Opto-electronical probe card for high-volume wafer level test of photonic integrated circuits

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MORE LIGHT

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PROBE TODAY, FOR TOMORROW

Content

- Application and background
- General test solution and setup
- Working principle
- Demonstrator
- Lab measurements and feasibility results
- Wafer prober compatibility
- Wafer-level test of EPIC DUT
- Conclusion and Outlook

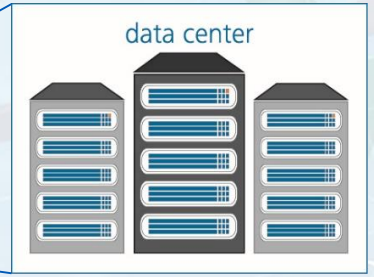
Application and Market requirements

UFO Probe™ - ultra-fast opto-electronic probe card.

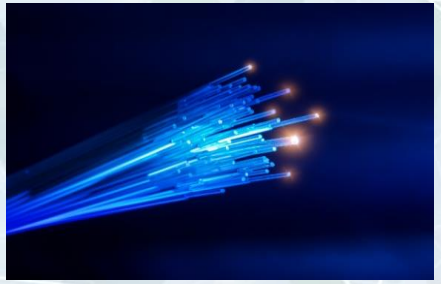
JENOPTIK developed a solution for high-volume wafer level test of photonic integrated circuits (PIC) for optical transceivers.

What's the driver?

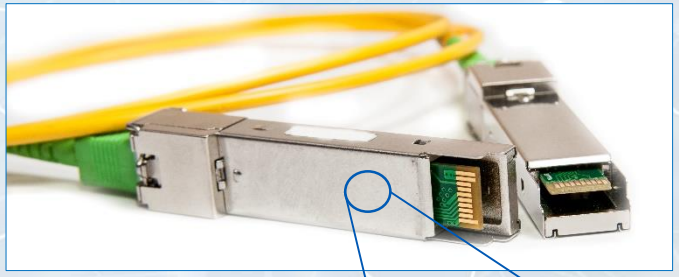
Connected World



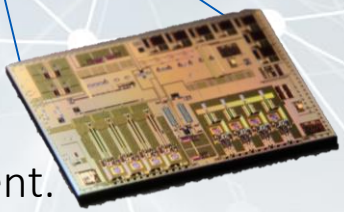
Higher data rates



Optical communication.



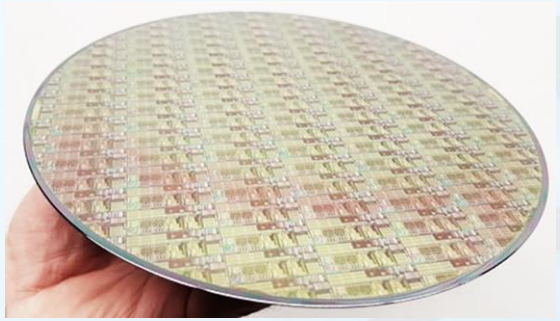
Signal conversion



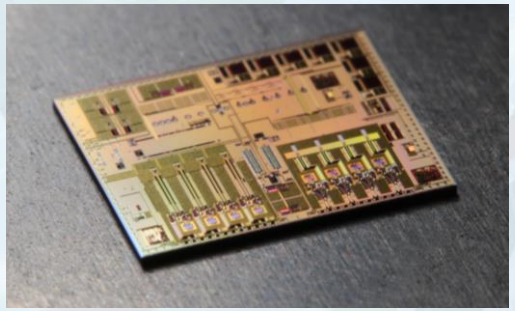
PIC as core component.

Application and Market requirements

Fabrication of photonic integrated circuits in CMOS technology



CMOS Wafer



Electronic Photonic Integrated Circuit

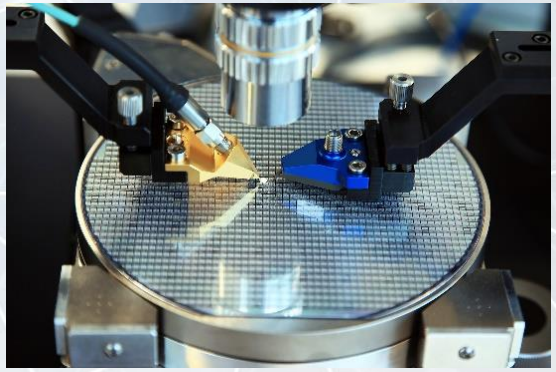
Optical ASIC or Module

The PIC ecosystem is still under development.

It needs to

- align with CMOS fabrication chain,
- meet current industry standards,
- **reduce costs!**

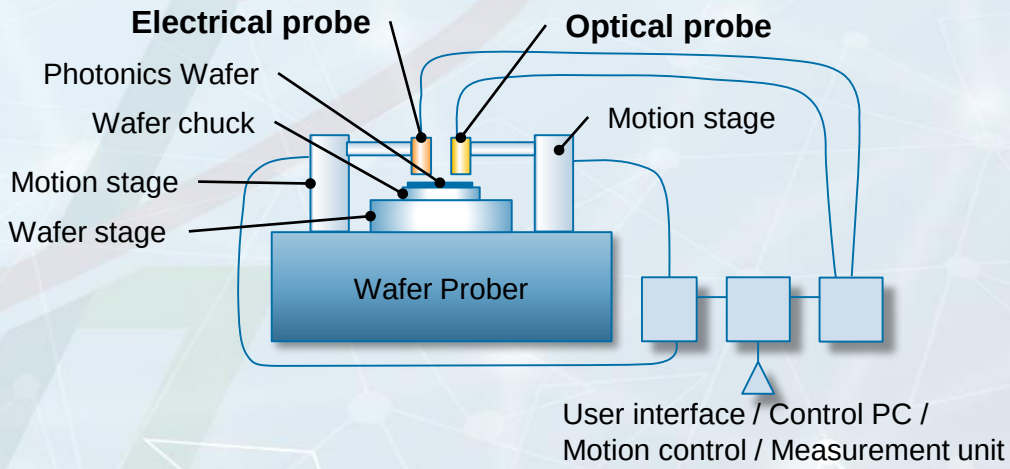
→ Opto-electronical testing plays a vital role!



Current and Ideal Wafer Level Test Solutions

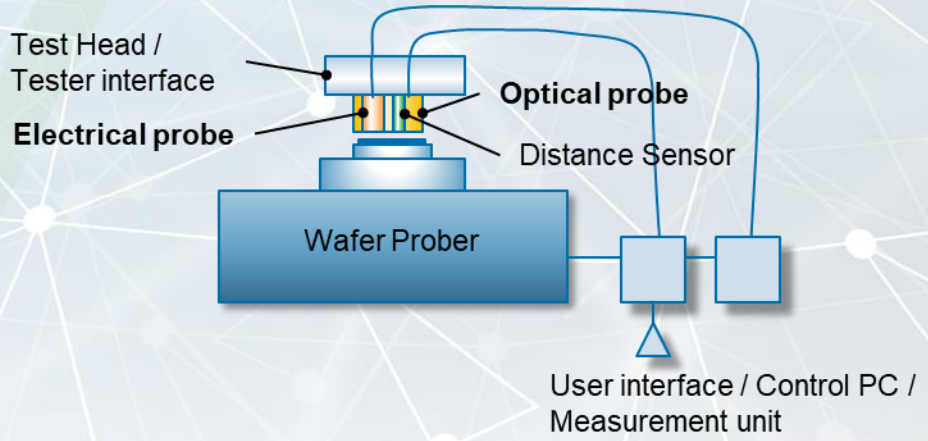
Current solutions

- **Fiber based**
- **Active alignment** in **sub-micrometer range**
- **Separated probes** - electrical and optical
- Dedicated or customized probing equipment
- **Little to no** possibility of **parallelization**



Ideal solution

- **Plug & Play** ready for existing standard IC wafer probers and automated test equipment
- **No active alignment** time per chip
- **Parallel qualification** → multi-DUT regime
- Operated by same personnel as standard IC equipment



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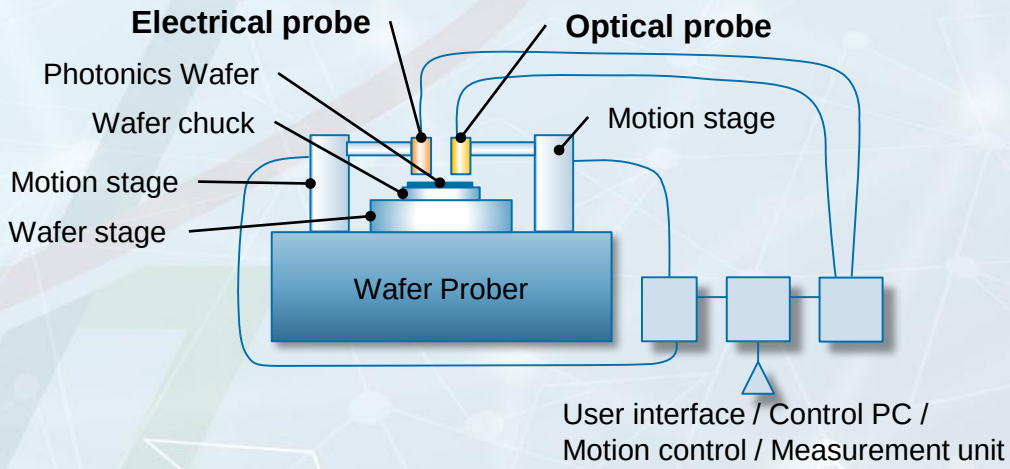

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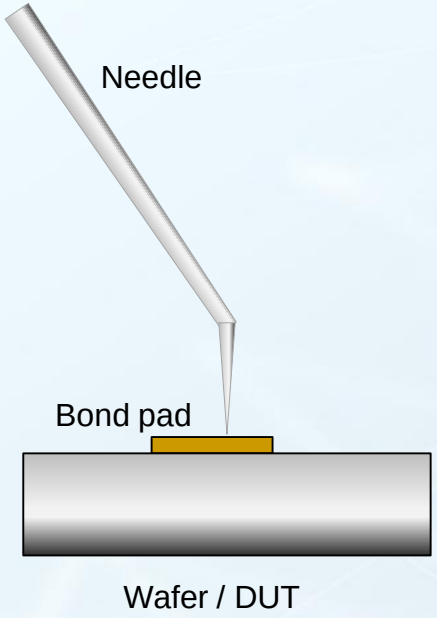
Consequences

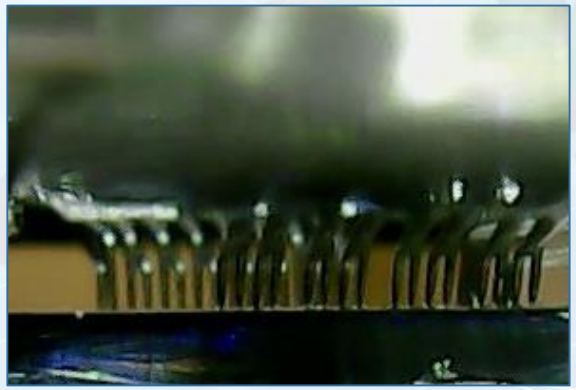
- optical and electrical probe in **one probe card**
- Compatible to existing interfaces
- Deal with **‚coarse'** prober alignment tolerances
- **Optics** that works **alignment insensitive**
- **Scalable** solution with simple handling

Working Principle

Big Question:

- How to get ELECTRICAL and OPTICAL probes together?





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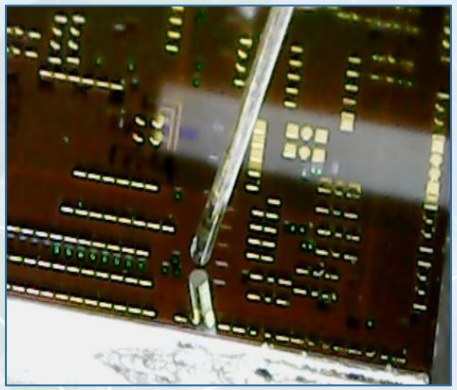
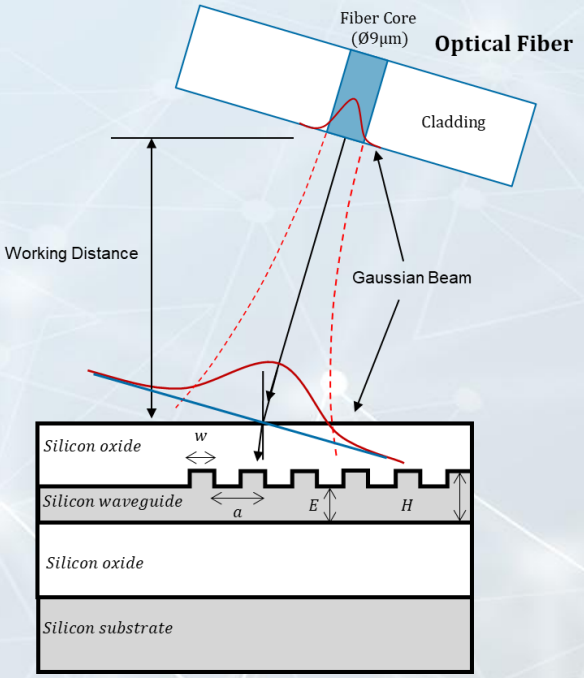




Micrometer position tolerance at bond pad

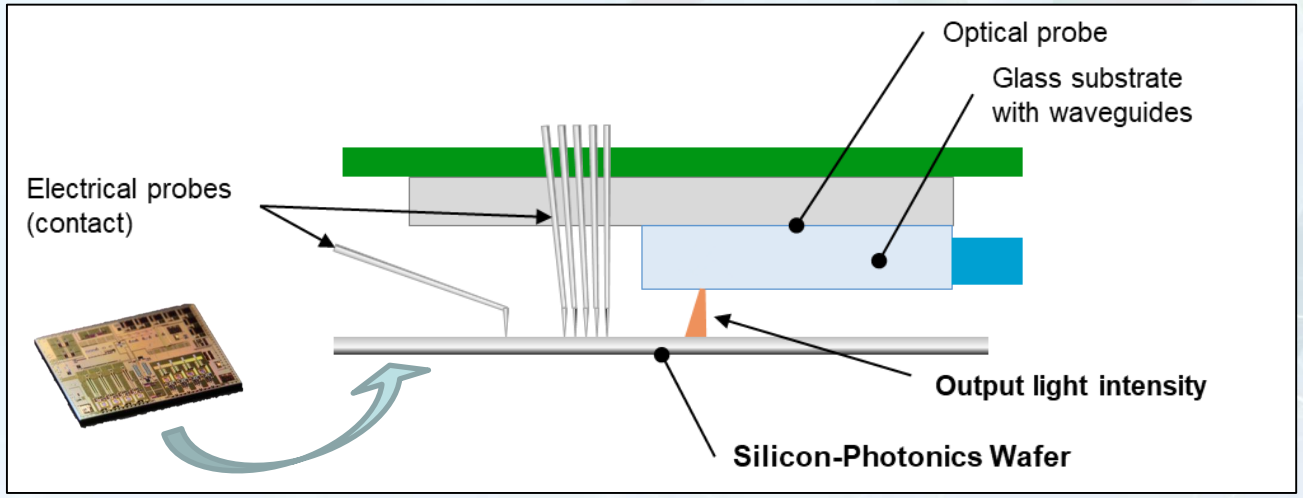
Sub-Micrometer position tolerance at grating coupler

Working Principle

Challenge of an opto-electronical probe card:

- Realize an alignment insensitive optical probe.

Schematic of the UFO Probe principle



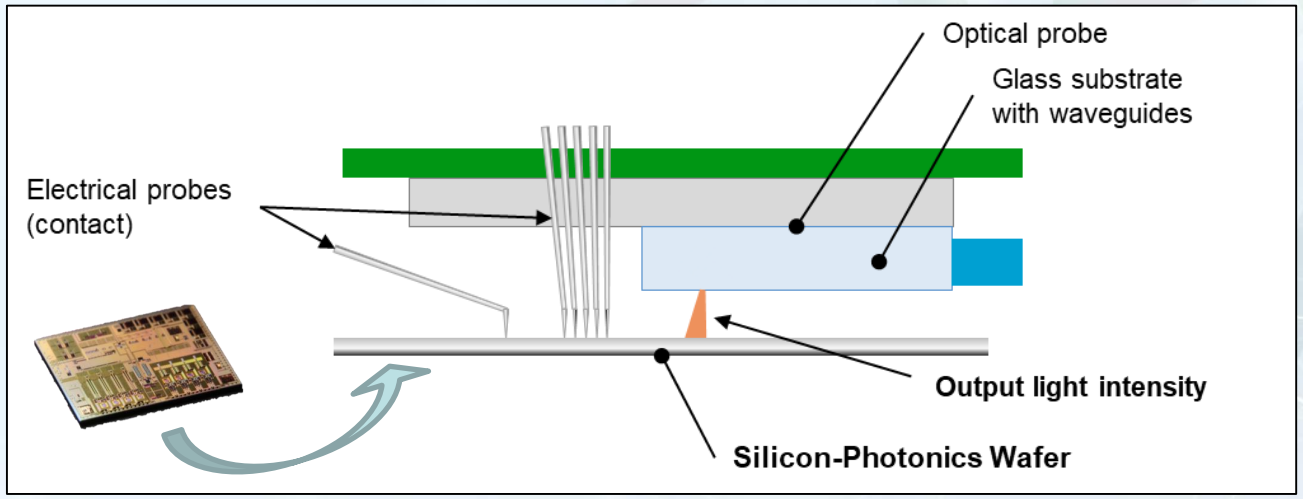
Working Principle

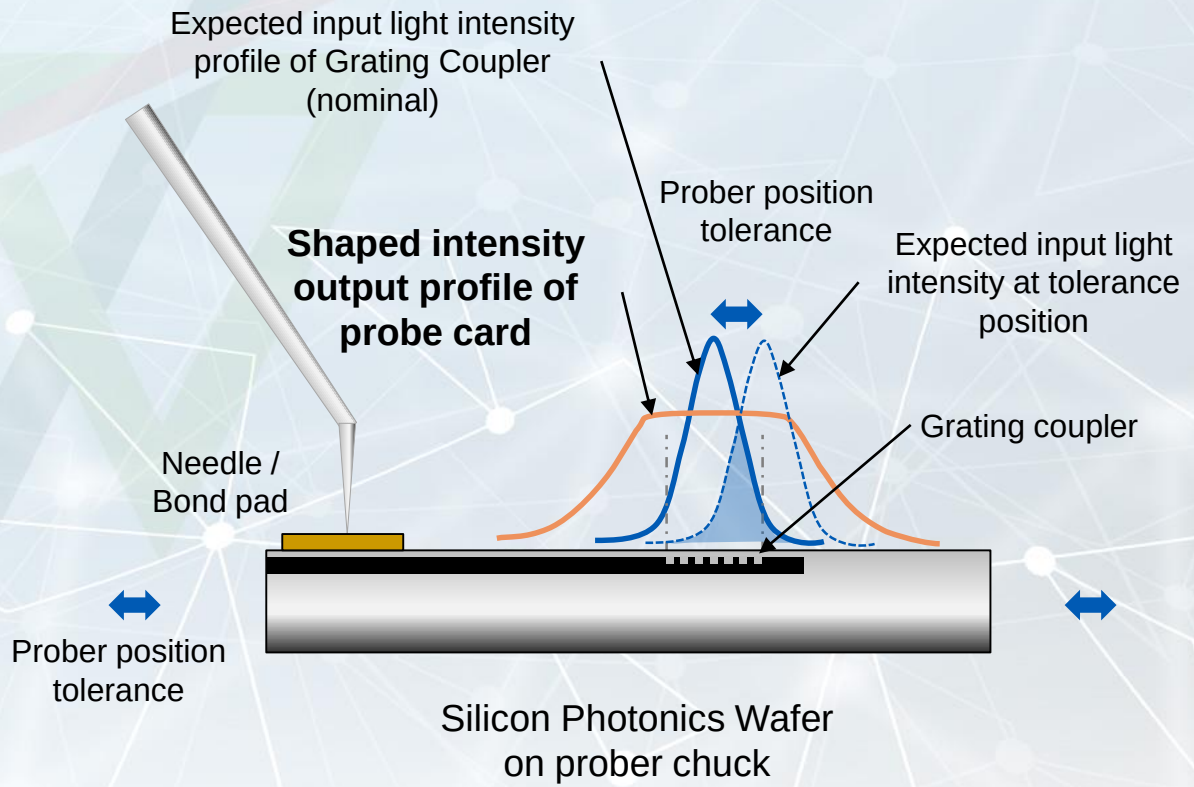
Challenge of an opto-electronical probe card:

- Realize an alignment insensitive optical probe.

Optical concept compensates prober alignment tolerances.

Schematic of the UFO Probe principle

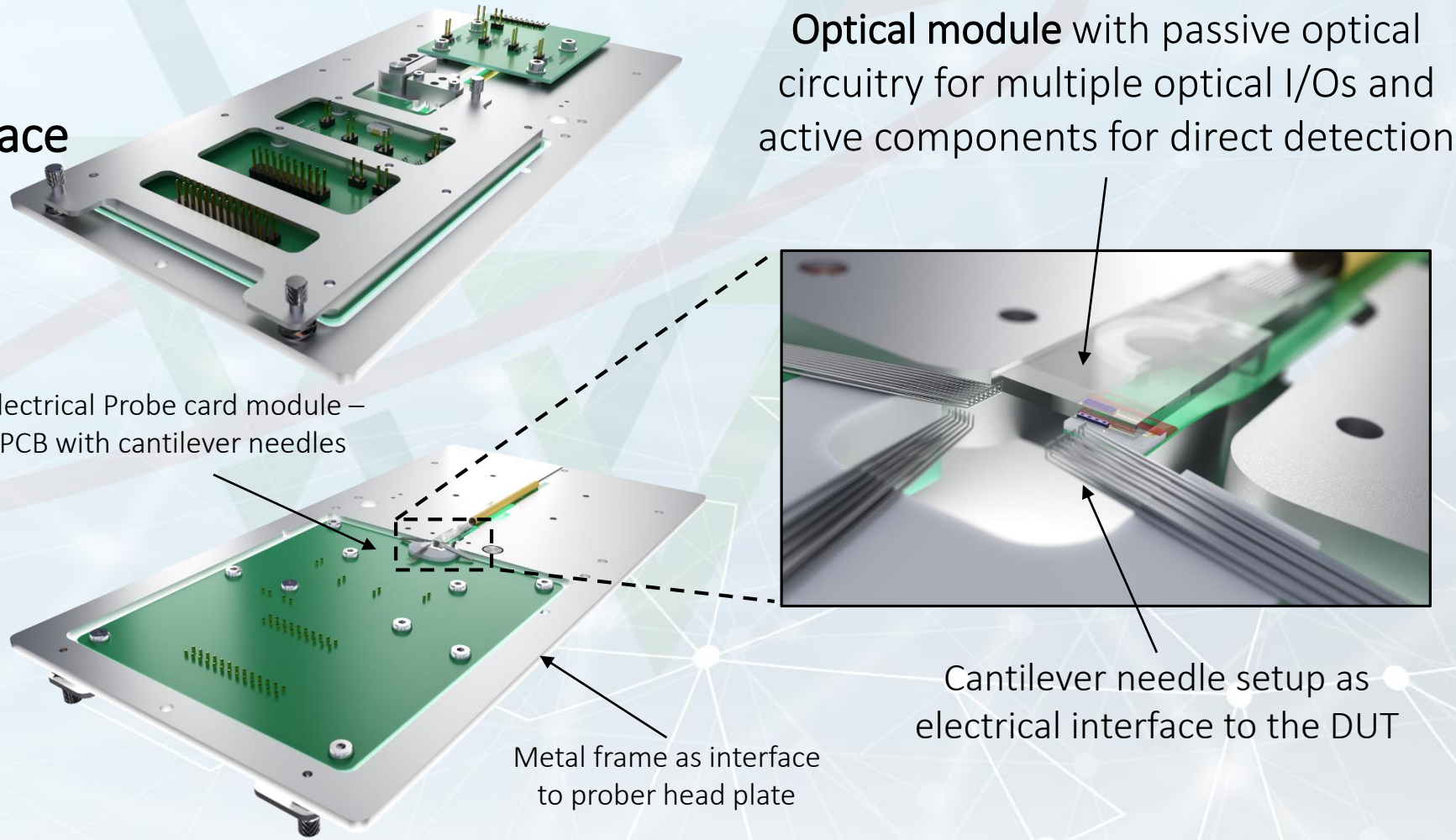




Technical Realization of Demonstrator

Demonstrator

- Standard prober interface (Eurocard format)
- Monolithic optical module
- 16 optical I/Os
- Alignment insensitive optical coupling
- Simultaneous optical and electrical probing



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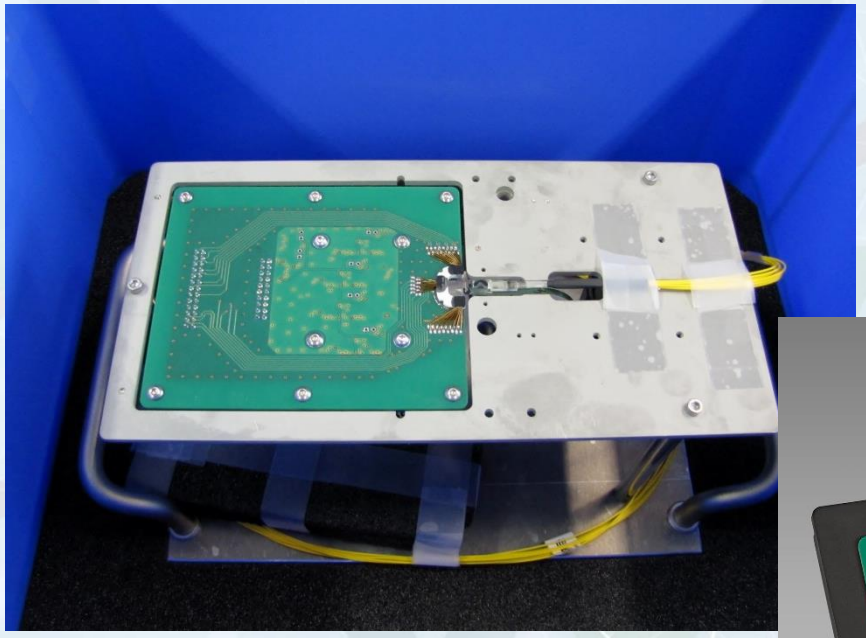
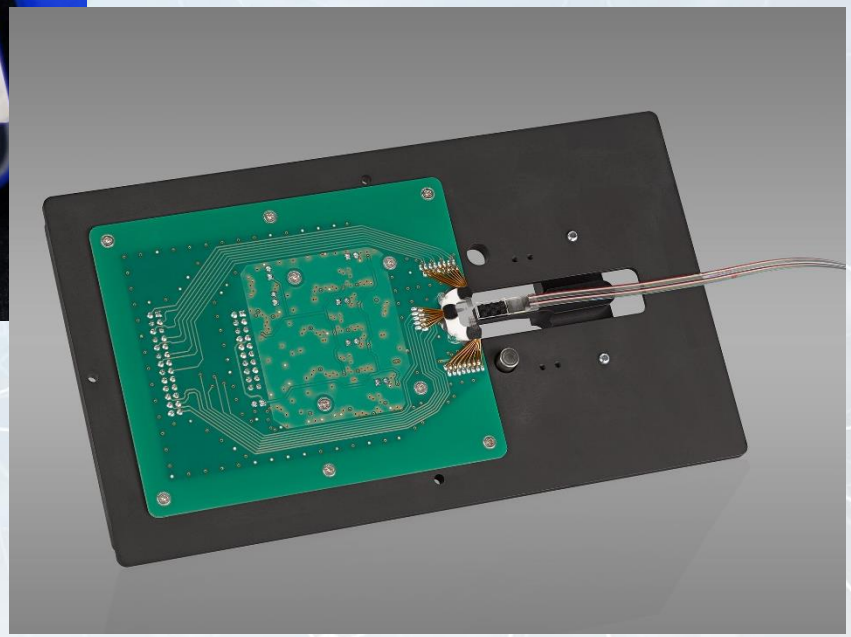


Functional Model for lab verification and integration purposes

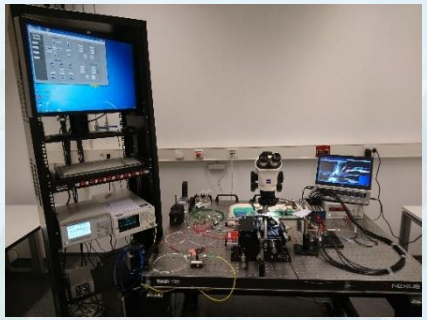
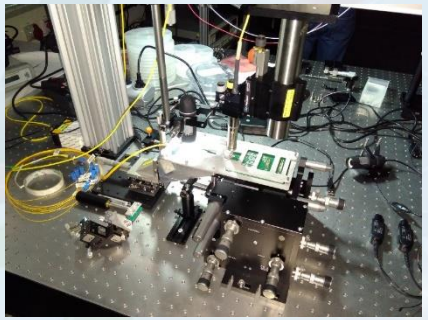
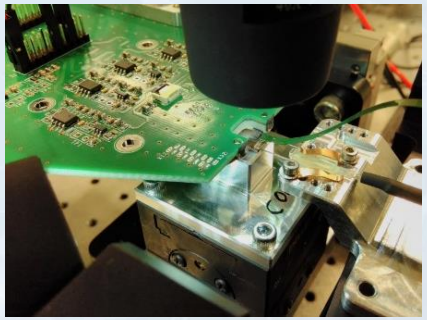


Functional Model for prober compatibility check

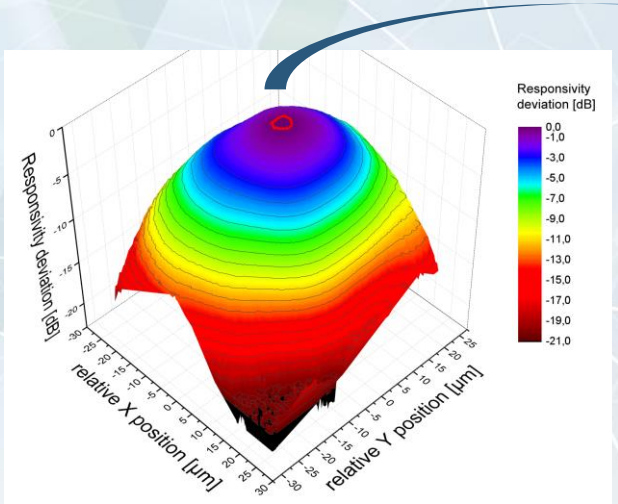
Demonstration of Working Principle

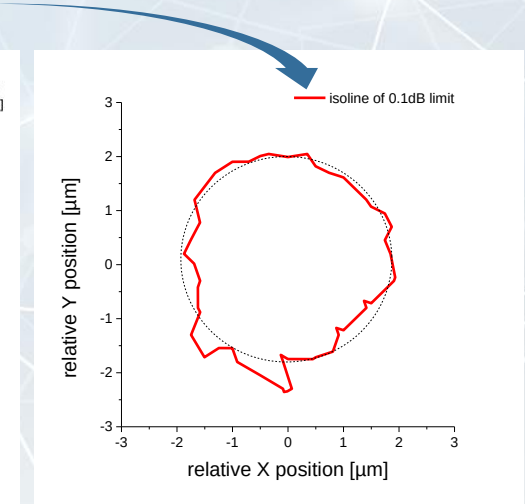
Conformation of optical working principle under lab conditions

- Build lab setups for raster scan, free space imaging, integration feasibility
- Manufacturing setups
- PIC samples provided by Sicoya

- Measured displacement for -0.1 dB sensitivity range
  - RX channel: ±1.9µm
  - Alignment loop: ±1.0µm



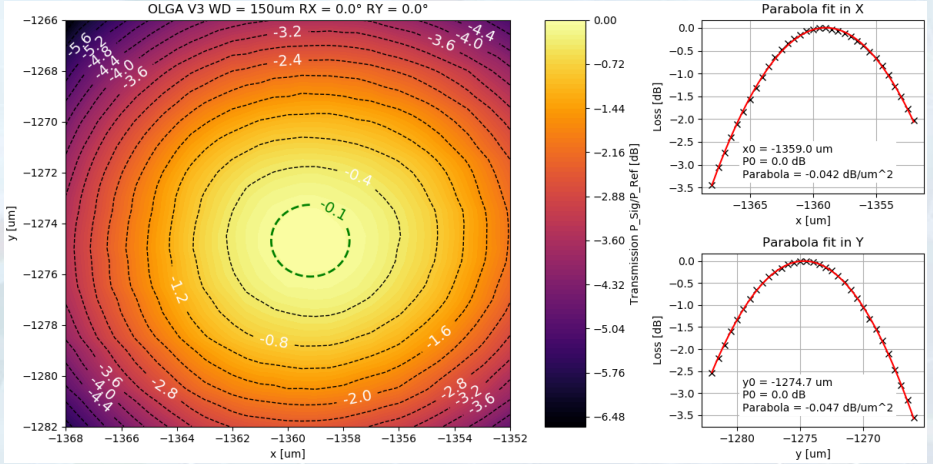


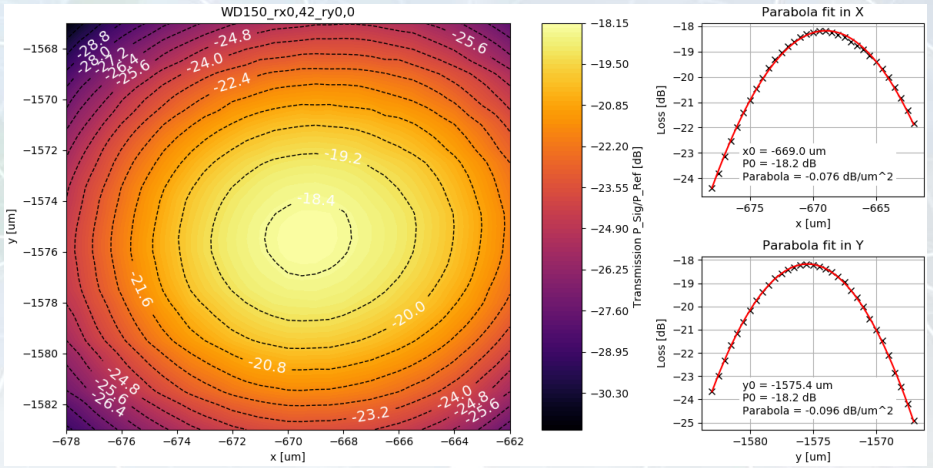
→ Working principle of probe card confirmed

Demonstration of Working Principle

Conformation of optical working principle under lab conditions

- Raster scans for different optical modules together with PIC
- Optical working distances (WD): typical 50 - 200µm
- Alignment sensitivity: ±1.25 µm @ -0.1dB and 150µm WD
- Setup insertion loss : ~-18dB to -24dB (incl. loss of optical module, over-illumination, DUT with GC and waveguide)



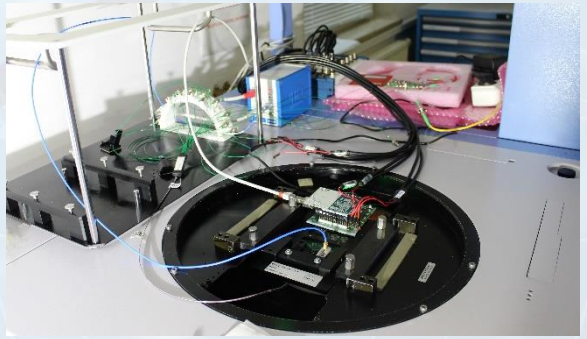


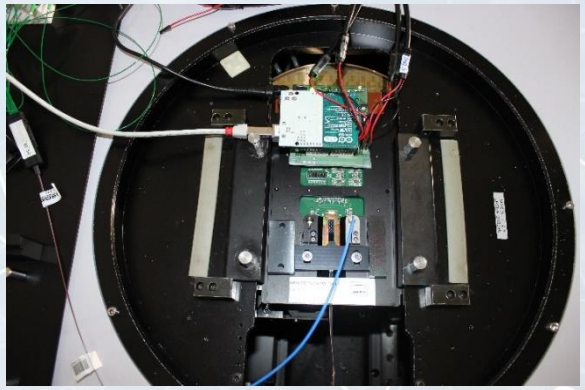
- Challenge:
  Alignment insensitivity, insertion loss and optical working distance are not independent parameters to optimize.
  → Find optimum for test case.

Prober compatibility

Conformation of optical working principle - fab conditions

- Initial wafer-level tests on an Accretech UF200R prober
  - Mechanical probe card interface
  - Communication with prober
  - Needle and probe card alignment
  - Optical test of PIC alignment channel



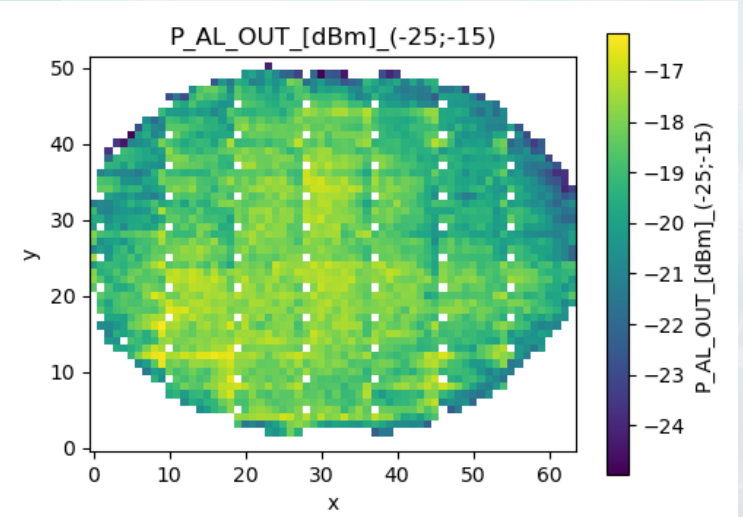


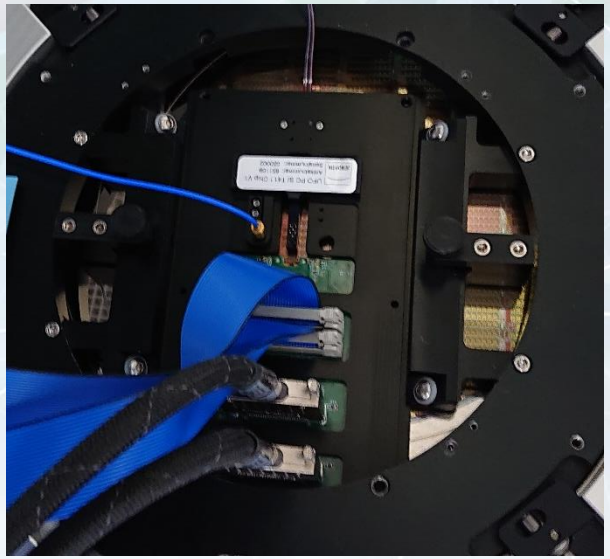
- Further tests on Accretech UF3000EX under test floor conditions
  - Online Cleaning successfully demonstrated
  - Probing stability and working distance
  - Alignment procedure and full test program

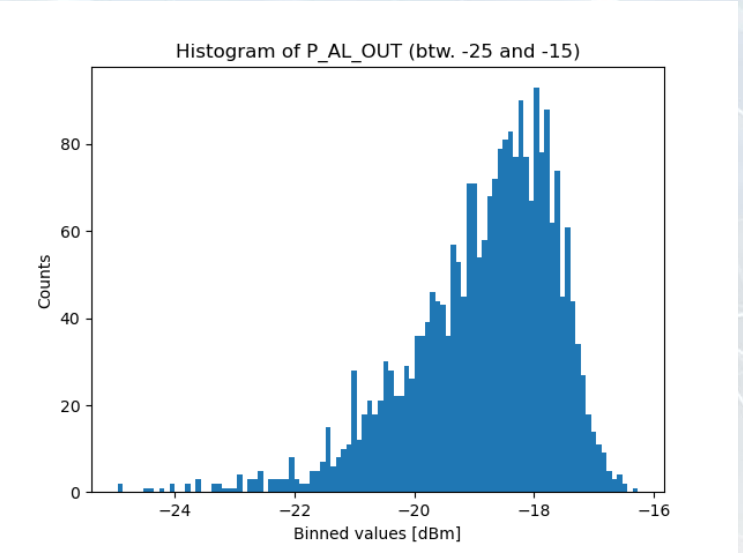
Device Wafer-level Test – Optical Alignment Channel

Wafer-level test of transceiver device

- Final production test
- RX, TX, alignment channel and comprehensive electrical tests in a single touch-down
- 1x alignment per wafer, no additional alignment per chip
- Example of wafer map for optical alignment channel

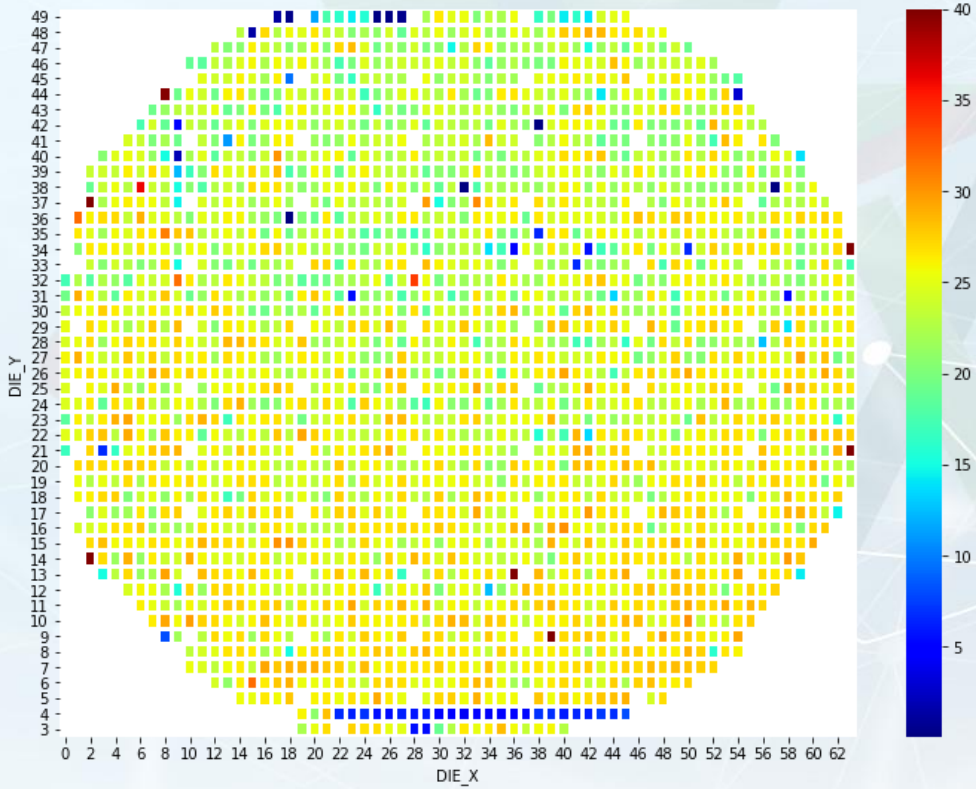


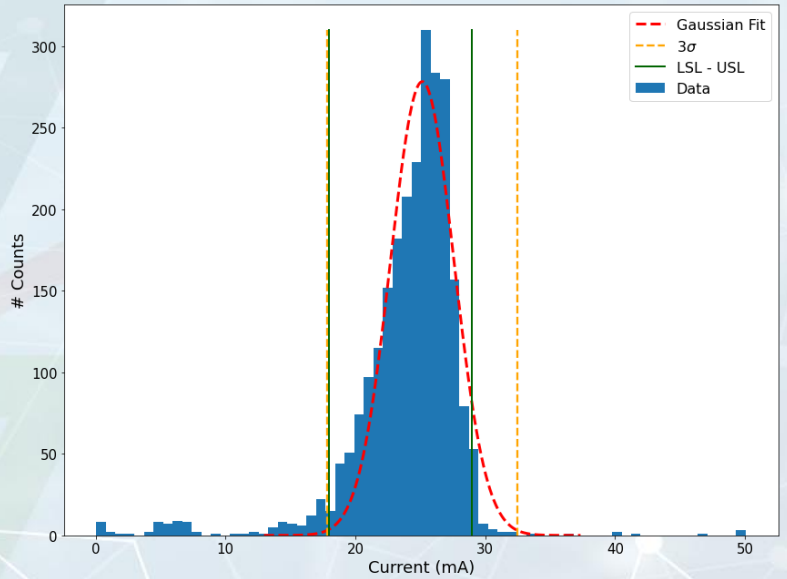


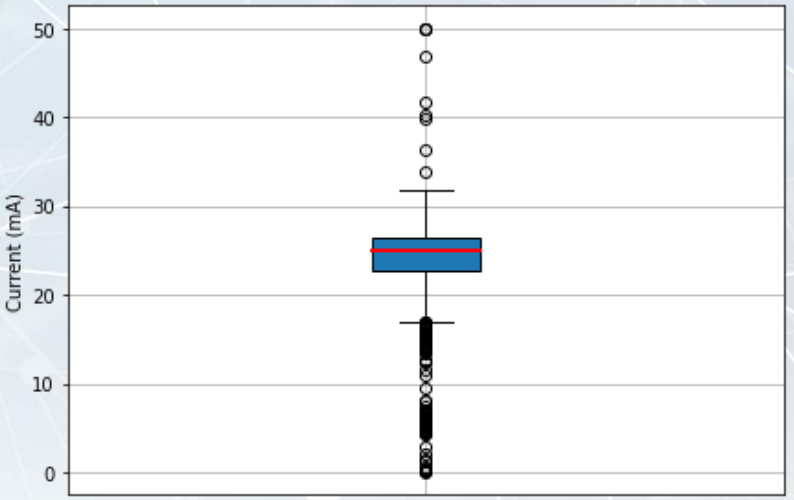


Device Wafer-level Test – Receiver input current

- Receiver supply current I_{VCCA}, VCCA = 2.5 V
- Current supply for RX input buffer, bandgap reference, RX CDR, RSSI detector, FSM Vtune

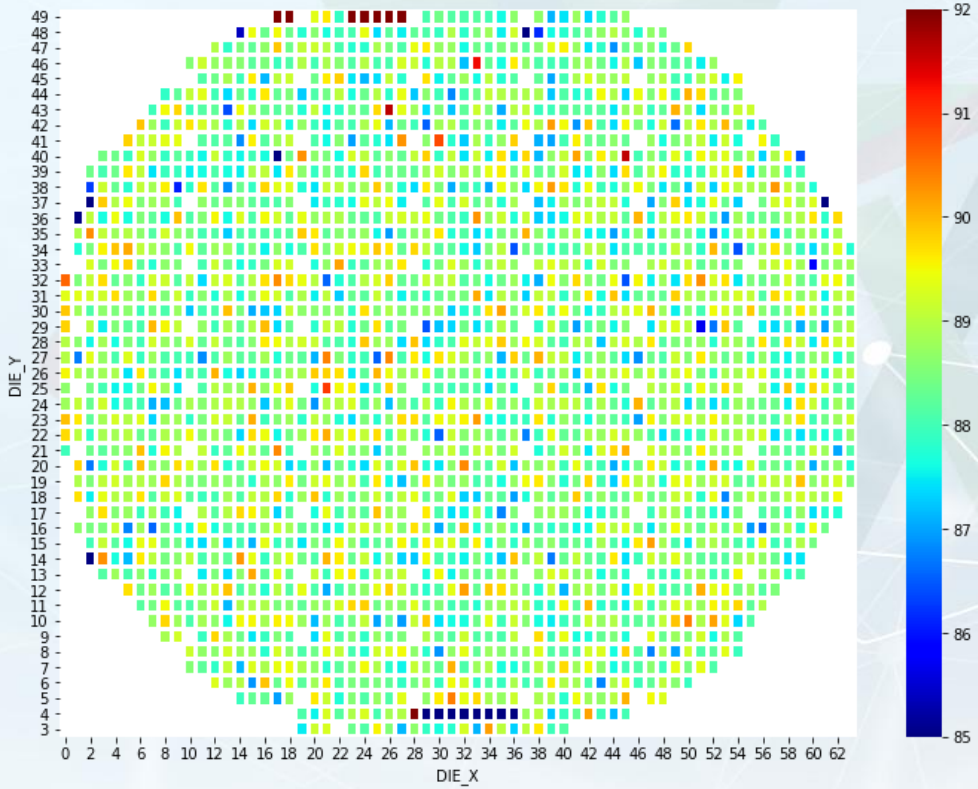


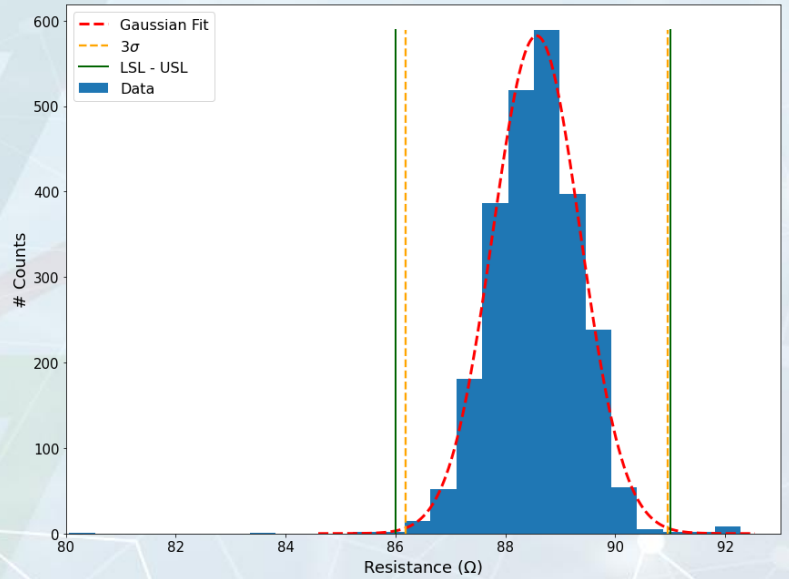


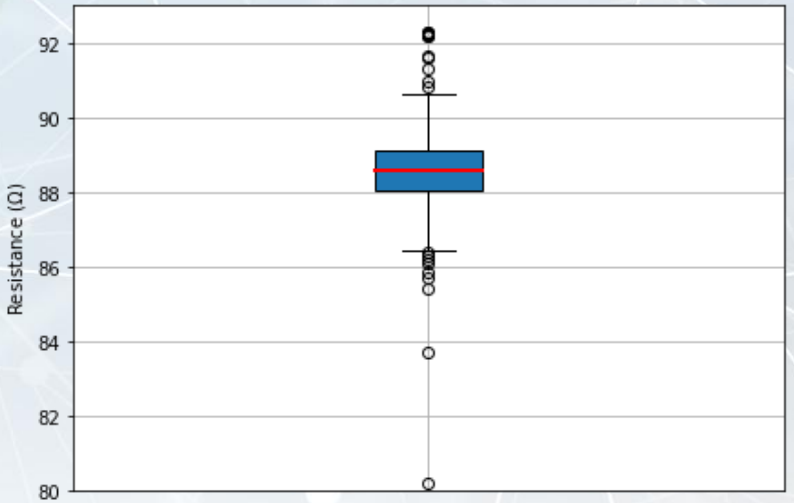


Device Wafer-level Test – Contact Resistance

- Contact Resistance

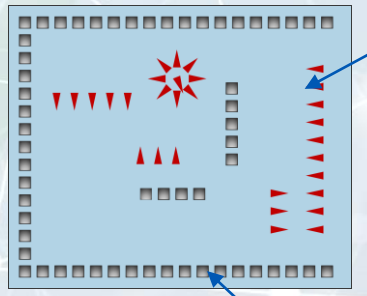






Conclusion & Outlook

- Realized a monolithic opto-electronical probe card for PIC measurement
- Proved working principle under lab and test floor conditions
- Showed compatibility with standard prober equipment
- Established final test for production runs
- Evaluation of insensitivity range vs. absolute loss ongoing
- Next steps:
  - Improvement of insensitivity range
  - Platform development for other needle types
  - RF capable probe card
- Outlook: probe cards for multi-DUT and high count optical I/O testing (switches)



Thank you for your attention!

Time for questions…