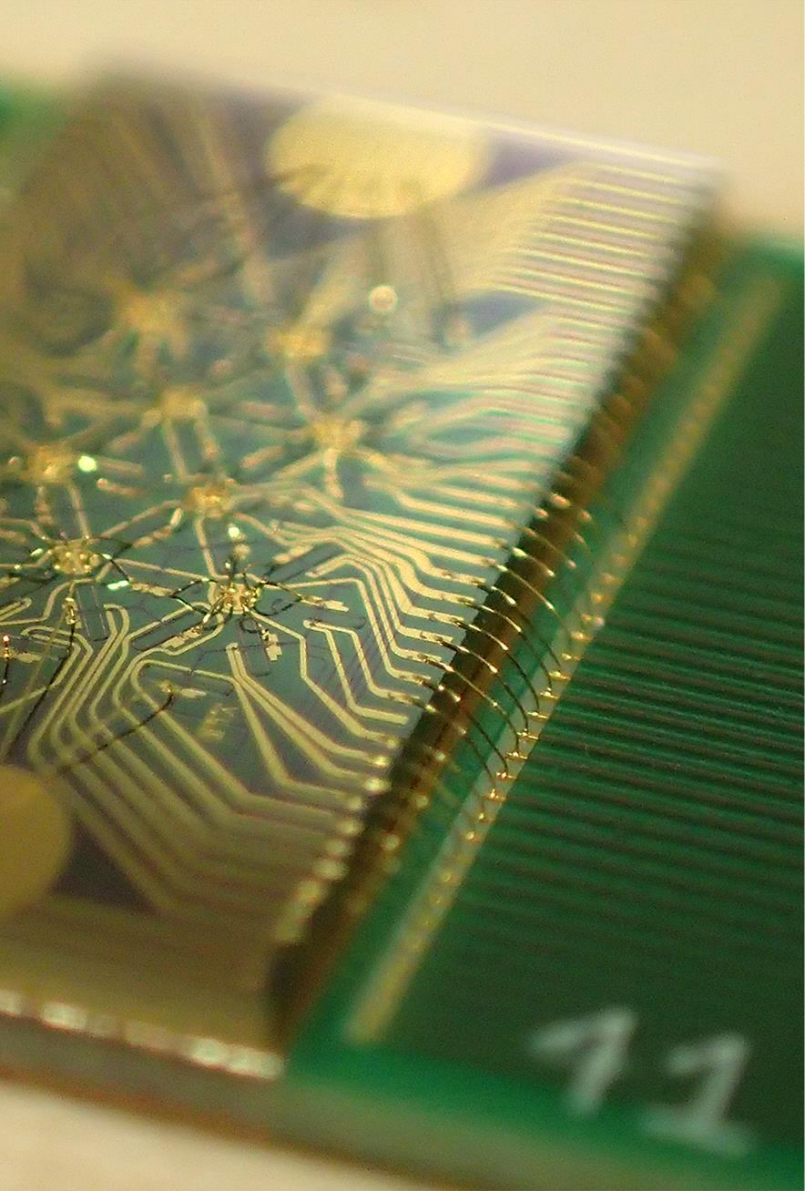


EUROPEAN PHOTONICS INDUSTRY CONSORTIUM

5th June 2023

EPIC Technology Meeting:
Photonic Integration and Packaging at Fraunhofer IZM

Scaling up the photonic testing back-end

HITACHI
Inspire the Next

VLC PHOTONICS
A Hitachi Group Company

About us

- VLC Photonics offers Photonic Integrated Circuit (PIC) engineering services, focused on design and testing.
- Company founded in 2011.
- Offices and clean-room labs in Valencia Technological Campus (Spain).
- 28 members of extensive academic and industrial experience, and keep hiring.
- Part of Hitachi High-Tech group since 2020.

About us (II)

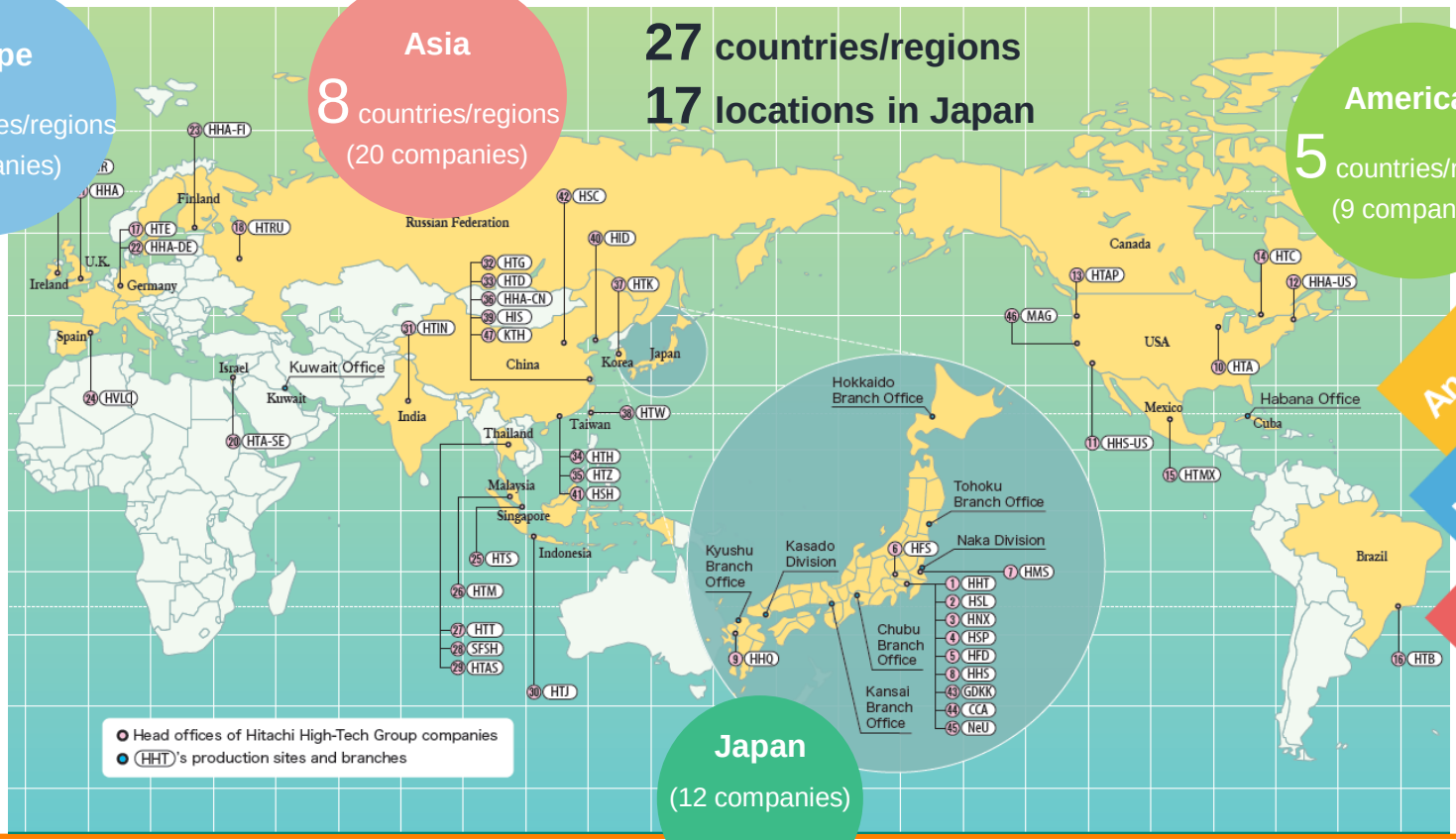
Hitachi High-Tech Corporation

Europe
11 countries/regions
(7 companies)

Asia
8 countries/regions
(20 companies)

27 countries/regions
17 locations in Japan

Americas
5 countries/regions
(9 companies)



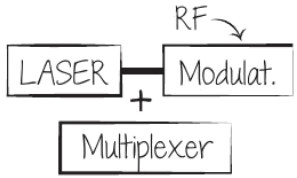
Japan
(12 companies)

Analytical & Medical Solutions
Nano-Technology Solutions
Industrial Solutions

VLC PHOTONICS
A Hitachi Group Company

Provision of PIC solutions

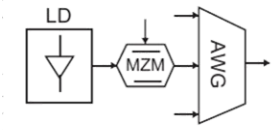
PIC development cycle



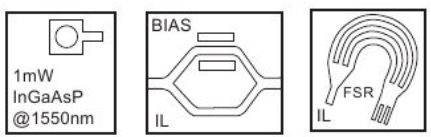
System concept

Photonic architecture

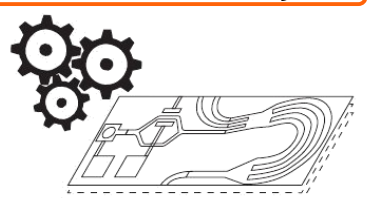
SOI
InP
SiN
PLC
Etc.

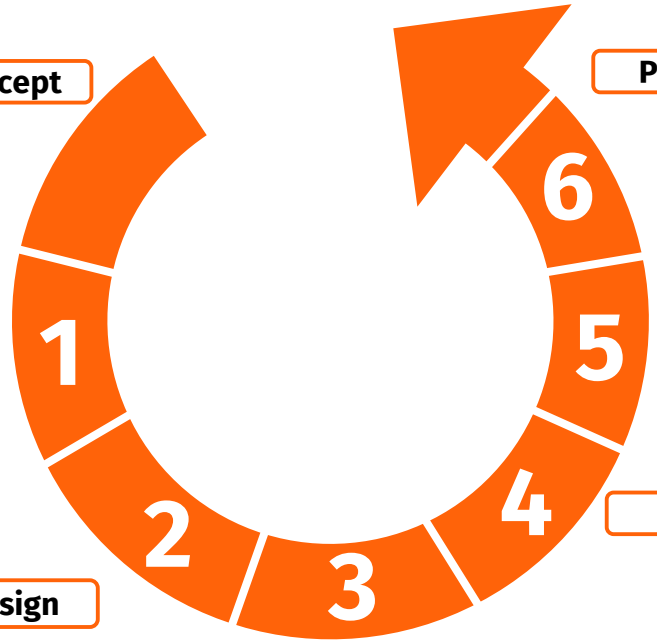


Component modeling and design

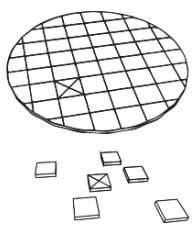


Circuit simulation and layout

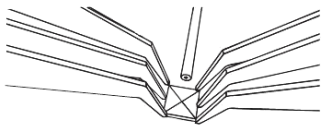




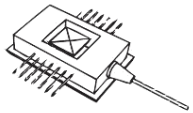
Manufacture



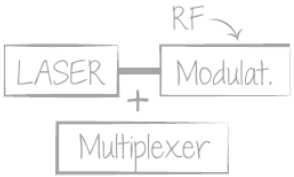
Chip/Wafer characterization



Packaging & Test

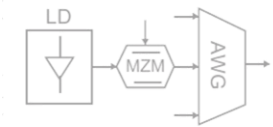


PIC development cycle

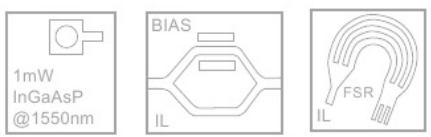


1. System concept
2. Photonic architecture

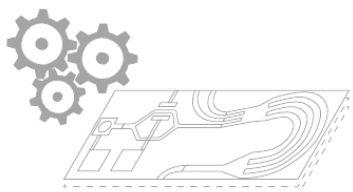
SOI
InP
SiN
PLC
Etc.



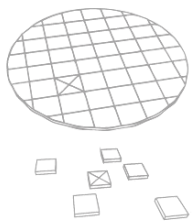
3. Component modeling and design



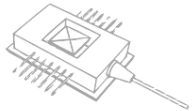
4. Circuit simulation and layout



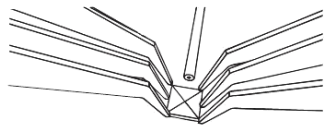
5. Manufacture



6. Packaging & Test

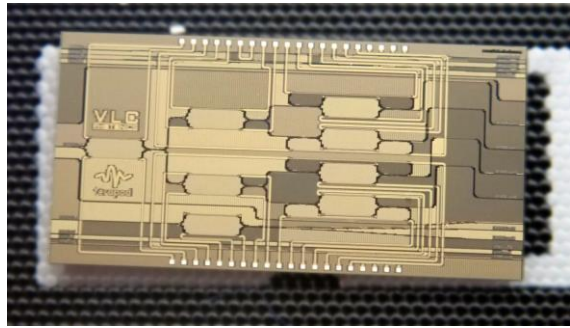


Chip/Wafer characterization



Characterization and test needs

- **It is still critical to do extensive component / circuit characterization when validating PIC designs in engineering.**
  - To validate fabrication process and its tolerances through sensitivity analysis (specially needed in photonics).
  - To confirm the intended layout functionality, and feedback the designs for statistical modelling.
  - To sort out known good dies (KGD) and provide feedback on foundry yield, for accelerating ramp up.



- **When moving to PIC volume production, scalability becomes an issue:**
  - Functional circuit testing is still required beyond fab metrology and PCM.
  - Need fast and low cost Wafer/KGD sorting/binning before packaging.
  - Significant CAPEX for parallelization, engineering and setup time required.

Characterization & Testing facilities

Two clean room labs (ISO class 6 and 8) with:

- Optical microscopes & SEM for detailed visual inspection
- Optical (vertical and edge light coupling) and electrical probing:
  - 5 semi-automated bare die characterization setups
  - 1 manual electrical wafer tester
  - 2 fully automated opto-electronic wafer testers
- Electrical measurement instrumentation for DC and RF signal testing up to 110 GHz and optical equipment to work from visible (400 nm) to mid-IR (up to 5 µm).
- Test assembly:
  - 1 manual & 1 automated wire-bonder
  - 1 flip-chip tool

Automatic Testing at VLC Photonics I

DEVICES

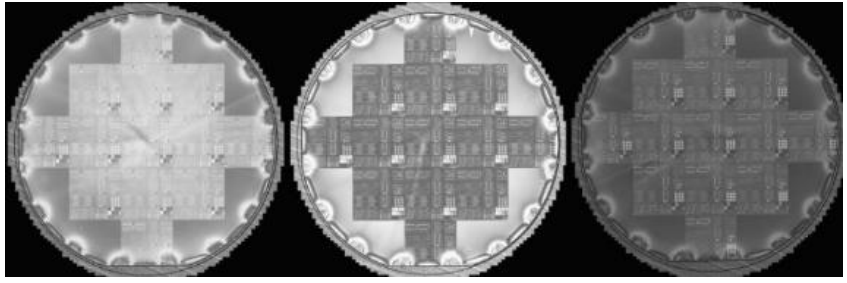
Our Wafer Level Testers are adapted to work with:

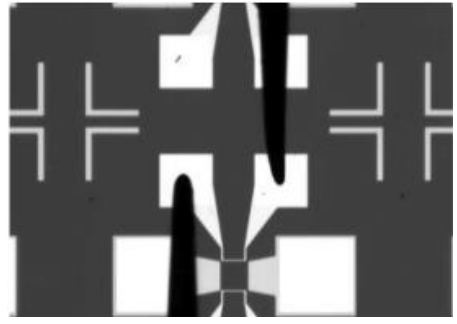
- Wafers, up to 12 inches.
- Bars, up to 12 inches.
- Diced chips (from 1mm x 1mm above).

ELECTRICAL PROBING

We have capabilities to do electrical testing from all 4 sides of the chip.

- DC Probing
  - Single needle.
  - MCM (Multi Contact Needles). Std. pitch: 100um, 150um and 250um.
- RF Probing
  - GSG. Std. pitch: 60um.
  - Up to 110GHz measurements.

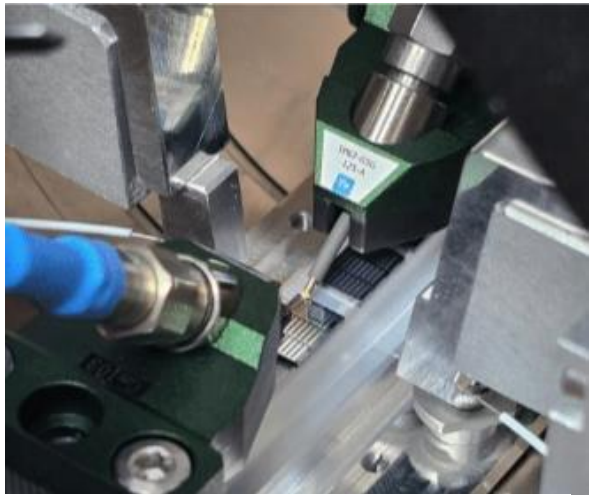




Automatic Testing at VLC Photonics II

OPTICAL PROBING

We have capabilities to do optical testing from **West** and **East** sides of the chip. North and South stages just can be used for electrical probing.

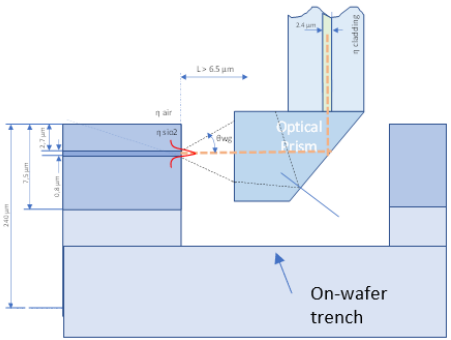


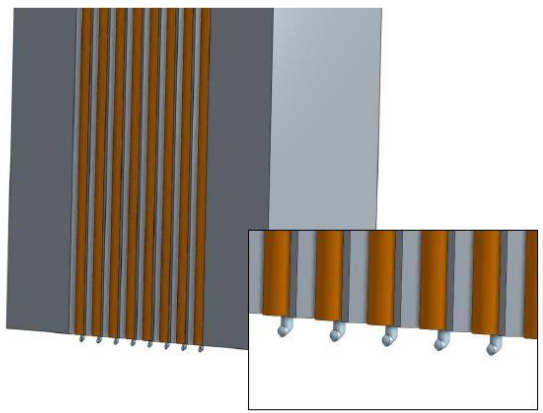
Vertical coupling (All types of devices)

- Cleaved fibers
- Fiber Arrays (FA)
- Leadless Fiber (Leadless FA)
- With or without Anti Reflection Coating (ARC)
- With automatic polarization control.

Edge coupling (Bars and Diced chips)

- Cleaved fibers & Lensed Fibers
- Fiber Arrays (FA)
- Fiber Arrays with lensed fibers (Lensed FA)
- With or without Anti Reflection Coating (ARC)
- With automatic polarization control.





Extra: Edge coupling with periscopes

- For non-diced wafers with trenches.

Automatic Testing at VLC Photonics II

OPTICAL PROBING

We have capabilities to do optical testing from **West** and **East** sides of the chip.

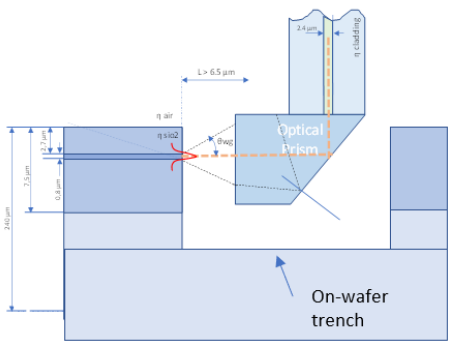
- We are open to evaluate all kinds of projects.
- We did even adapted our WLTs to use **integrated lasers** as optical probes.

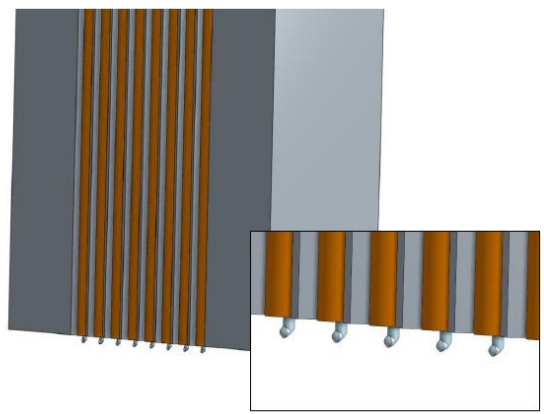
Vertical coupling (All types of devices)

- Cleaved fibers
- Fiber Arrays (FA)
- Leadless Fiber (Leadless FA)
- With or without Anti Reflection Coating (ARC)
- With automatic polarization control.

Edge coupling

- Cleaved fibers & Lensed Fibers
- Fiber Arrays (FA)
- Fiber Arrays with lensed fibers (Lensed FA)
- With automatic polarization control.





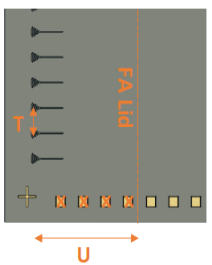
Extra: Edge coupling with periscopes

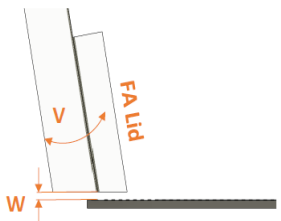
- For non-diced wafers with trenches.

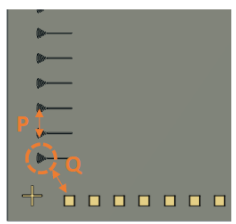
Testing guidelines and ADKs

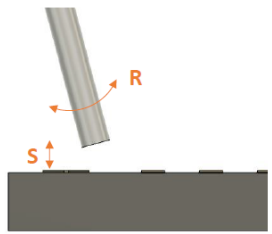
- **Testing layout guidelines.**
  We gathered all the specs to be required by the chip design to be tested in a PDF manual.
  Feel free to ask for it.

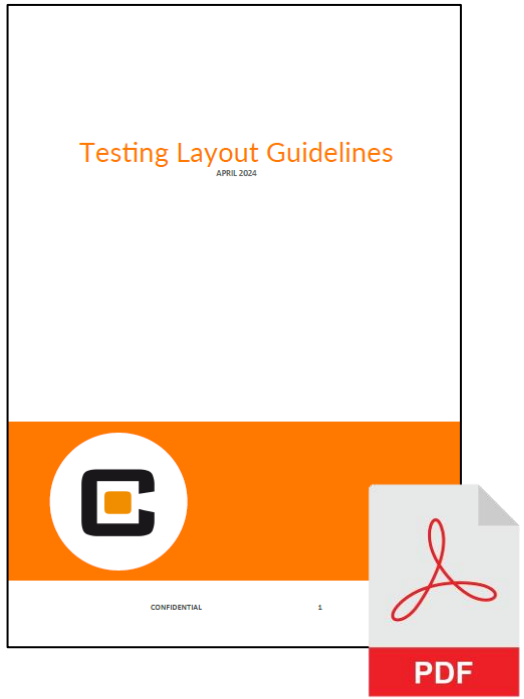
- **Assembly Design Kits (ADKs)**
  Available for some foundries and EDA software frameworks.
  Compatible with test and packaging requirements.











Parameter	Minimum requirement	Recommended
T: Optical ports pitch	127µm / 250 µm	127µm / 250 µm
U: Optical ports clearance area	1250 µm (for standard FA)	1500 µm
V: Optical ports vertical coupling angle	7° to 13°	10°
W: Vertical safety distance	30 um	

Parameter	Minimum requirement	Recommended
P: Optical ports pitch	50 µm	127µm / 250 µm
Q: Optical ports clearance area	50 µm	250 µm
R: Optical ports vertical coupling angle	7° to 13°	10°
S: Vertical safety distance	30 um	

High-speed is key

Examples of previous projects:

DUT	Structures	Measurements
Six 6” wafers, >300 dies	>5k	~50k
Two 8” wafers, >1800 dies	>14.5k	~58k
>50 dies	>140	>31k

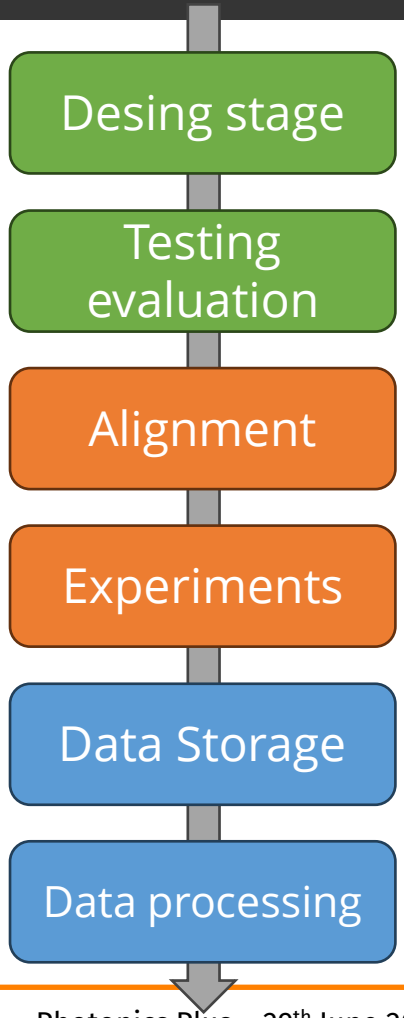
Example times

Probing time: 4 s
Measurement time: 1 s
measurements: 50k

TOTAL TIME = ~3 days

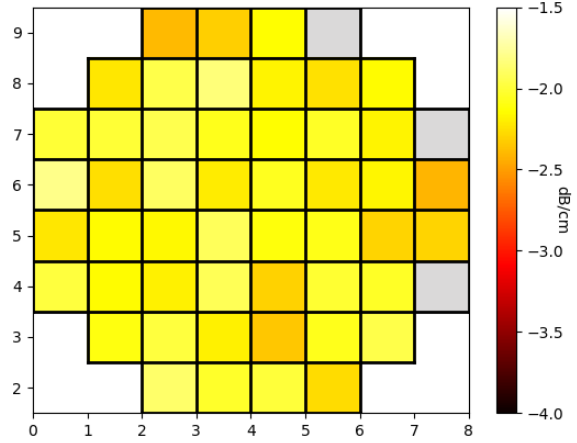
- Fast probing and trace acquisition times are essential when scaling up.
- Smart characterization plan and execution is a must for insightful but time-practical test campaign.
- We developed a tool to estimate the testing times considering the different types of probing we offer and the different experiments we have in our portfolio.

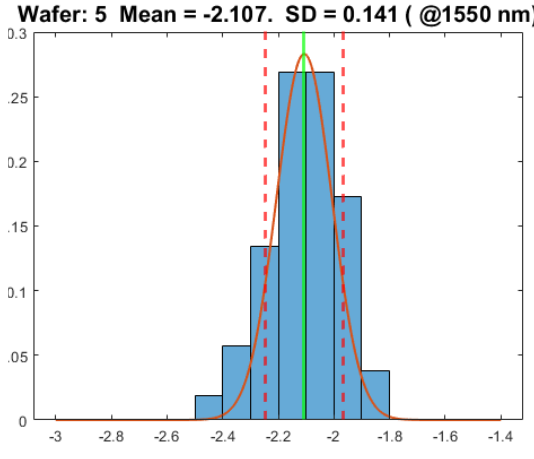
VLC Testing environment

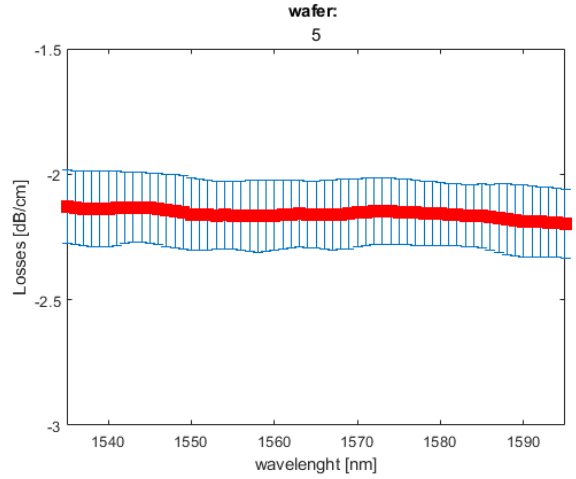


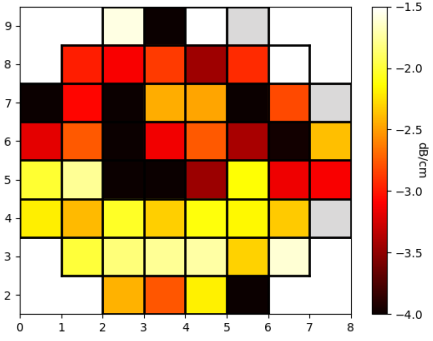
- Different software's are used.
- We automatically extract **ports names** and their **coordinates**.
- We create **tables** with the structures to test, their ports and the experiments to run in each probing position.
- Coordinates are imported into **Ficontec PCM** software and probes moved to position.
- Once in position we run the selected experiments using our **python libraries** to control the instruments.
- Data gathered is both saved in the **VLC's database** and as **CSV files**.
- Finally, we used python to gather the data back from the database and **auto-process** the results.

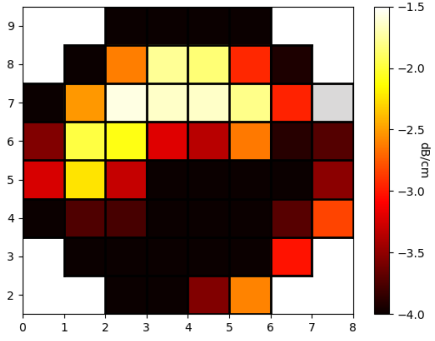
Process control and yield analysis

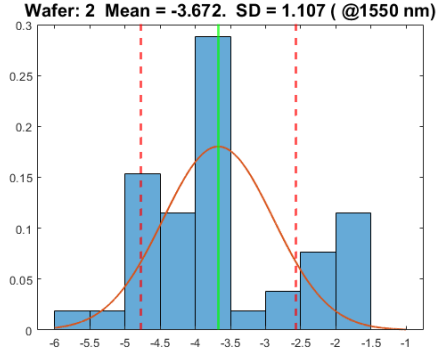


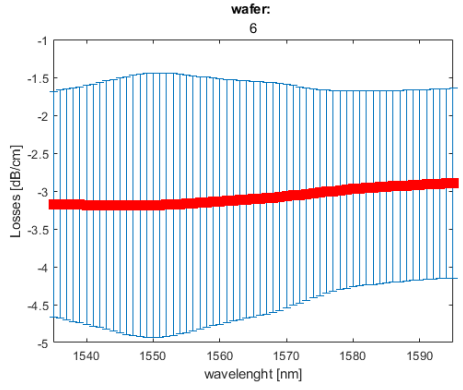






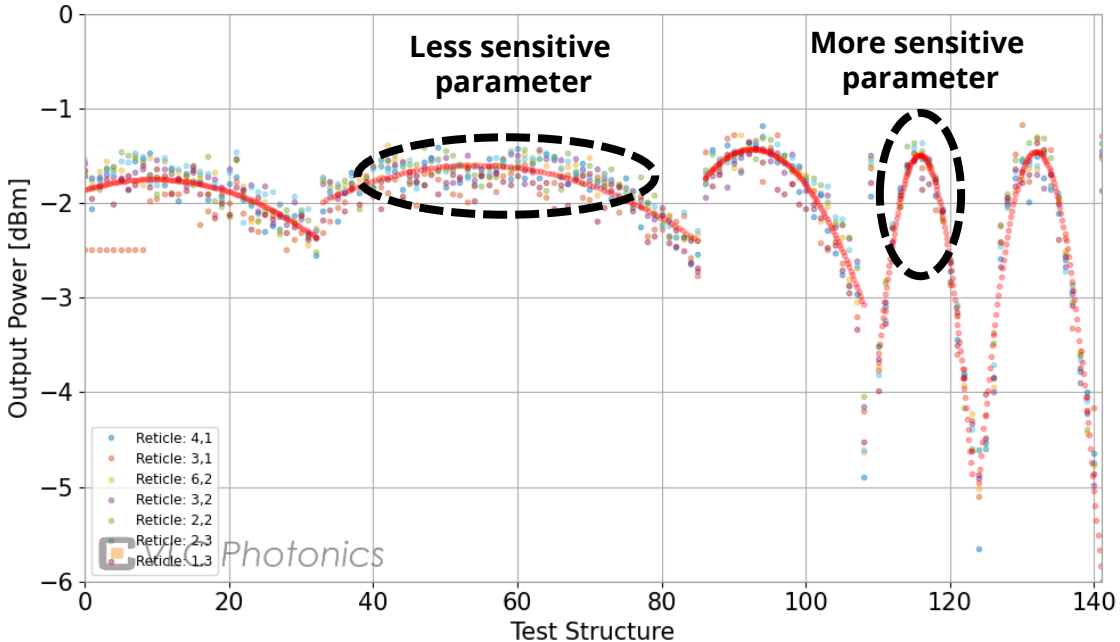






Component sensitivity analysis

Example of design parameters sweep over 140 test structures in 7 reticles



- Repeatability of bare die measurements with manual alignment is poor (>0.5 dB).
- WLT ensures that alignment and trace acquisition are done automatically with minimal variations (mechanical, thermal etc.)

RF testing key for next-gen datacom PICs

- **Lightwave Component Analysers (LCA's) for parametric testing of devices like high speed modulators in transceivers.**
  - Up to 110 GHz turn-key test system for optical RX and TX
  - Suitable for die and wafer level testing
  - Return to zero and nonreturn-to-zero (RZ / NRZ) and pulse amplitude modulation (PAM) formats
  - S-parameter testing over the full 1260 nm to 1620 nm range

Thank you for your attention!

VLC PHOTONICS
A Hitachi Group Company

Contact details

info@vlcphotonics.com

www.vlcphotonics.com

@vlcphotonics

linkedin.com/company/vlc-photonics