Supporting a Swiss PIC ecosystem – services & opportunities at CSEM

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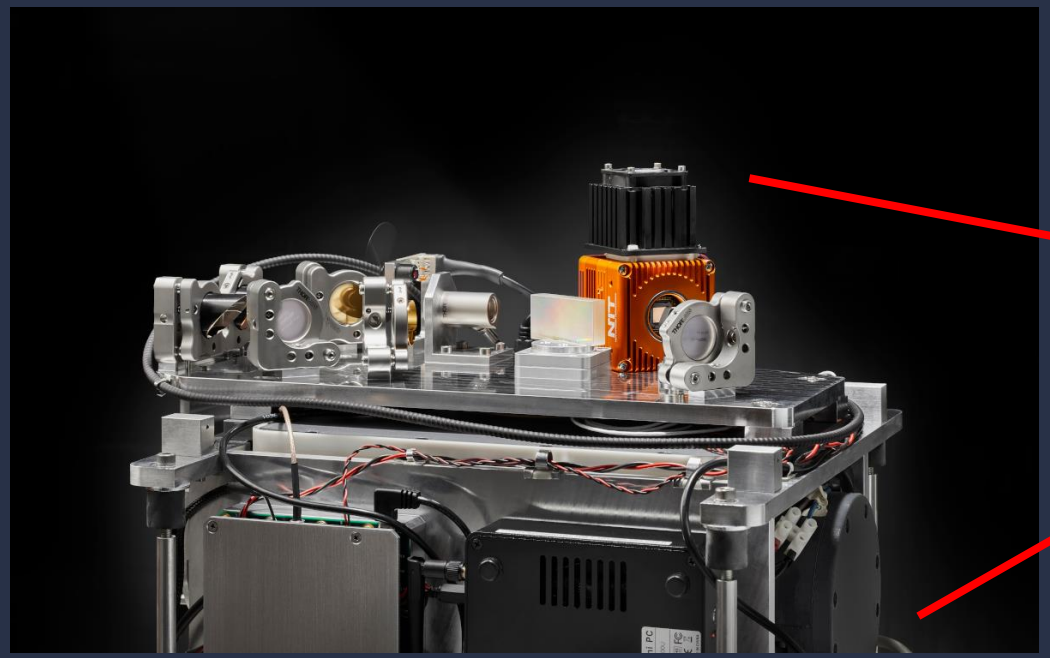
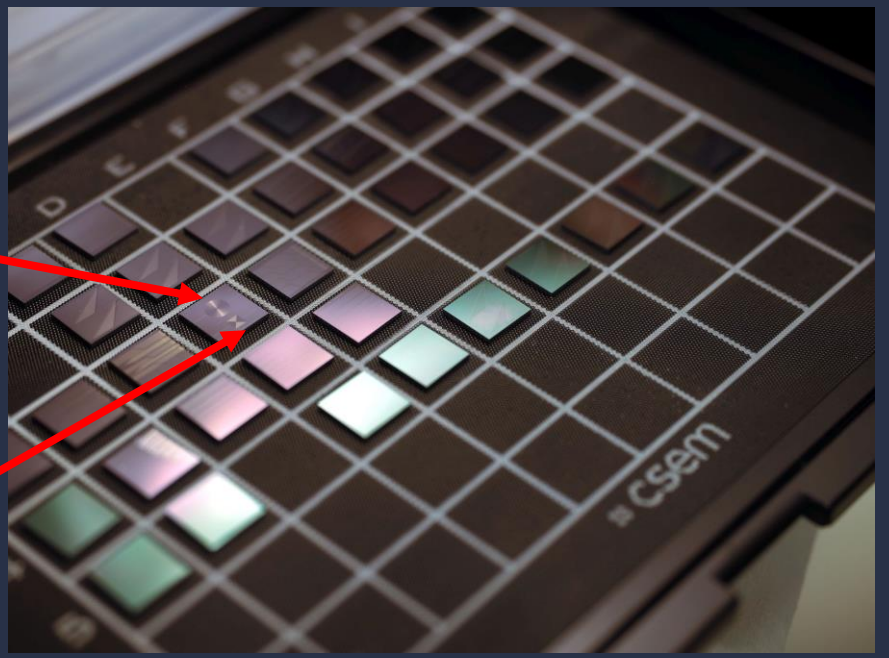
Why go for PICs?



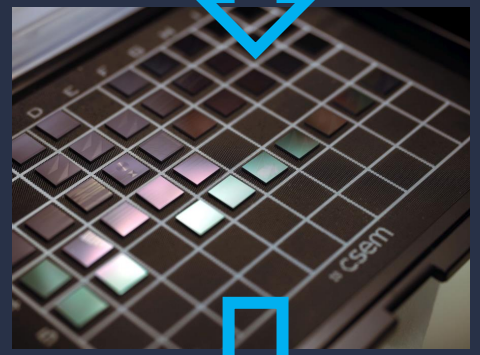


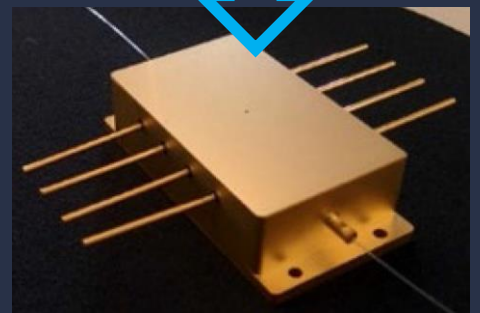
Advantages and disadvantages

Property	Bulk optics	Fiber optics	PICs
Size of final optics	--	-	++
Manufacturability	--	O	+
Price per optics	-	O	+
Maturity	++	++	O
Number of components available	++	O	--
Wavelengths	All	Many	Some
Optical bandwidth	++	-	-
Isolators	Yes	Yes	No
Polarization insensitive	Yes	Can be	No
Losses per component	Low	Medium	Medium
System complexity limited by	Size	Size and/or losses	Losses and/or tolerances

But progress does not come for free…

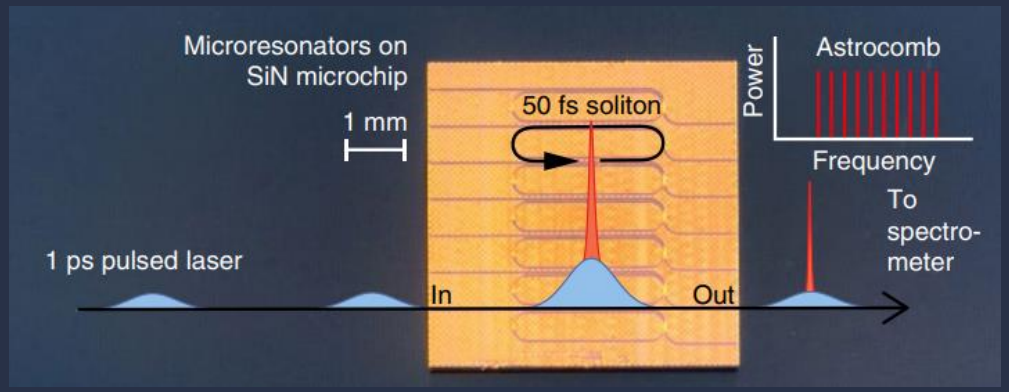
1) What optical components do I need?
2) Which PIC platform provides these?
3) How do the components look like?
4) How does the PIC circuit look like?
5) How does the optical circuit behave?
6) Where do I fabricate my PIC?
7) Does my PIC work?
8) How can I improve my PIC?
9) How do I package & integrated my PIC?

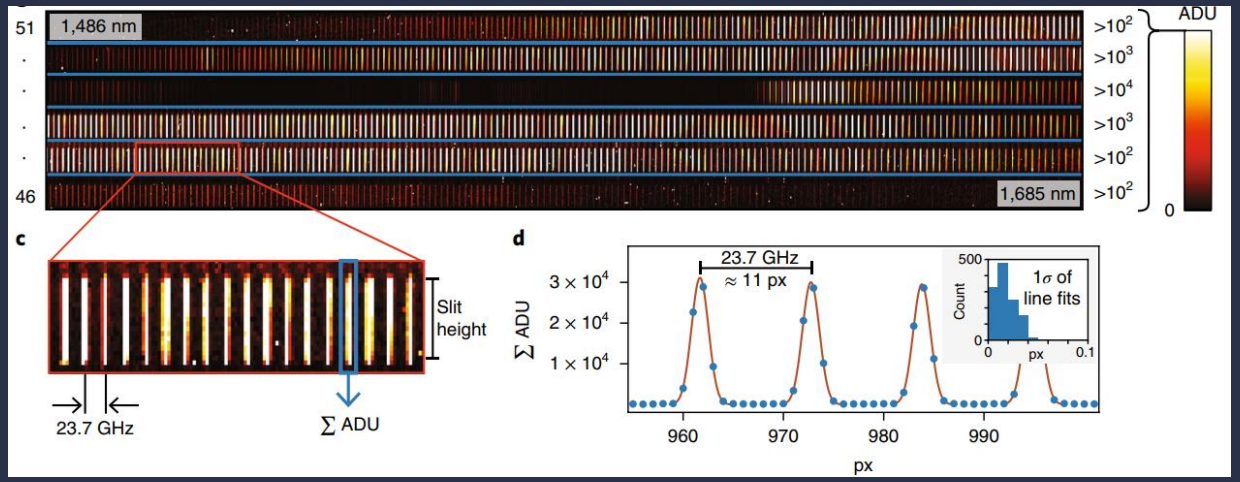




The ecosystem is here to help you

Microresonator PICs at CSEM





Advantages

- Very high frequency spacing
- Small and light

Collaboration with EPFL/LPQM

- Concept at CSEM
- Fabrication at EPFL
- Implementation at CSEM
- Out-of-lab demonstration by CSEM together with astronomy partners

Results

- One of very few in-the-field demonstrations of such devices
- Bridging science to applications

Obrzud et al., Nature Photonics (2019), 10.1038/s41566-018-0309-y

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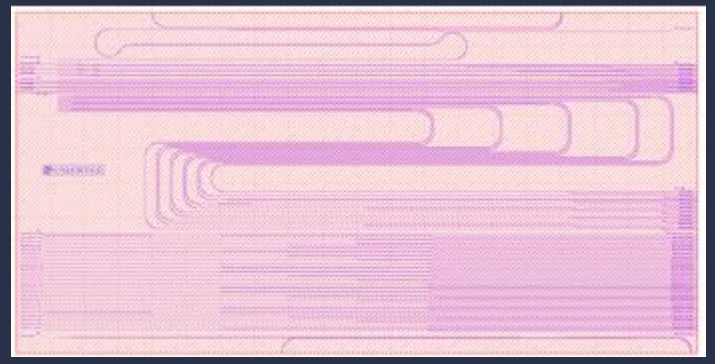
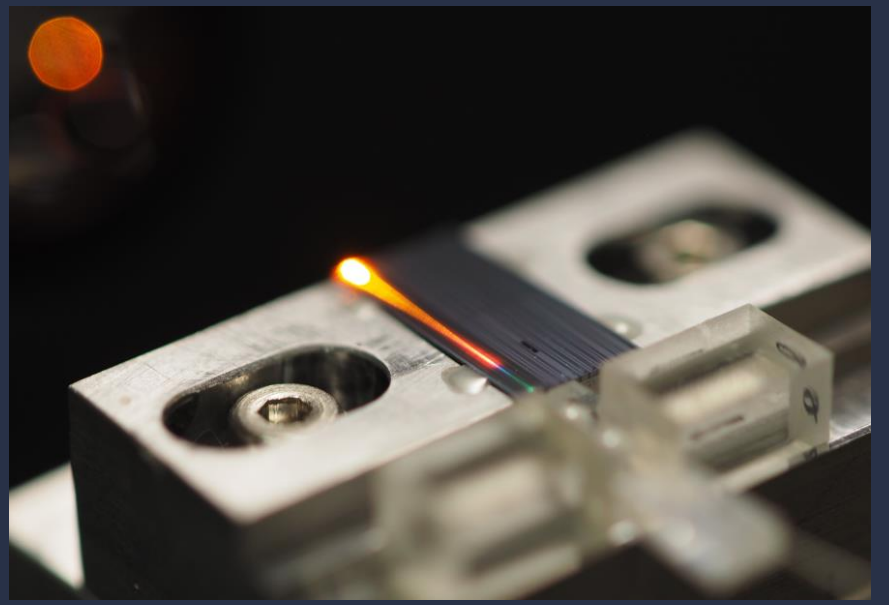
Metrological PICs at CSEM





Advantages

- Very efficient for nonlinear optics
- Monolithic integration of optics

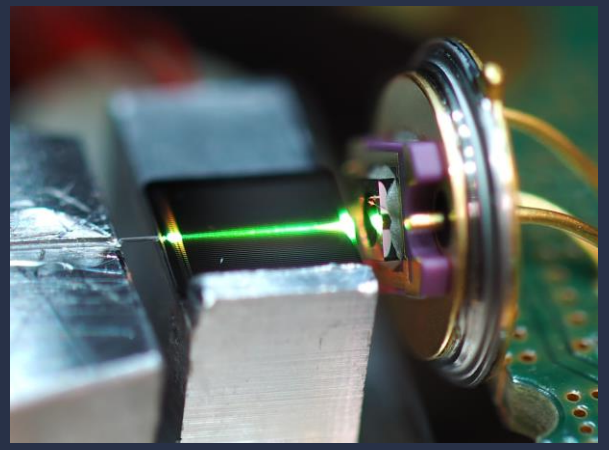
Collaboration with Ligentec

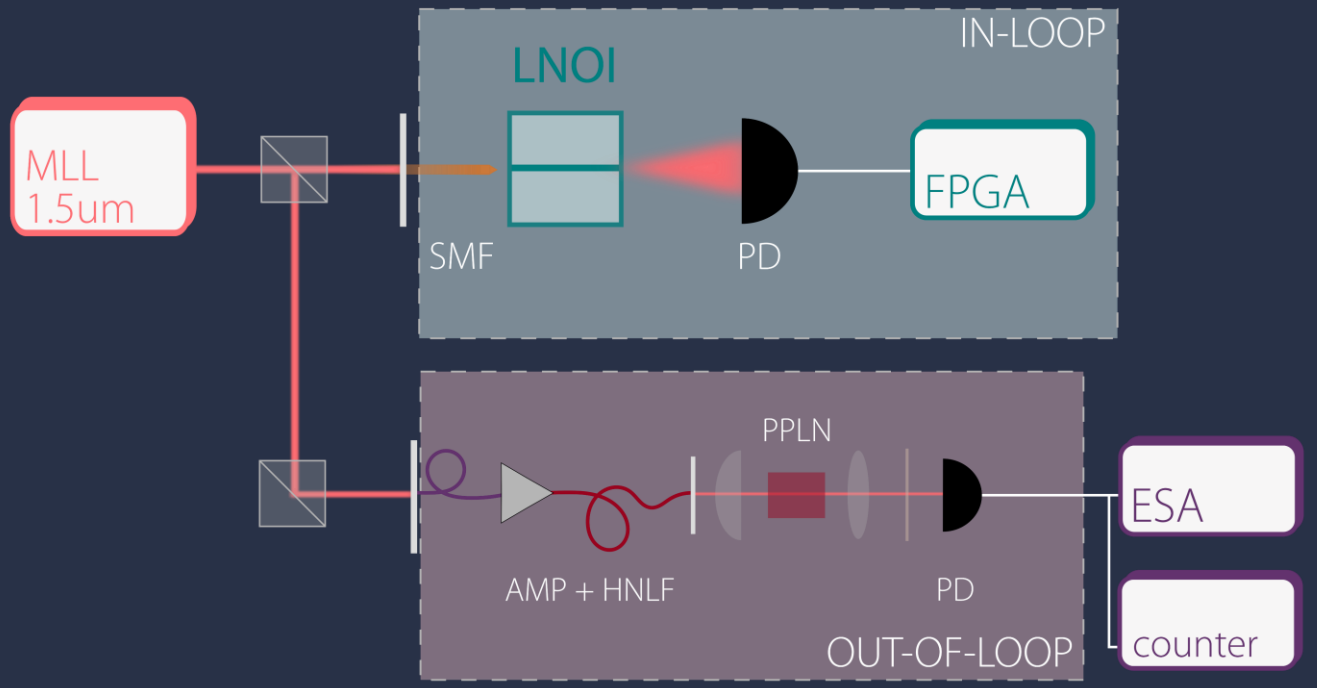
- Concept, simulations and tests done by CSEM
- Fabrication done by Ligentec
- PIC design done in collaboration

Results

- PIC for an optical atomic clock
- Including new required components

Lithium niobate PICs at CSEM





Advantages

- Very versatile, new PIC platform
- $\chi^{(2)}$ / electro-optic & $\chi^{(3)}$

Experiment

- Developed at CSEM
- Collaboration with ETHZ/ONG
- Experiments done at CSEM

Results

- Very efficient self-referencing
- Another versatile PIC platform available in Switzerland

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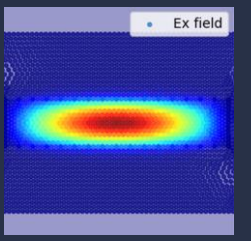
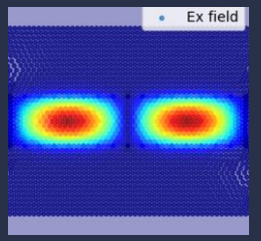
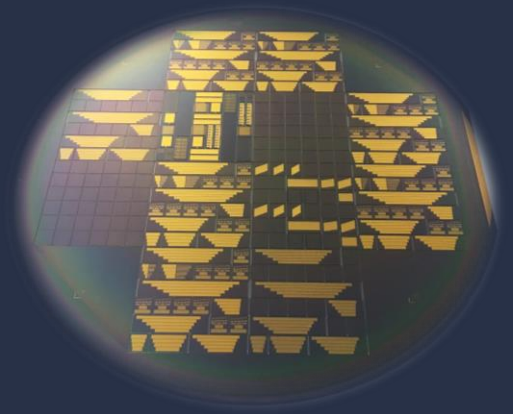
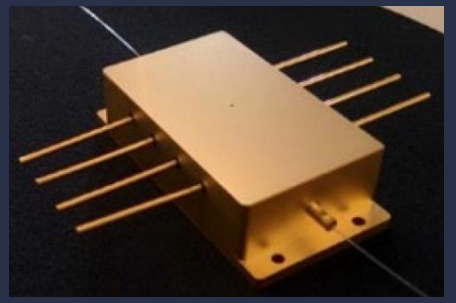
PIC-related services and project opportunities

- Consultancy on general questions
  - Choice of platform, suitability of approaches, …
- Help for concept and design
  - Chosing components, building designs, …
- Fabrication of LNOI PICs
  - 4 to 5 wafers per year with fixed design rules
- Testing of PICs
  - Linear characterization, electro-optic & RF characterization
- Packaging and integration
  - Optical packaging, electrical integration









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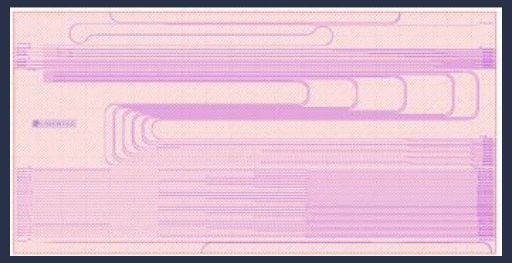
PIC conception and design



PIC design

- Experience with different platforms
- Several tools available for simulations & design
- Can be combined with testing

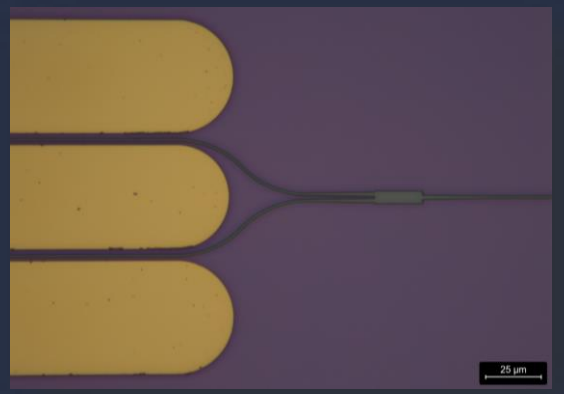
Example applications

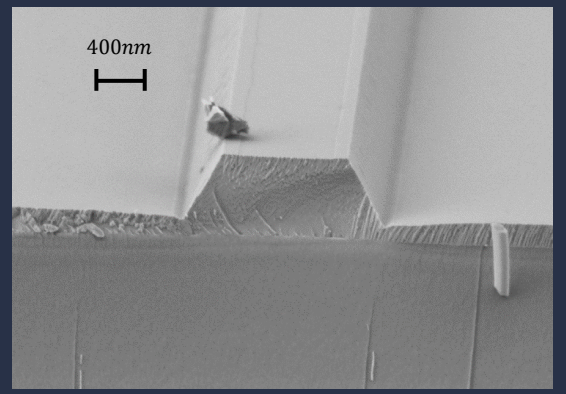
- Sensing
- Metrology
- Research

Opportunities at CSEM

- Flatten your learning curve
- Benefit from synergies in Switzerland
- Stay independent

LNOI PIC fabrication





Advantages of LNOI

- Very versatile, new PIC platform
- Wide transparency
- Very high $\chi^{(2)}$/electro-optic & $\chi^{(3)}$

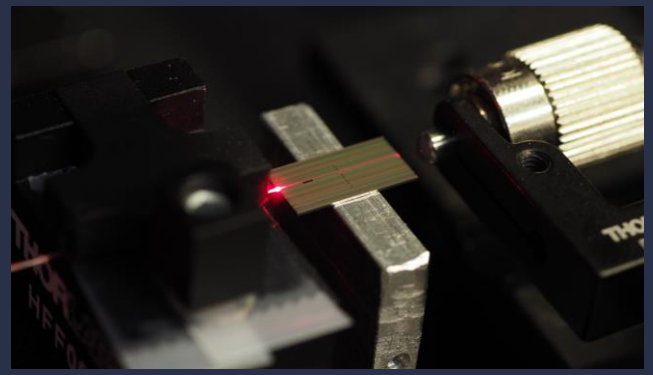
Example applications

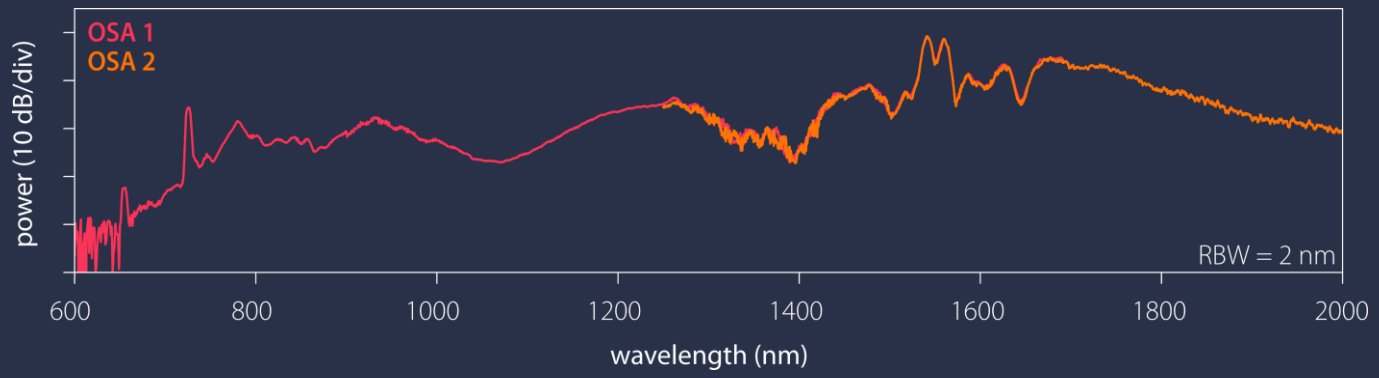
- $\chi^{(2)}$ devices for quantum applications
- Electro-optic PICs for RF
- Efficient frequency conversion

Opportunities at CSEM

- Access to LNOI PICs
- Participate in the development

PIC characterization at CSEM





Characterization at CSEM

- Linear and nonlinear
- Several widely tunable wavelengths
- Broadband light sources
- RF up to 50 GHz

Example applications

- Characterization of individual components
- Test of entire PIC systems

Opportunities at CSEM

- Taping into existing expertise and labs
- No infrastructure investments required
- Independent of the foundry

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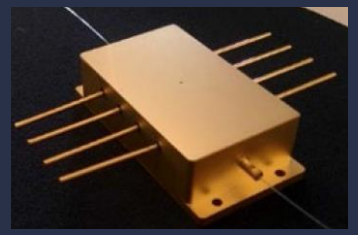
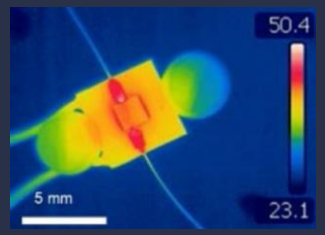
Integration and packaging

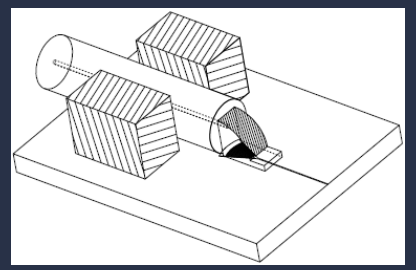
- From design to prototyping in cleanroom environment
- Heterogeneous integration of multiple functionalities (high frequency, fluidics, etc.)

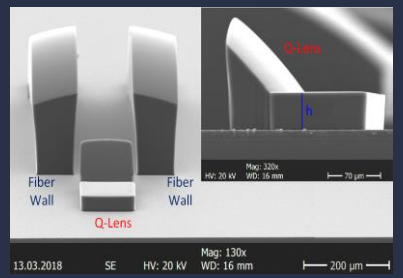
Thermal management and hermetic solutions





UV-replicated waferscale fiber optic connector for waveguide grating couplers





Q2 2021: Machine Installation

- Flexible 6 DOF assembly
- Fibers – Waveguides – Lasers

Collaboration with Aixemtec to support on

- process development & tooling
- production transfer

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CSEM's project acquisition expertise

- European projects
  - Quantum Flagship Macqsimal
  - Pilot line Phabulous
- SNF projects
  - Sinergia
  - Bridge Discovery
- Innosuisse
- ESA & ESO
- Other funding sources

Let‘s continue building the PIC ecosystem together!

- There are many things to do before one can exploit PICs
- But there are partners in Switzerland
- CSEM can help you to find your way

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