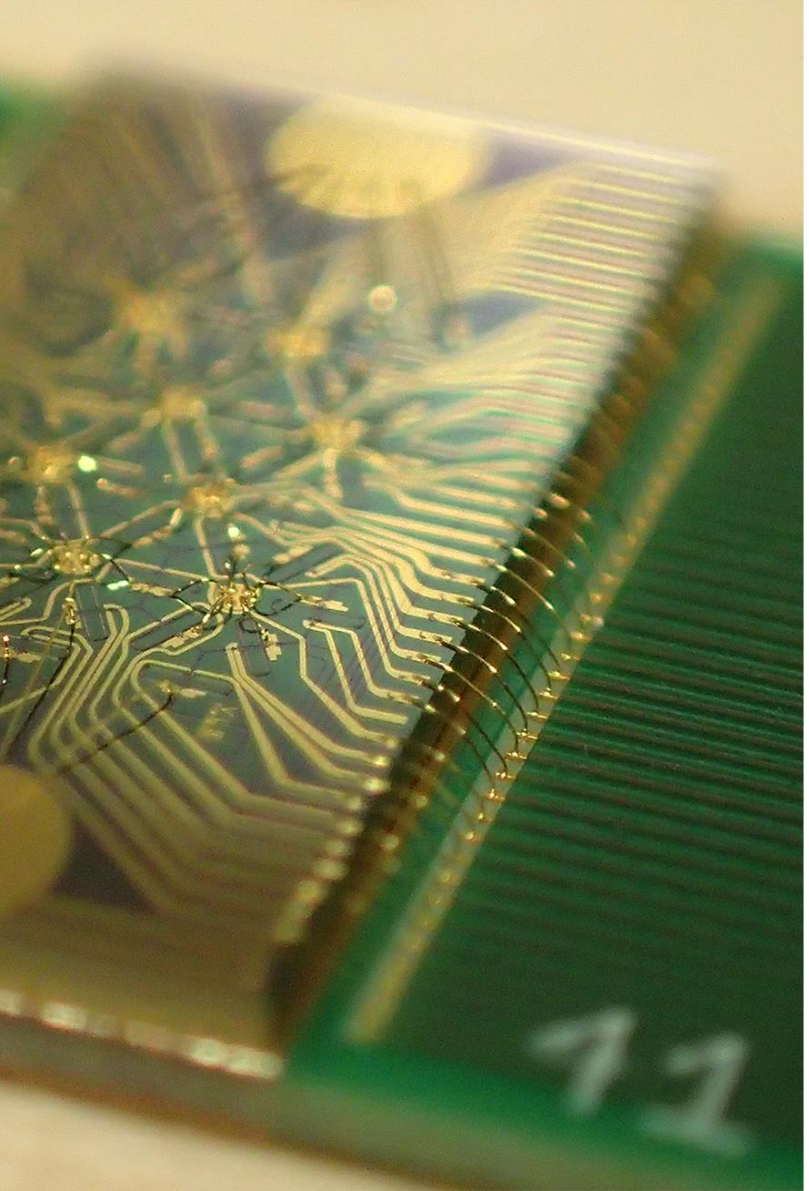

07 September 2022

Productizing a PIC: from Design IP to Scalable Testing

VLC PHOTONICS
A Hitachi Group Company

About us

- VLC Photonics offers Photonic Integrated Circuit (PIC) development services, focused on design and testing.
- Company founded in 2011.
- Offices and clean-room labs in Valencia Technological Campus (Spain).
- 21 members of extensive academic and industrial experience, and keep growing.
- 13+ years in the field of integrated optics and Photonics.
- Part of Hitachi High-Tech group since 2020.

About us (II)

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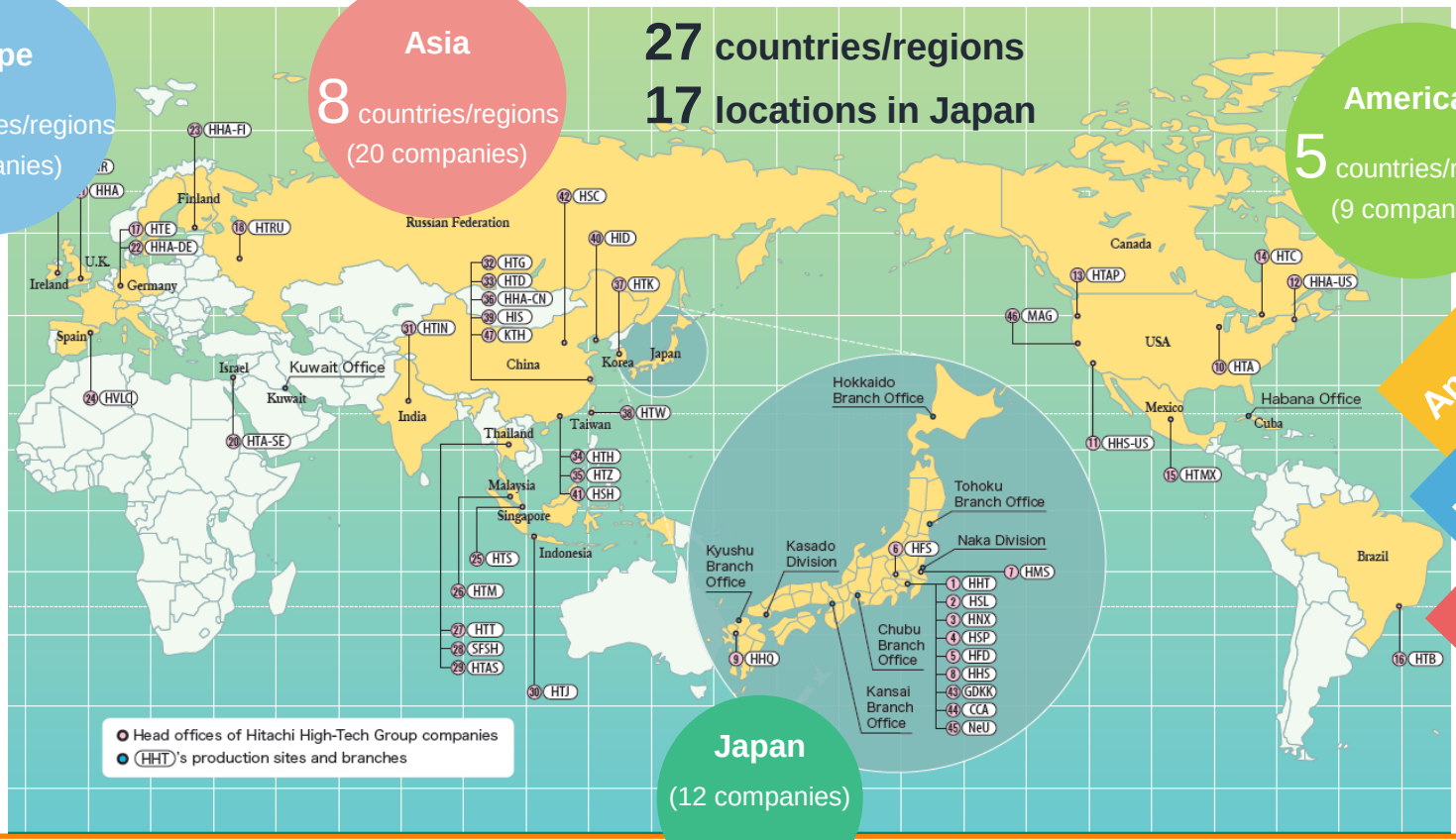
Hitachi High-Tech Corporation

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

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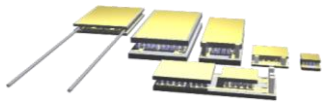
PIC provider
Industrial Solutions
complementing the
solutions and
services of HHT

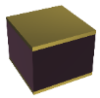
HHT optical components supply

Optical Lens

Thermo Electric Cooler



Thermistor



Ceramic Package

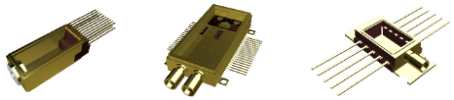
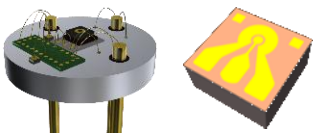
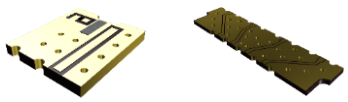


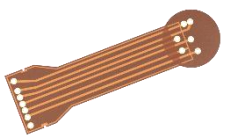
Photo Diode



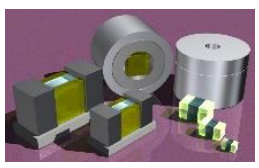
Ceramic Submount

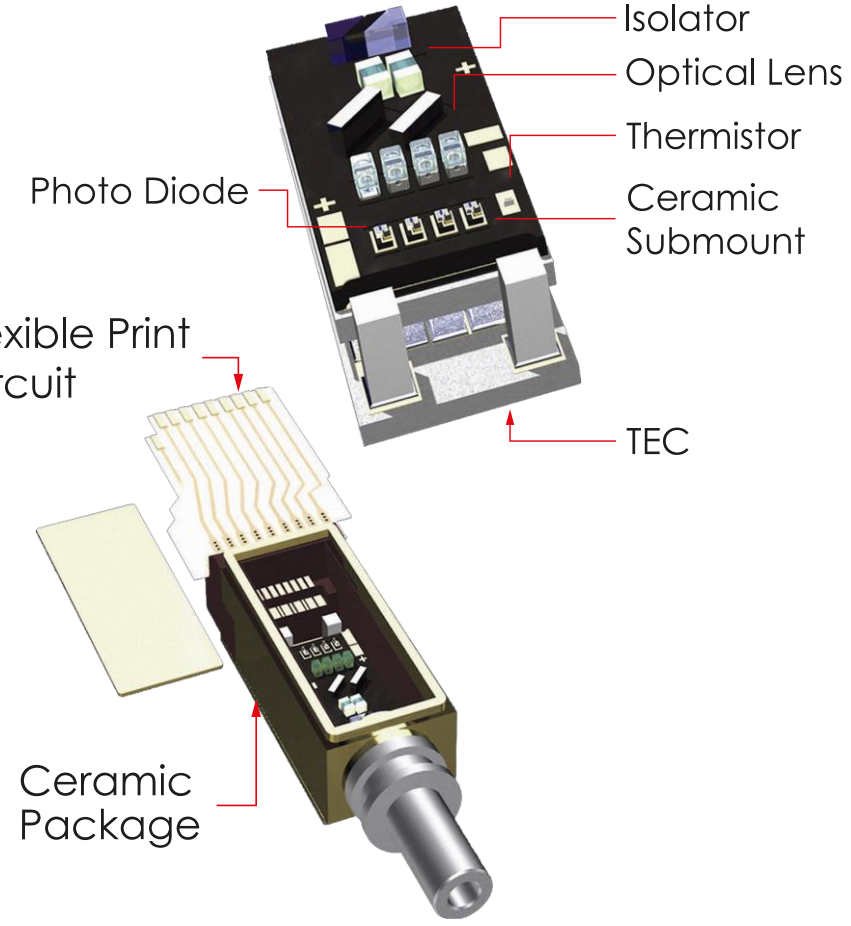


Flexible Print Circuit



Isolator





Our solutions

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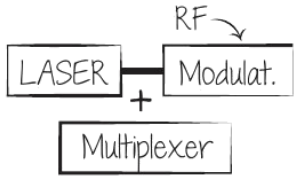
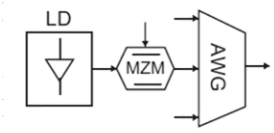


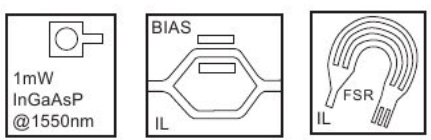
System concept

Photonic architecture

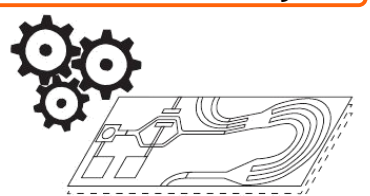
SOI
InP
SiN
PLC
Etc.



Component modeling and design



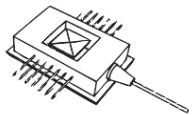
Circuit simulation and layout



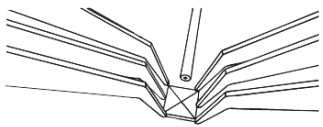
10 years of PIC development services!

1 2 3 4 5 6

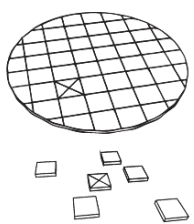
Packaging & Test



Chip/Wafer characterization



Manufacture



ISO 9001:2015

Semiconductor Design IP

- **It helps to speed up chip development and lower risk and cost, by licensing validated designs that can be embedded into more complex circuits.**

- **Semiconductor design IP has been well stablished in the last two decades:**
  - +3.6B$ market in 2018
  - Fabless companies
  - ARM (45%) and Synopsys (17%) dominate market share
  - Most of it is digital electronics design

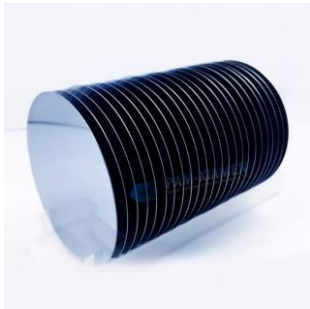
- **Main categories are:**
  - Processor: CPU, DSP and GPU
  - Interface: protocol-based function like USB, PCI Express, Ethernet, MIPI, SATA, DP, but also Die-to-Die (D2D) interface and memory controller.
  - Other Physical: SRAM and other memory compiler, physical library, Analog & Mixed-Signal, Wireless Interface, etc…

Differences with photonic design IP

- **Wafer fabs:**
  - Electronic foundry landscape dominated by 5 main players: TSMC, UMC, SMIC, Samsung, GF. Well stablished IP ecosystem and framework.
  - Photonics foundries are less and smaller. No IP licensing framework.

- **Cost of design IP validation:**
  - >250M wafers/year in electronics, very high yields.
  - Lot's of R&D, NRE and legal expenses required in photonics compared to the possible market, given the lower TRL.

- **Market demand:**
  - Global electronics market is several orders of magnitude larger than photonics one.
  - Most of the photonic product developments are being done by start-ups now.



Current photonic design IP status

- **Most of the players have developed a full fab process, or custom module on top of a generic foundry process.**
  - Not so fabless anymore, significant CAPEX tied to a fab (~IDM's)
  - Differentiation not in design but in front-end/back-end
  - Usually offer optical engines = validated PICs
  - No open access libraries or PDKs

- **Lack of standards:**
  - Many new emerging applications: quantum, LIDAR, AI, AR…
  - Design IP is still very customized, limiting its potential customer base
  - Risk of development obsolescence in a quickly evolving field

- **Lots of interesting patented or published designs by academics or small start-ups lack real-world applicability.**

- **Validation for a guaranteed commercial offering still very challenging.**

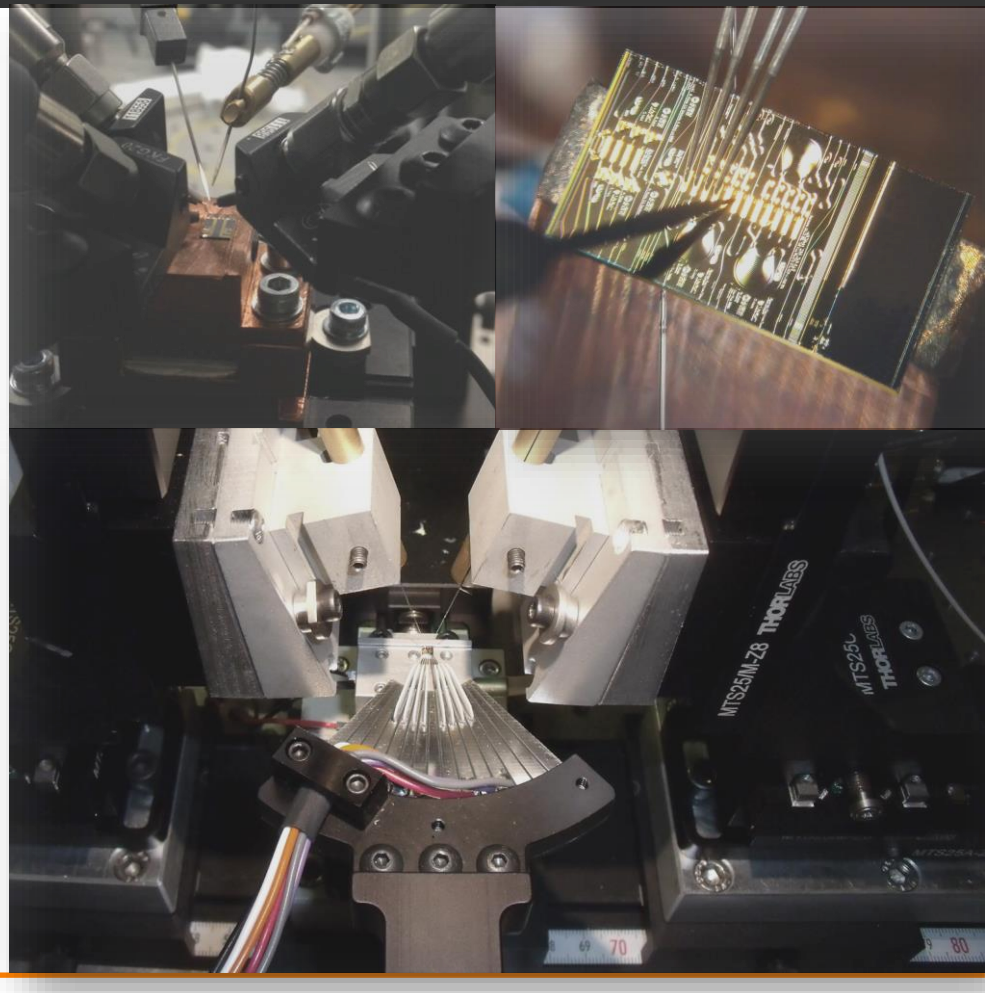
Back-end needs for PIC validation

- **It is still critical to do extensive component / circuit characterization when validating PIC designs towards production.**
  - Optical alignment
  - Opto-electronic measurement
  - Processing and Root cause analysis

- **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 and packaging
  - Parallelization is hard, significant CAPEX and setup time required

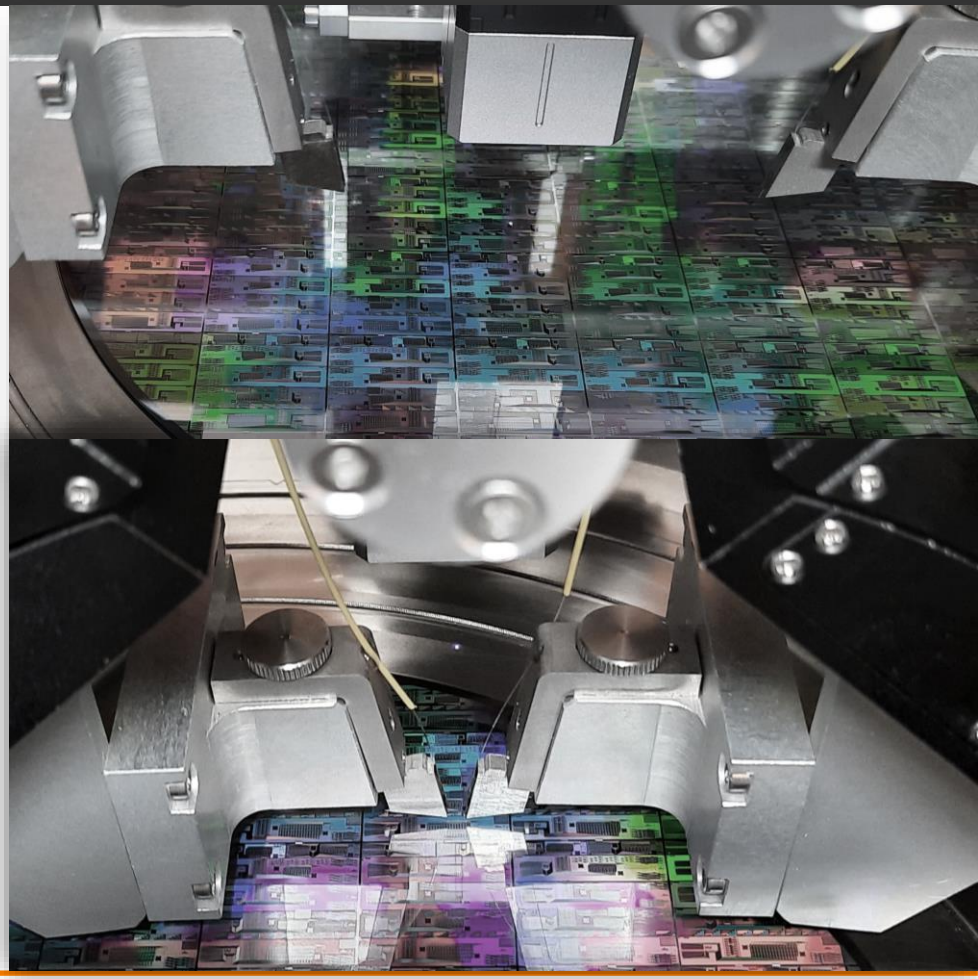
Advantages of outsourcing the photonic back-end

- **Infrastructure investment:**
  - Cleanroom lab
  - Opto-electronic probing stations
  - High-end instrumentation
  - Consumable stocking
  - Redundancy for non-stop operations
- **Engineering expertise:**
  - Automation
  - Photonics
  - Big data processing and analysis
  - Quality certifications & calibrations
- **Timing:**
  - Procurement
  - Installation and configuration
  - Hiring and training



Focus on characterization & test

- Close design loop from fabricated to measured devices with big data, allowing for statistical parameter modelling.
- Provide feedback to customers & foundries for process yield improvement, to accelerate product development and volume ramp up.
- Automate identification of KGD to sort dies/wafers in production, and towards packaging.



Automated Wafer-level Photonic tester

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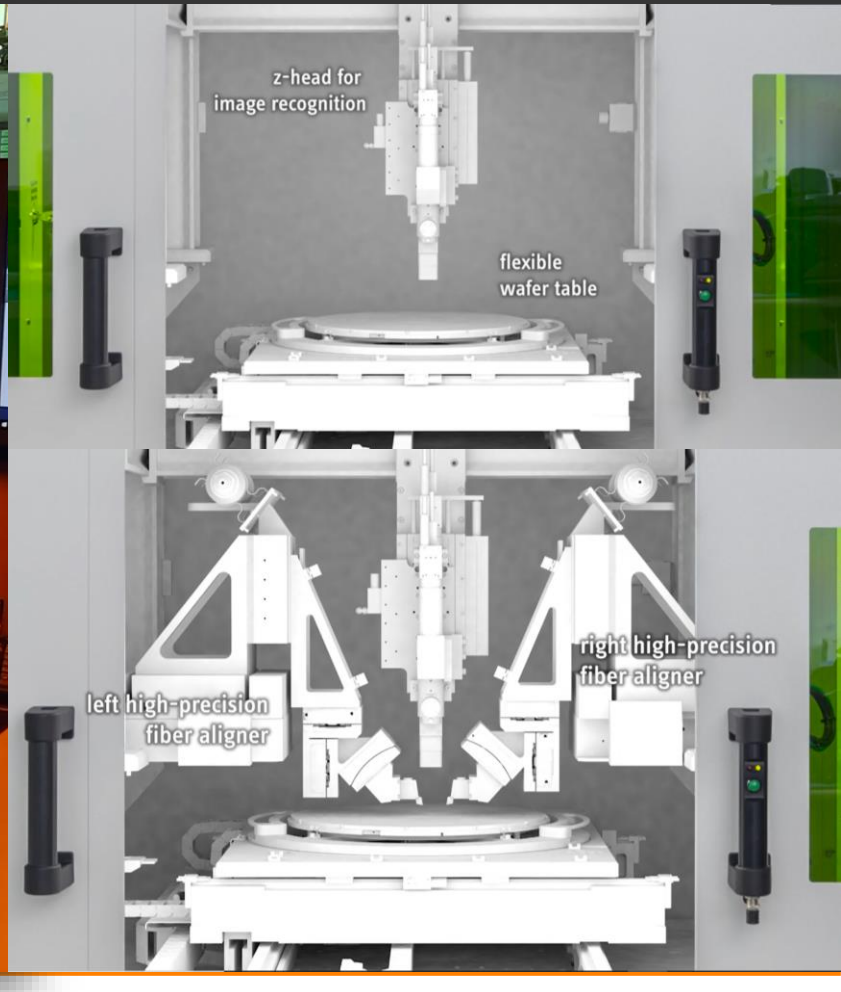
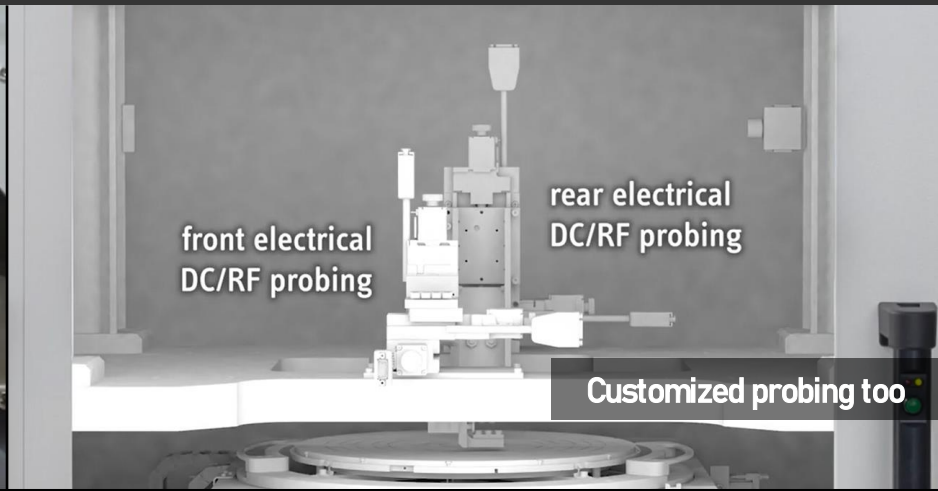
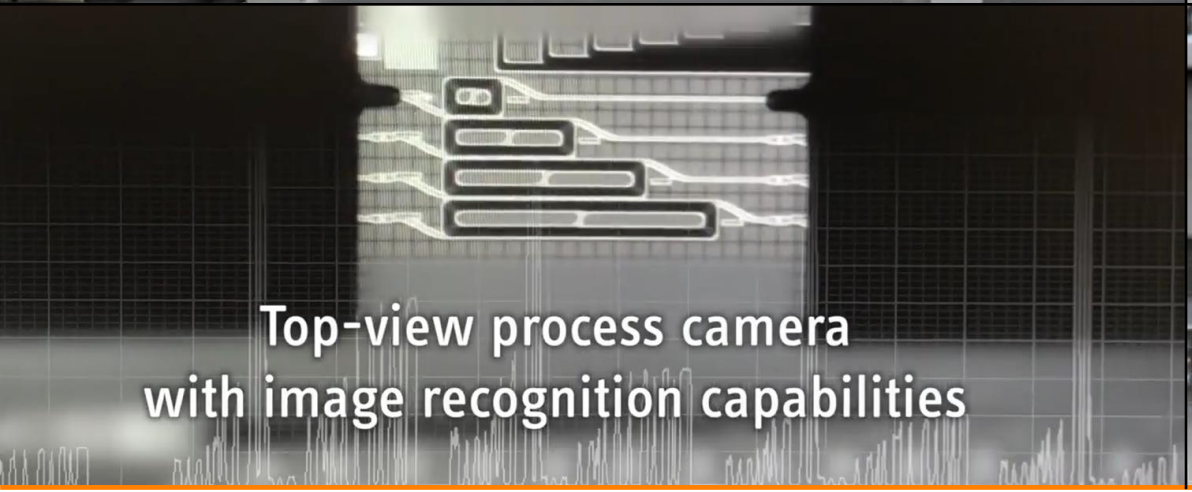
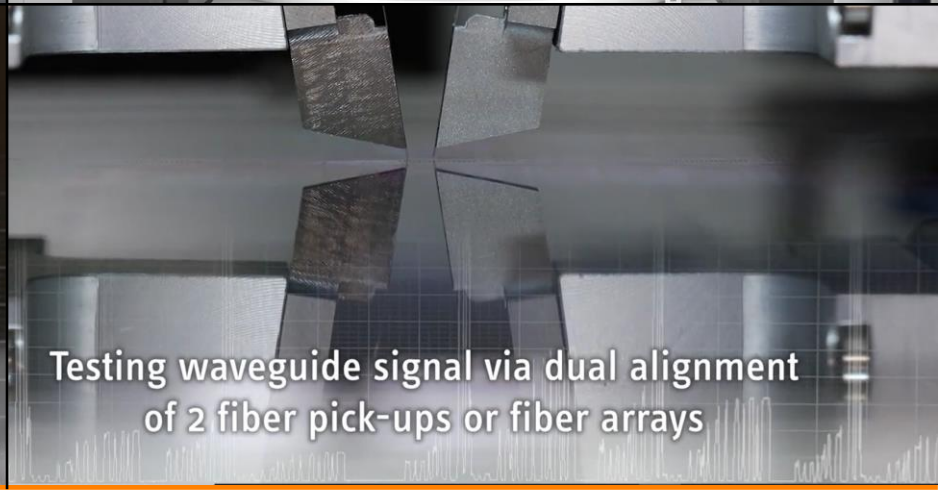
Full production enclosure wafer-level tester



Automated Wafer-level Photonic tester







Automated Wafer-level Photonic tester

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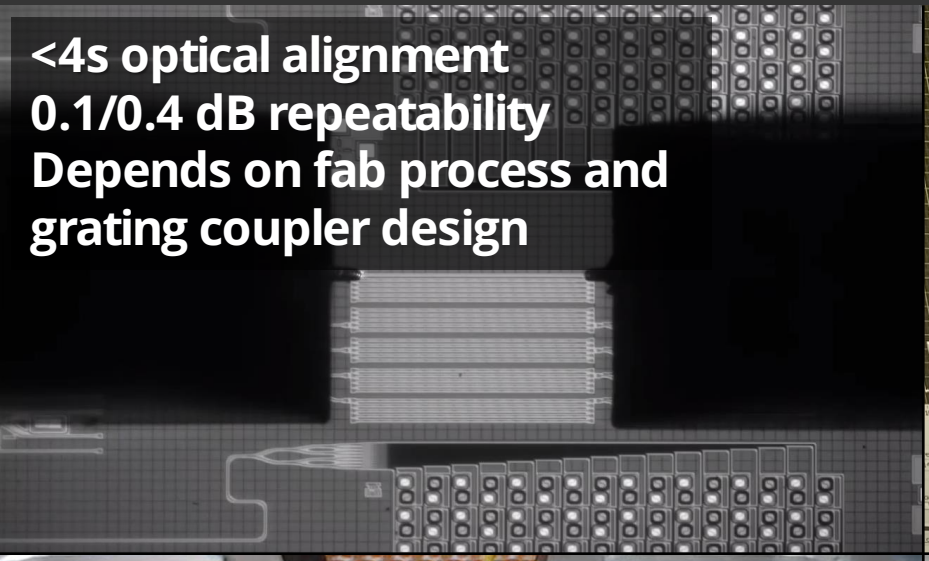
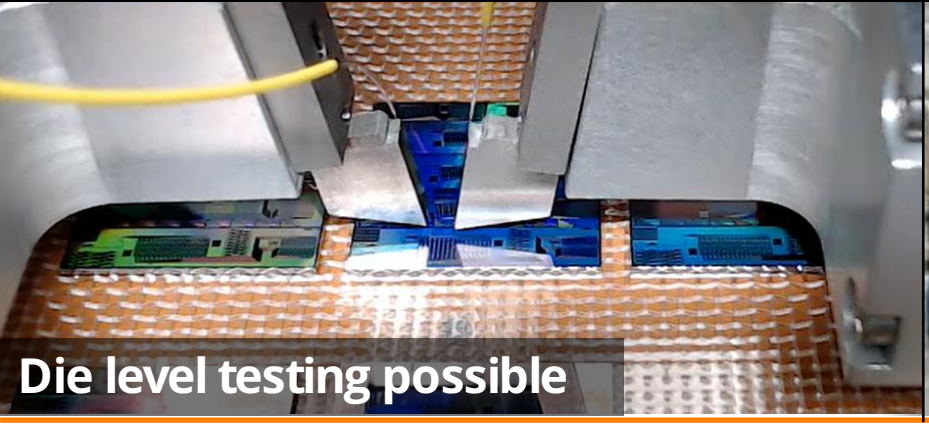
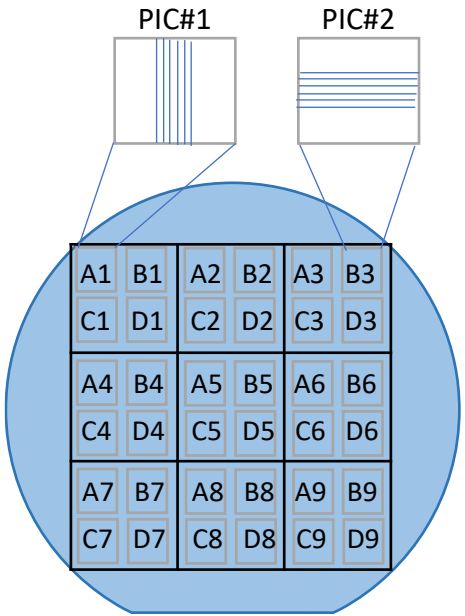


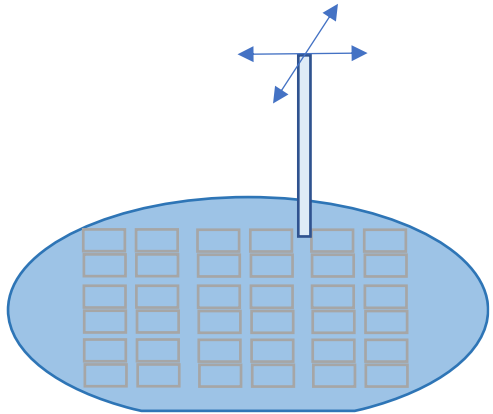


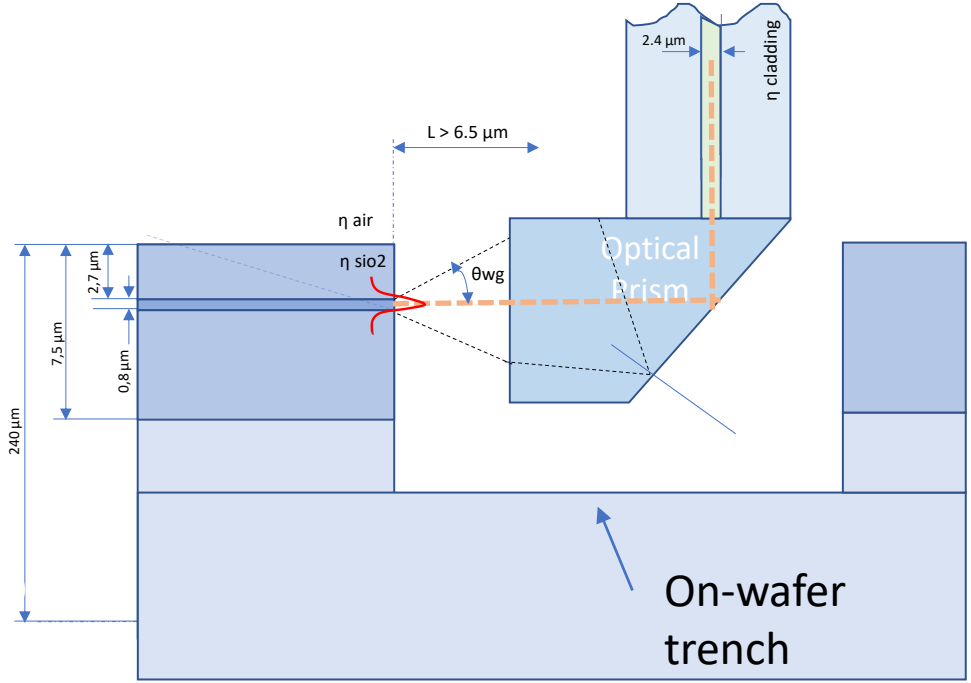
Edge coupling WLT

- Tool adapted for optical edge coupling via deep-etch wafer trenches.

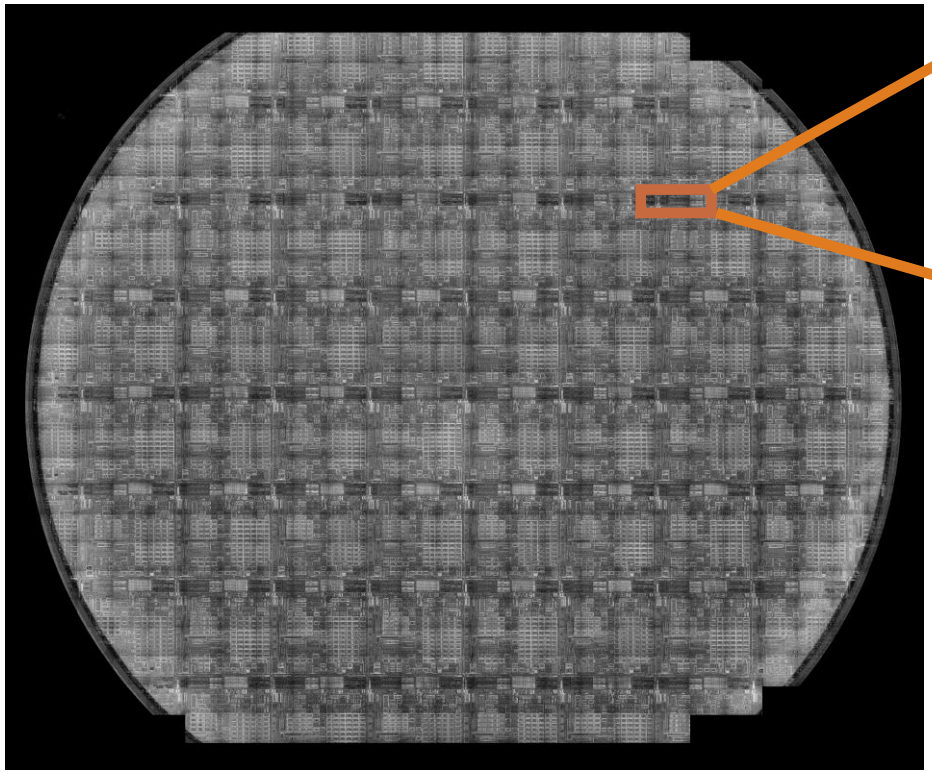


Wafer

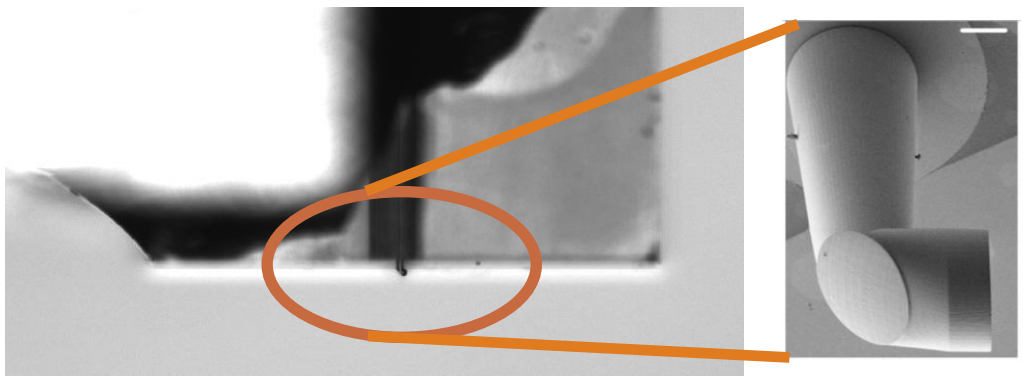

Test on wafer with a fiber



Edge coupling WLT (II)



V-groove trenches



3D printed micro-lens

MFD 2.3-10.4 µm

Speed and Repeatability are 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

- Fast probing and trace acquisition times are essential when scaling up.
- Smart characterization plan needed for insightful but time-practical test campaign.

Speed and Repeatability are key

Examples of previous projects:

DUT	Structures	Measurements
Six 6” wafers, >300 dies	>5k	~50k
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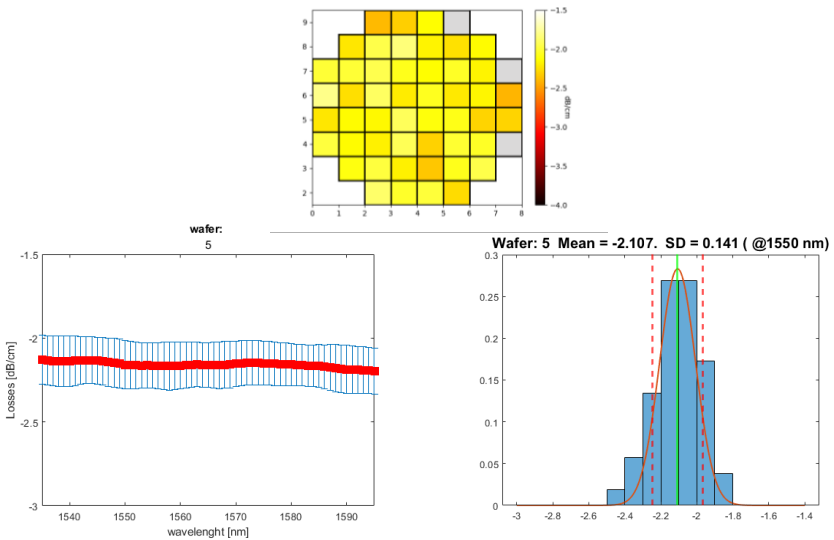
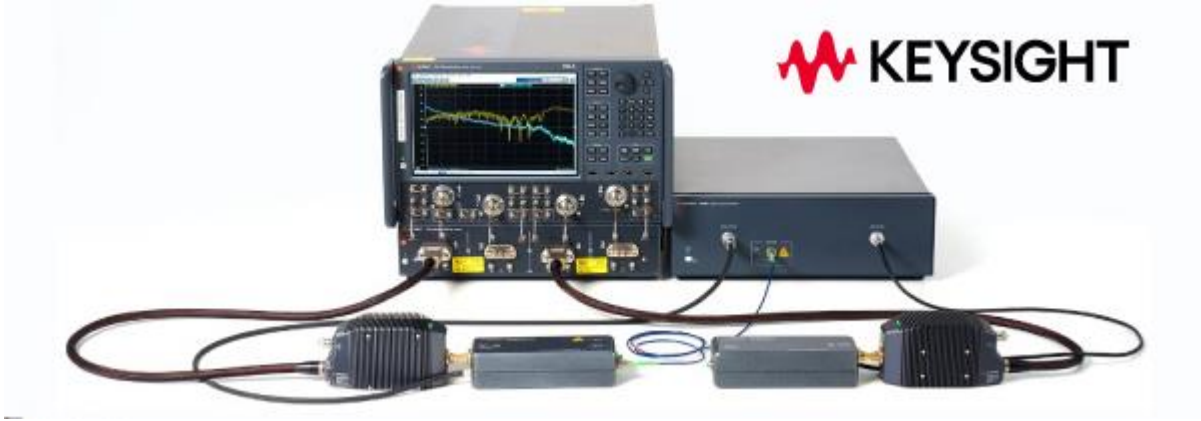
>50 dies	>140	>31k

- Fast probing and trace acquisition times are essential when scaling up.
- Smart characterization plan needed for insightful but time-practical test campaign.

- 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 Analyser (LCA) for parametric testing of devices like high speed modulators in datacom transceivers.**
  - 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
  - Available for both automated die and wafer level testing

Take aways

1. To develop design IP or productize any PIC, **characterization and test** are significant **cost & time bottlenecks**.

2. To produce state-of-the-art PICs in volumen, any **photonic back-end technology needs to be scalable** from the start.

3. **VLC/Hitachi High-tech** have the resources and expertise to support PIC developments all the way to production.

Thank you for your attention!

VLC PHOTONICS
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