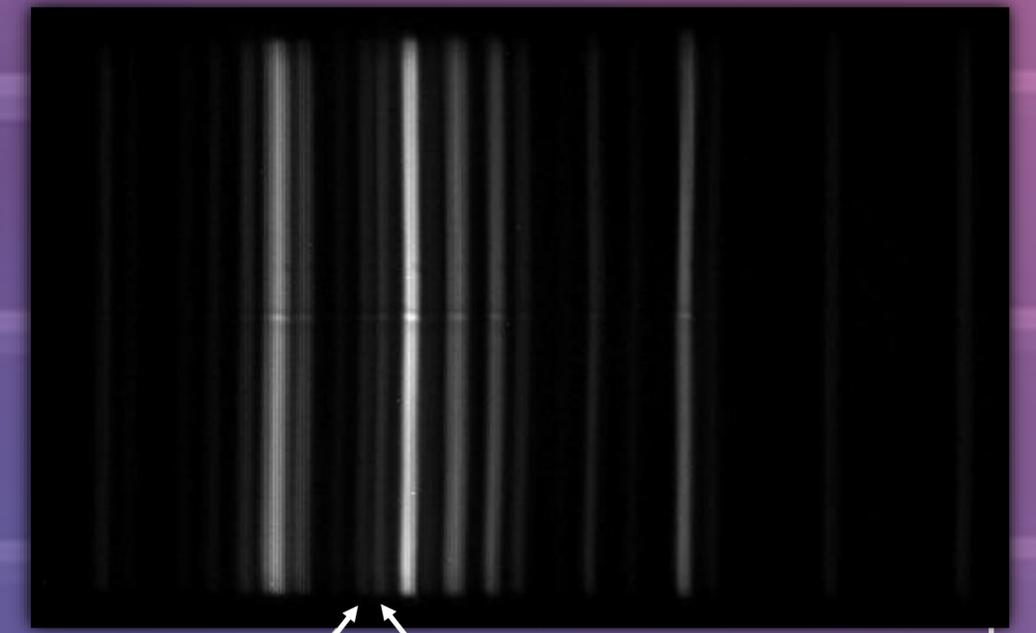
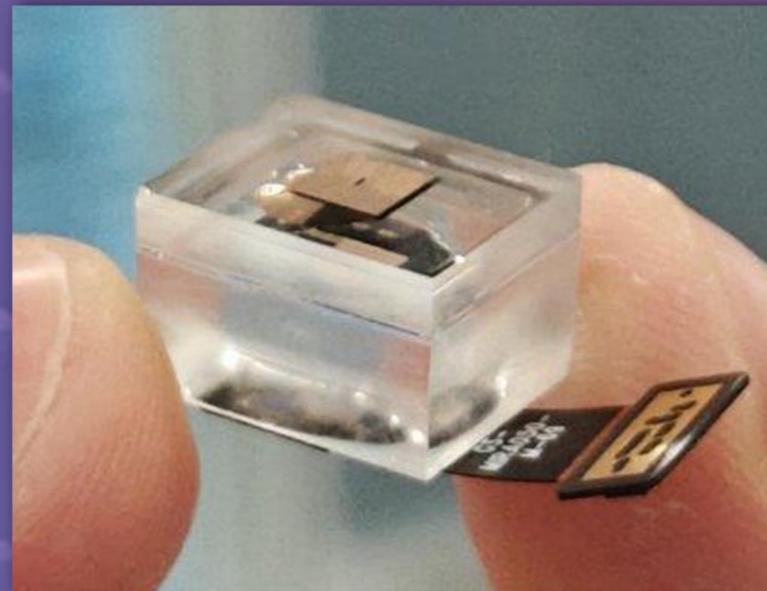
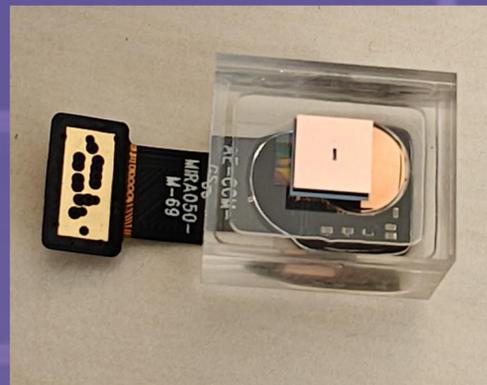
Object slippage: Detect object glide and react accordingly



Mini NIR Spectrometer



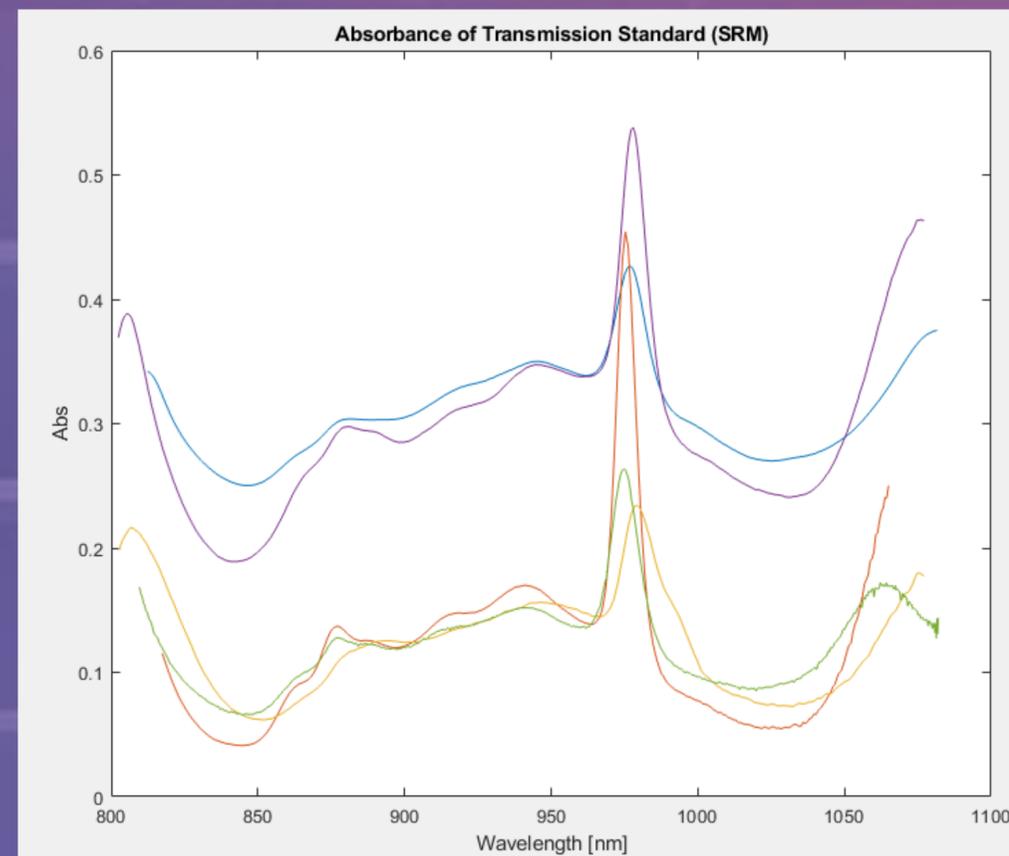
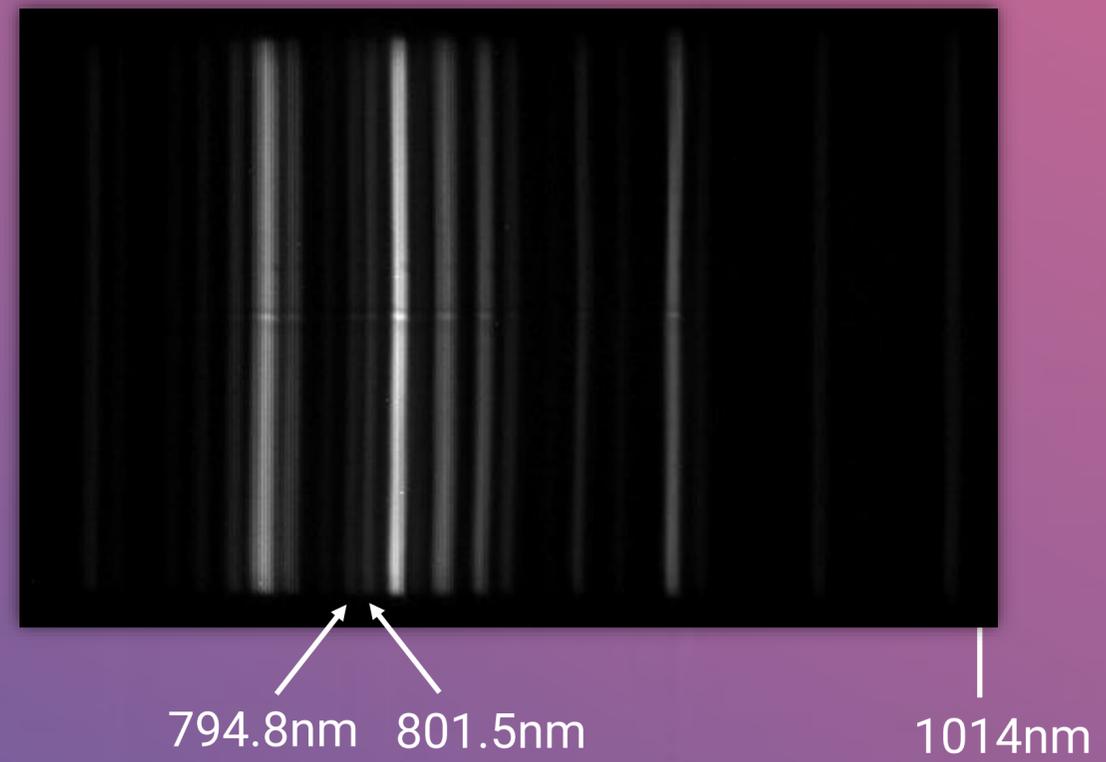
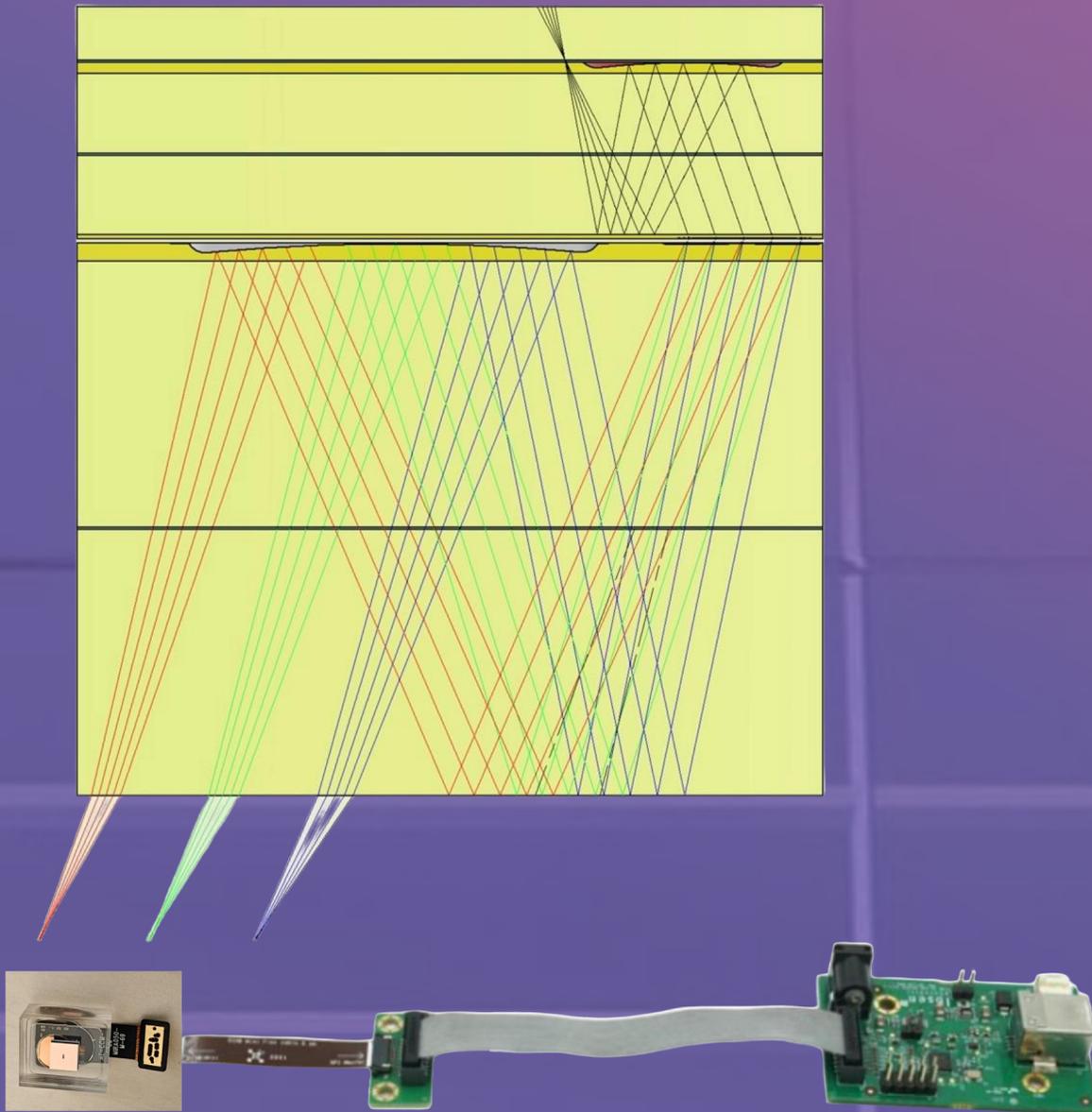
Client case:
770-1070nm
NA 0,22
Res. 8 nm



794.8nm 801.5nm

1014nm

Mini NIR Spectrometer



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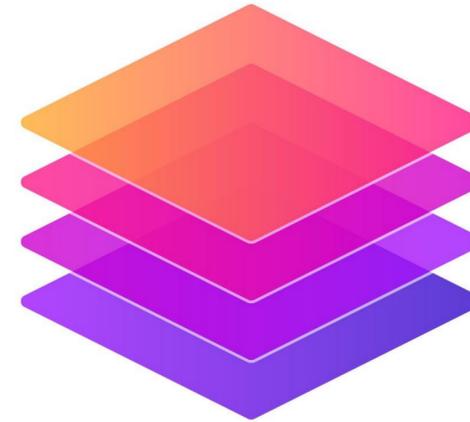
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Thank you!



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