# PIC Packaging and Swiss PIC

21/03/2024, Neuchatel

Peter M. Moselund

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Swiss Photonics
Integration Center

Photographer: Markus Teller

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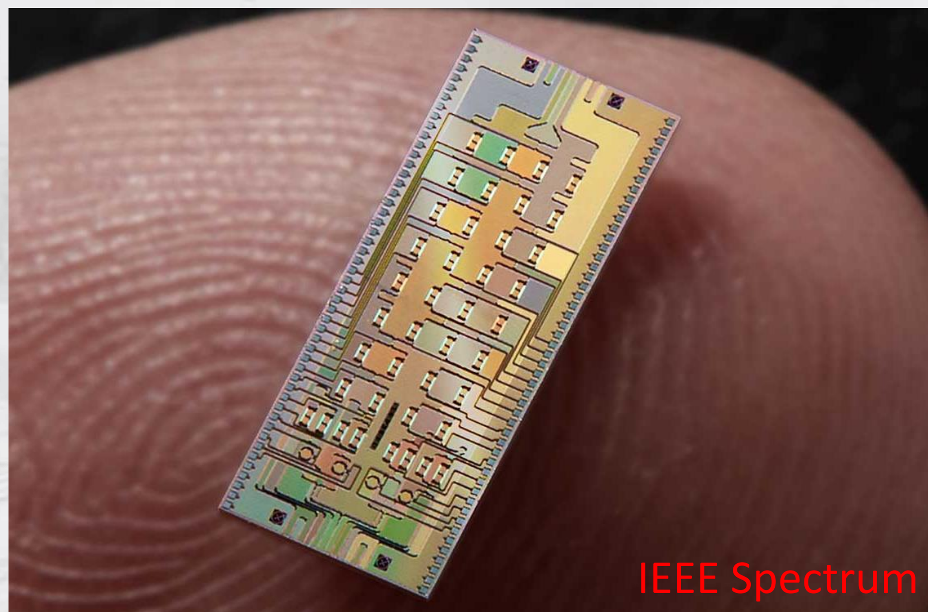
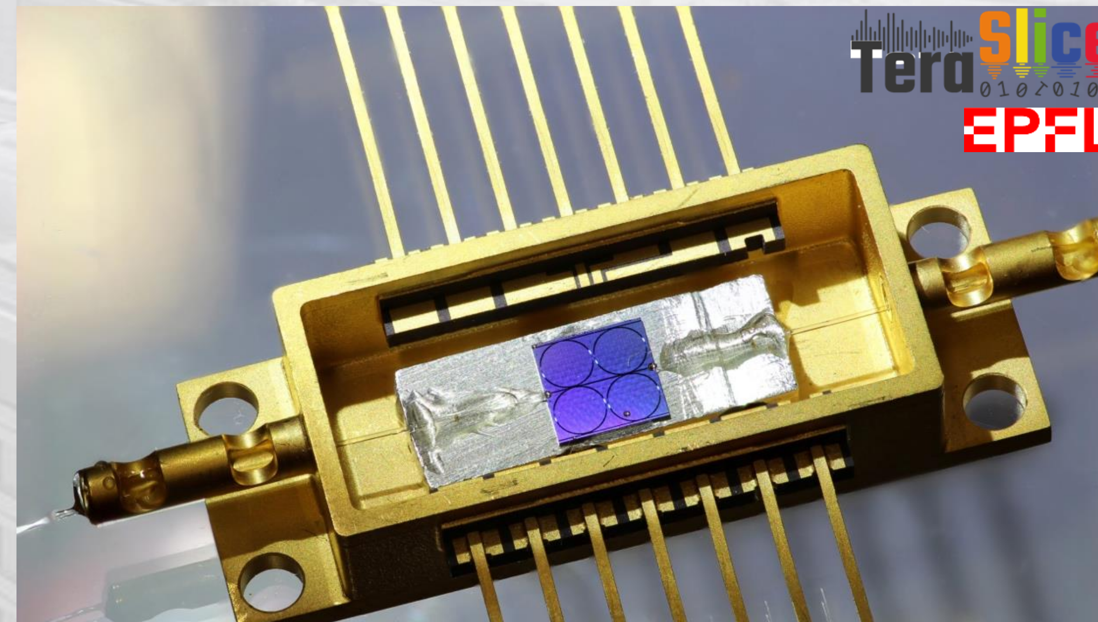
# Why PIC packaging




**PICs are useless,**




**unless they are packaged!**

**Need for Photonic Integrated Circuit Packaging**

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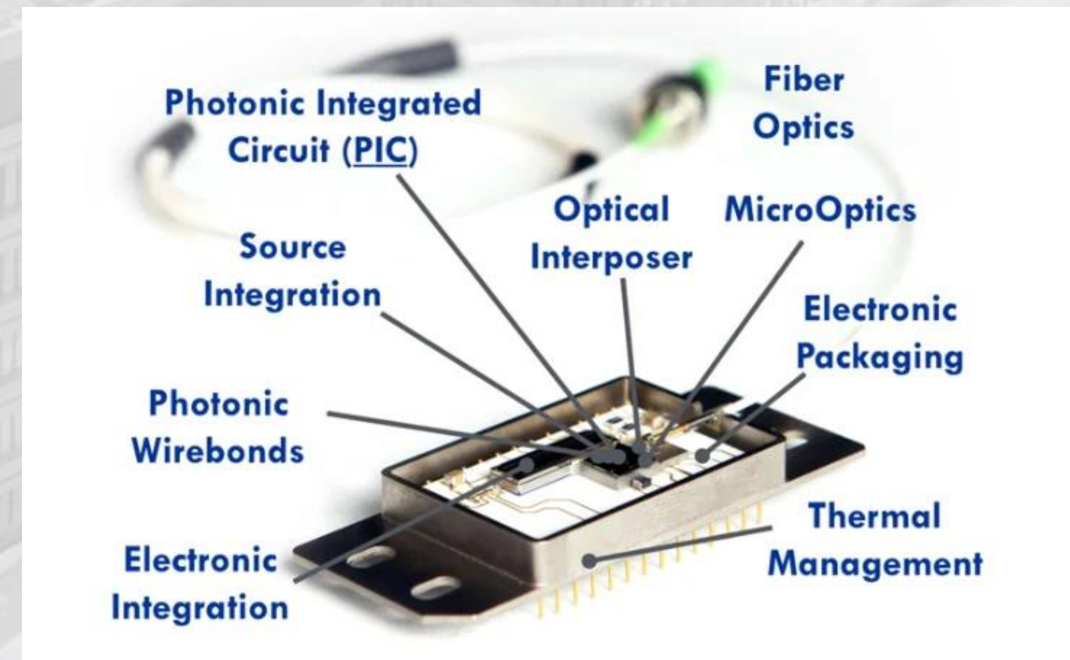
# Photonic packaging requirements

- Design and implement low loss, reliable interfaces
  - Optical interfacing (fibers, micro-optics etc.)
  - Electronic interfacing
  - Thermal handling
  - Mechanical matching
  - Environmental shielding




PIXAPP Photonic Packaging Pilot Line

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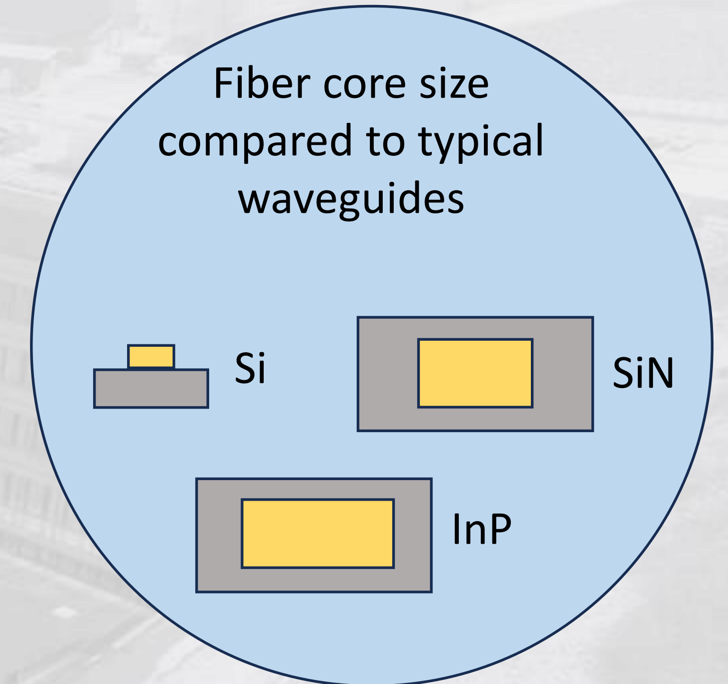
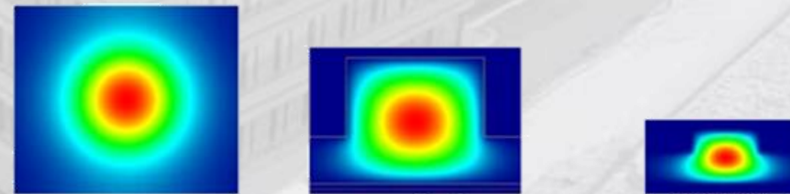
# PIC Packaging: Optical coupling loss

- 3 main sources of optical loss
  - Miss alignment
  - Mode size and shape mismatch
  - Refractive index mismatch



Mode shape missmatch

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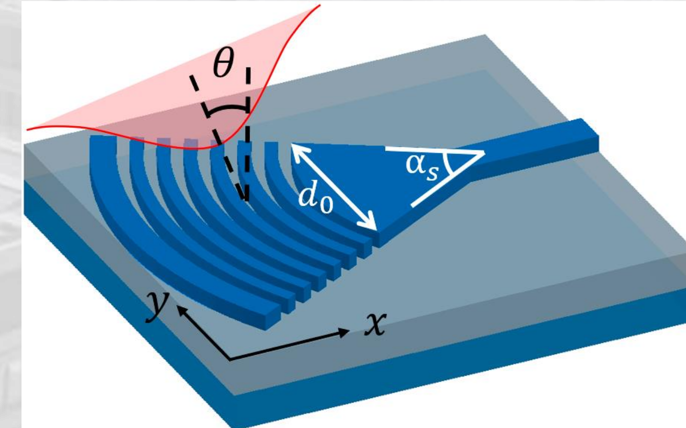
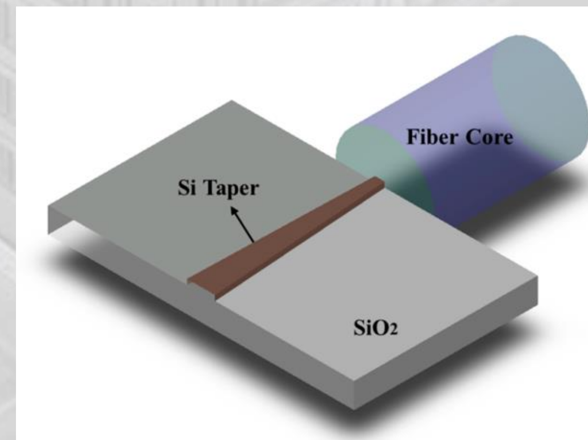
# PIC Packaging: Optical interfaces

- Fiber Waveguide interfaces
  - Grating coupler
    - Enables testing
    - Matches mode size
    - Polarization dependent
    - Narrow band width
    - Significant loss (2-3 dB)
  - Edge coupler
    - Lower loss
    - Wide bandwidth
    - Polarization independent
    - Requires mode matching
    - Alignment critical
    - Difficult testing
  - Other solutions




*Micromachines* **2020**, *11*, p. 666




*Appl. Sci.* **2020**, *10*, p. 1538

*KTH Royal Institute of Technology*

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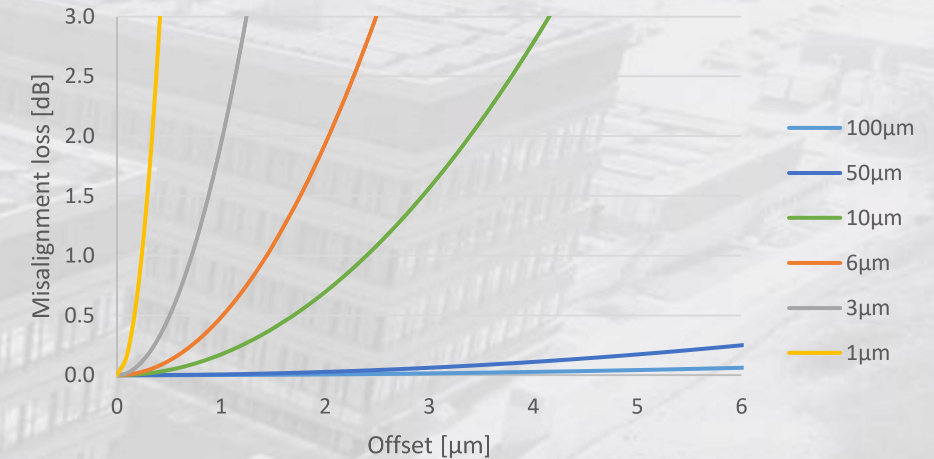
# Modefield & alignment tolerance




- Alignment tolerance depends on mode size
  - Typical fiber production tolerance
    - Cladding diameter ± 0.7 µm
    - Core-clad concentricity ≤ 0.5 µm
  - Single fiber placement accuracy
    - ± 0.5 µm
  - Core position will vary min ± 1.7 µm with passive/cladding alignment

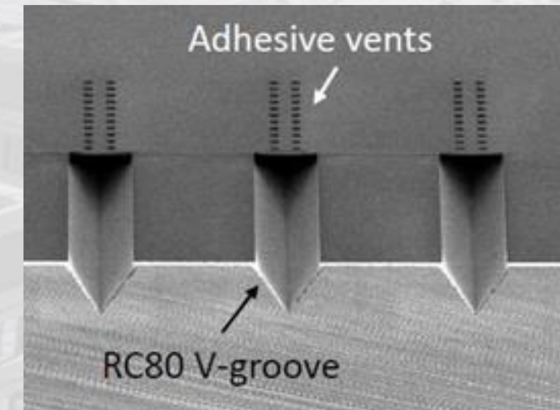
    → Passive alignment of standard fiber can never be better than ≈ 0.5 dB Loss unless the beam is expanded

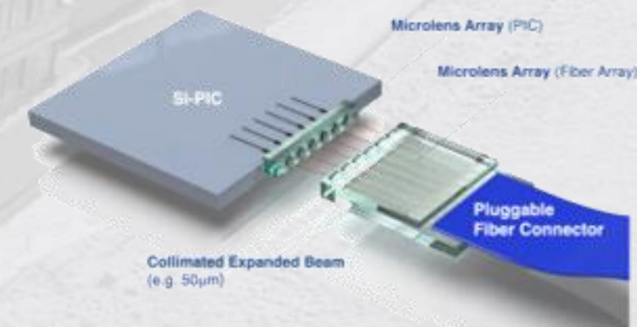
  - But increasing beam increases angle sensitivity

Photographer: Markus Teller

# PIC Packaging: two main trends

- Fiber Waveguide interfaces
  - Telecom
    - 1-2 dB loss is acceptable
    - Cost & volume requires passive alignment
    - In-house packaging solutions is the norm
    - R&D focus: New functionality and wafer based alignment methods
  - Scientific e.g. Quantum
    - Low volume, less cost sensitive
    - Low loss <0.5 dB targets
    - Varying other requirements
    - Active alignment mainly used
    - Packaging primarily outsourced

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# PIC Packaging is complex

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# Swiss PIC

- AM-TTC center which supports industry with photonic integration services

- Initial financing 2023-2028

- Supported by European leaders e.g. Tyndall, Phix, Ficontec

- Currently commencing operation, initial packaging line fully in place Sept 2024

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# Facilities etc.

Facility & Staff

- >200 $m^2$ Cleanroom under construction, next to PSI cleanroom
- Will employ 8-9 packaging experts

Equipment planned so far

- Fiber attach / Micro assembly machines e.g. ficontec
- Precision die bonder
- Wirebonders
- Optical testing
- Reliability testing

Investing 3 mCHF in 2024 and 1 mCHF annually thereafter in further assembly equipment.

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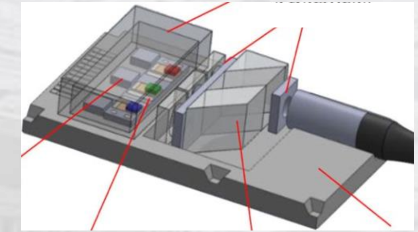
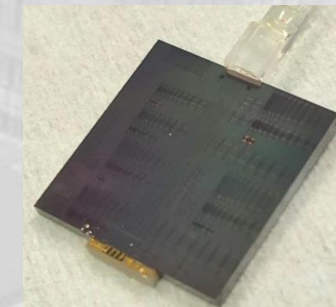
# Swiss PIC technology focus



Die level (not wafer level) packaging in 3 groups:

- Micro-Optical Hybrid Photonic Systems

  Packaging involving microscale 3D optical elements

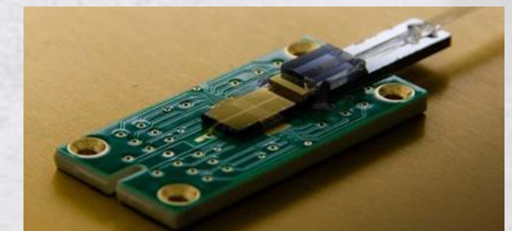


- Photonic Integrated Circuits

  Packaging centred around one or more planar chip elements

- Quantum Photonics Packaging

  Utilizes elements of the other groups but targeting the special needs of Quantum tech.



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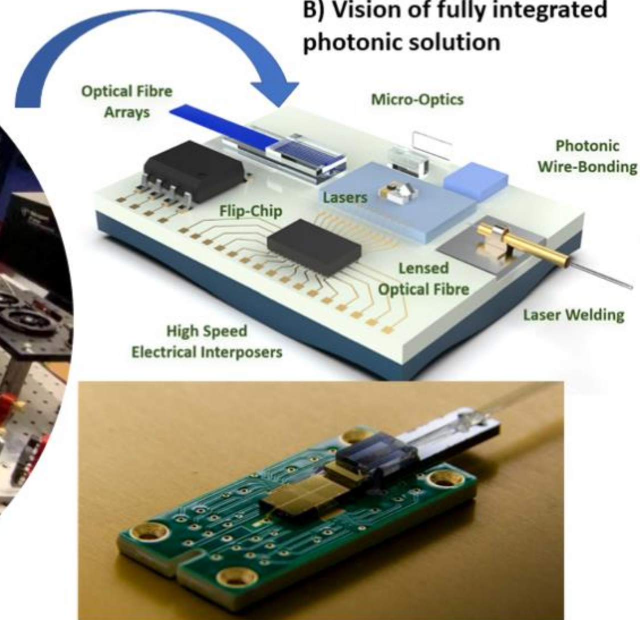
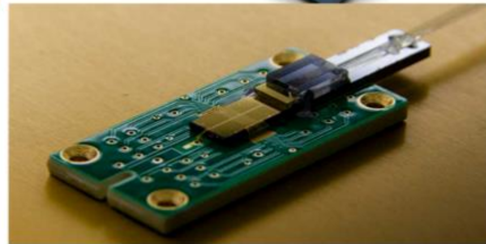
# Swiss PIC activities

A) Part of current ion-trap quantum computing set-up at PSI

B) Vision of fully integrated photonic solution



C) Qubit control through a waveguide array coupled to a fiber bundle

*PIC schematic taken from: "Bundalo et al. IEEE J. Select Top. Quant. Electron, vol. 28, 2022"*

**Support the integration**

Be the go-to partner for photonics packaging associated services in Switzerland:

- **Feasibility** studies
- Package **design** support (thermal, RF, etc.)
- Environmental **testing and qualification**
- **Development** and testing of new packaging technologies
- Rapid **prototyping** to small volume manufacturing
- Seamless **transfer** to in-house or contract manufacturers

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# Target Services

- Packaging design assistance
- Package production
- Equipment training
- Collaborative work model
- Equipment access
- Support for insourcing

- Prototype to pilot series chip level packaging services (1-100 units)

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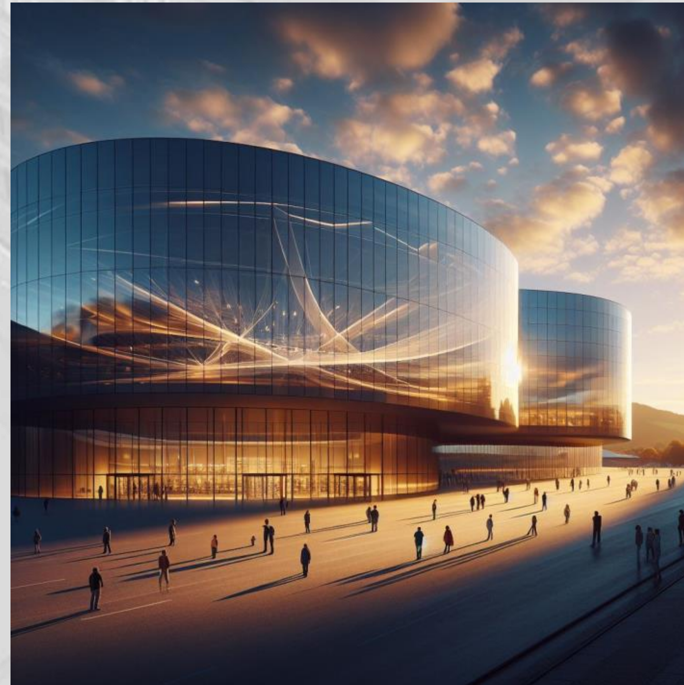
# Swiss PIC is open for business



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