Maturity of automated assembly and testing of PICs enables solutions for LiDAR, transceivers and RF photonics in aerospace.

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photonics assembly & testing

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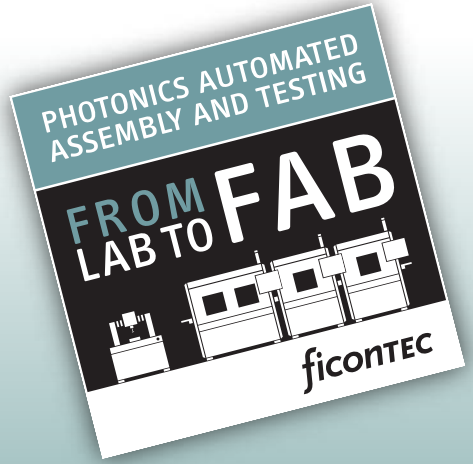
What is my 15 min talk about …

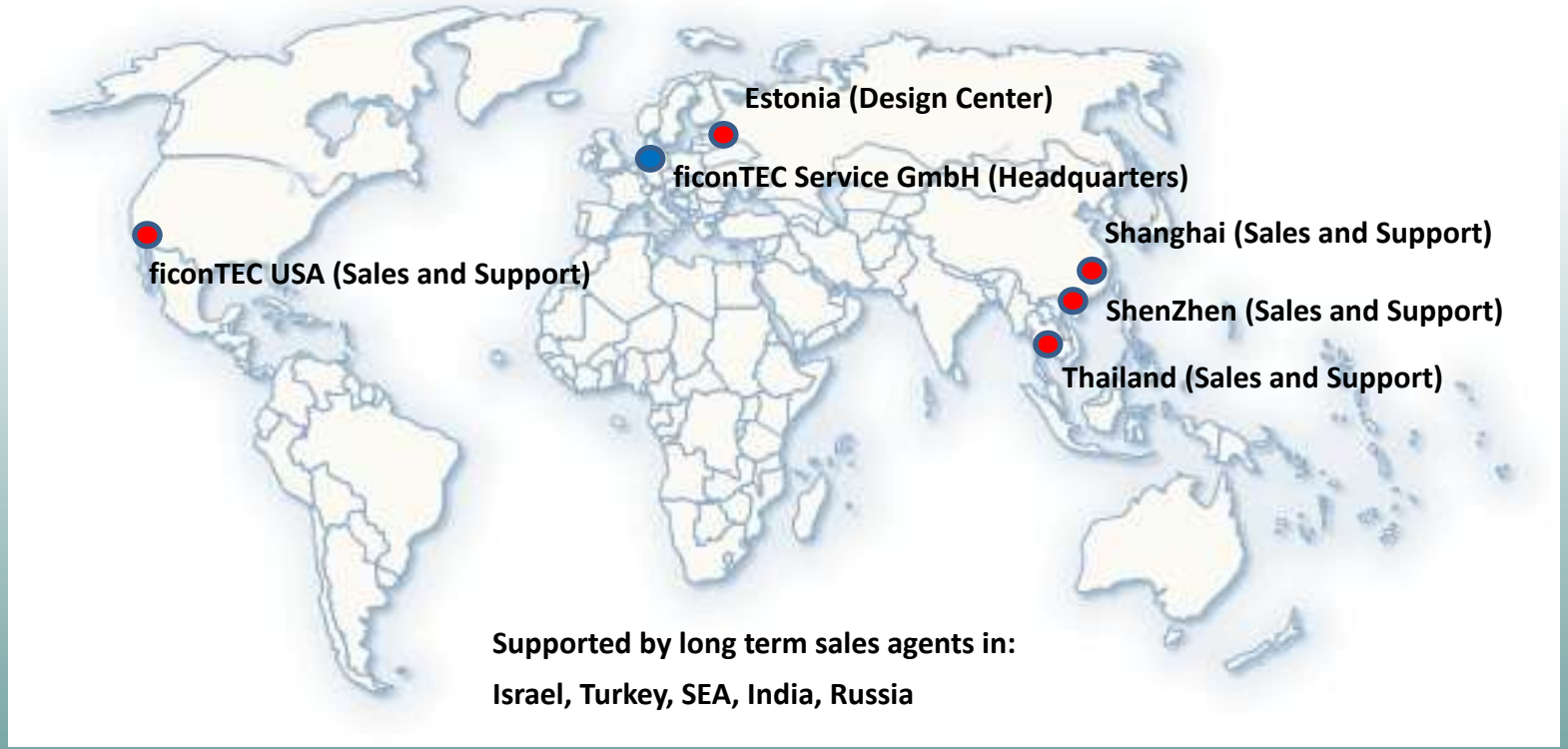
- **I like the EPIC events ..**
- **We are a machine manufacturer** and rather agnostics towards both materials (SiPho, InP, LiNb) and processes (to which our machines are adapted / customised)
- Most of our traditional customers are in the telecom - datacom segment
- **I 're-discovered' ESA at the previous EPIC event in June 2017 …**
- **I attended ICSO (International Conference on Space Optics) in Crete in October 2018: there are numbers in space photonics !**
- ficonTEC has grown a lot since 2017 and also entered new areas of photonics, both in automated assembly and **testing**
- **I would like to share few facts & thoughts with the audience …**



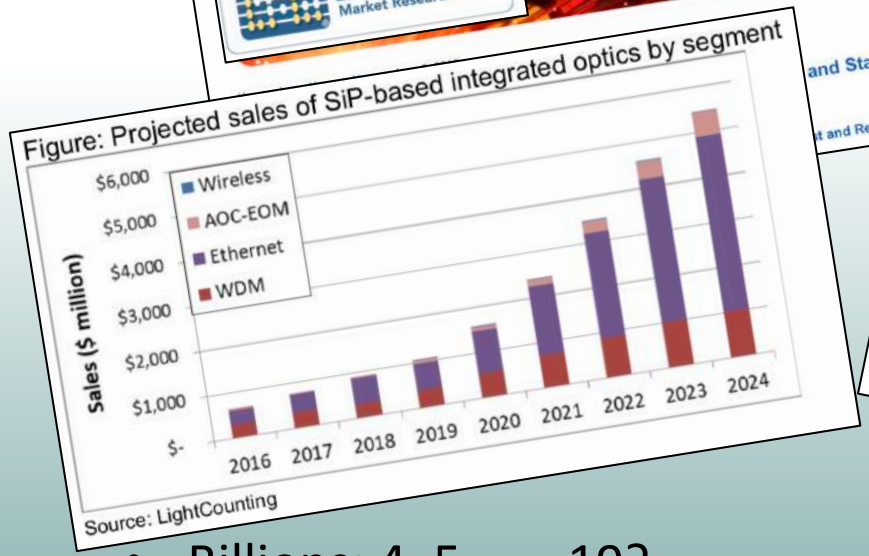
Our mission / who we are / what we do

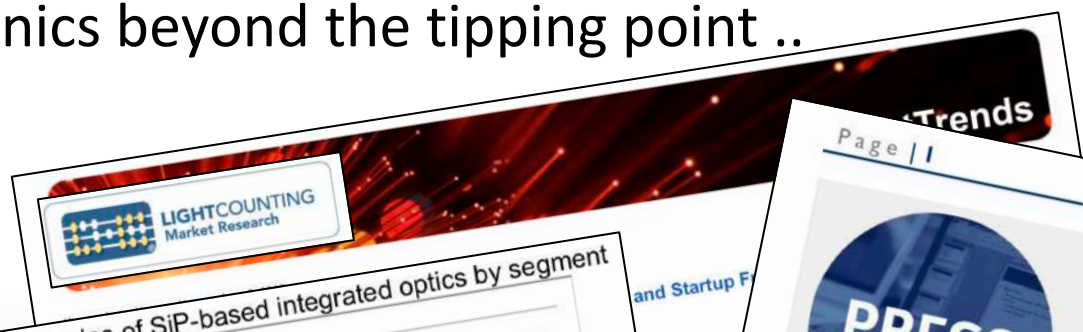
- **A 40 MEuro / 200 people company (2018 data)**
- **Our machines are the ‘embodiment’ of customer process needs**
- **From Lab to Fab**
- Machines tailored to customers requirements based on a modular platform
- > 700 machines shipped to the biggest photonic companies world wide with support teams in China, US, Thailand and Taiwan
- **145 machines shipped in 2018**
- **200 on order for 2019**
- **Stressing the limits of organic growth ..**

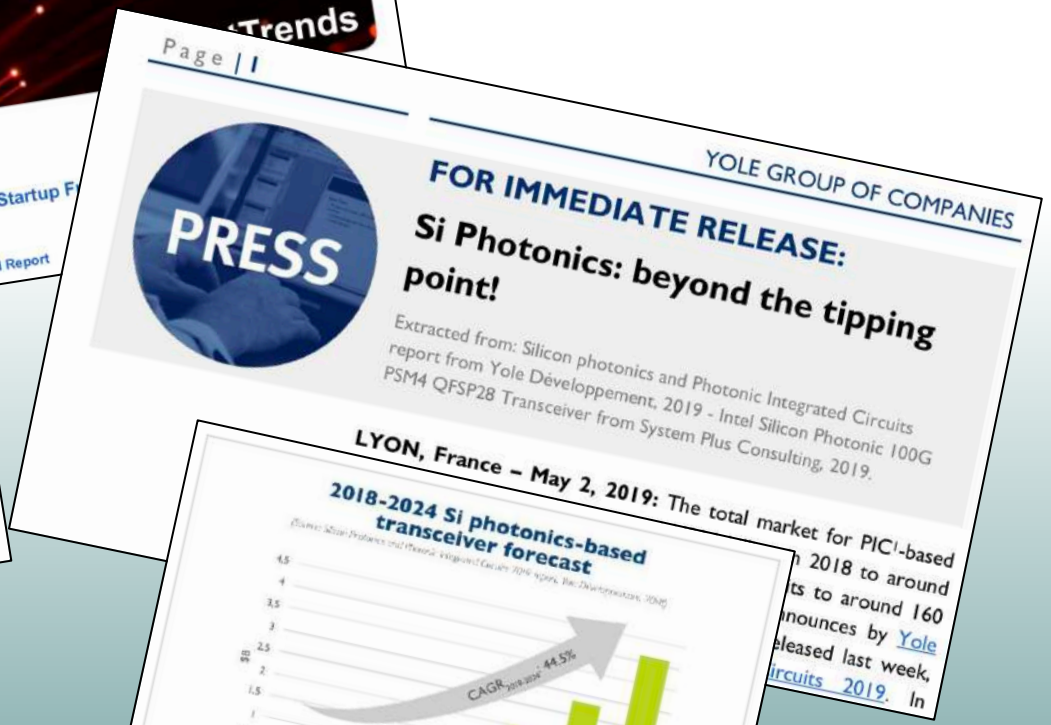
Strong International Presence (> 90% Export)



Photonics beyond the tipping point ..



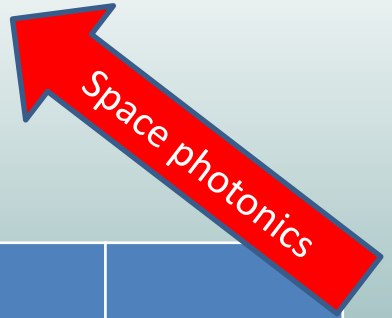




- Billions: 4, 5, …., 19?
- We are a 40 Meuro / 200 people company …

PIC market growth & company growth

- **Some numbers on machines delivery:**
  - **2018: based on existing production capabilities**
  - **2019: based on in-house POs and EXTENSION of production capabilities**
- **2018: 80% is telecom/datacom, 15% is LiDAR, 5% is 'weird & wonderful'**
- **Solid state / flash LiDAR business acquired in < 1 year**



	2014	2015	2016	2017	2018	2019
No. of Machines	45	55	75	95	145	200

Packaging photonics for space (from 2017 .. to be rediscussed?)

What	Telecom, Datacom, Bio-med, IoT, etc.	Space / aerospace
Market dynamics	Fast, very fast	Slow, very slow
Volumes	High, very high	Small, very small
Package	Towards organic, non hermetic?	Ceramic, metal, hermetic
Product life-span	Short (few years for data centres…)	Long, very long
Rad-hard	Not required	Required
Bonding process	UV cured epoxy preferred	Laser induced soldering preferred?
Temp ranges	Limited	Extended
Qualification & reliability / testing / burn-in	Moderate to low (on sample basis acceptable?)	Long, extended, 100%, ….

No longer true?

Some examples (* courtesy of Cordon Italy, funded projects and in-house development)

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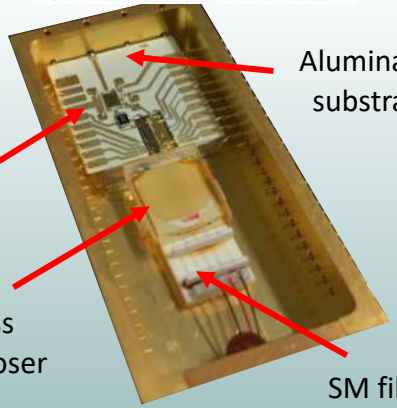
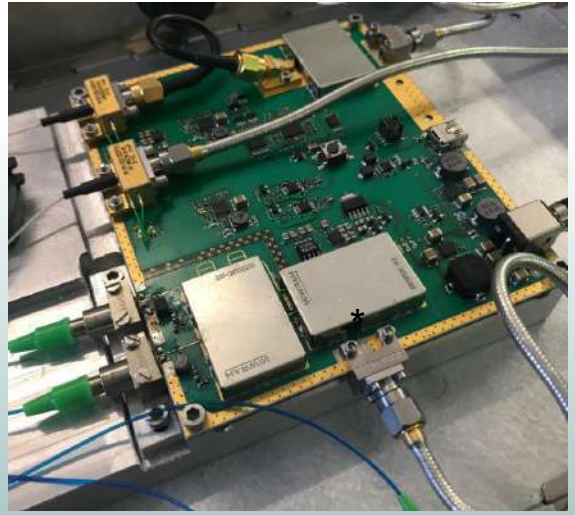
Free-space micro-optics assy

JePPIX Joint European Platform for Photonic Integration of Components and Circuits



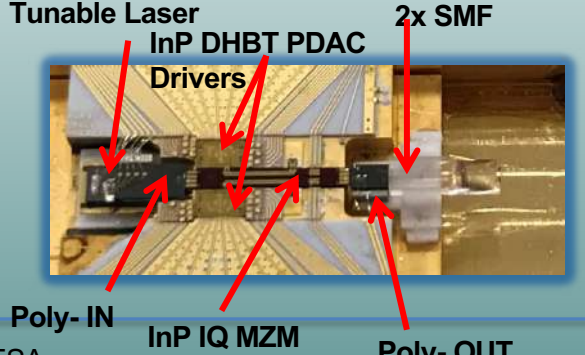
Package dimensions: 50 mm x 25 mm x 9 mm



Dual Channel RFoF Wide Bandwidth Optical Link

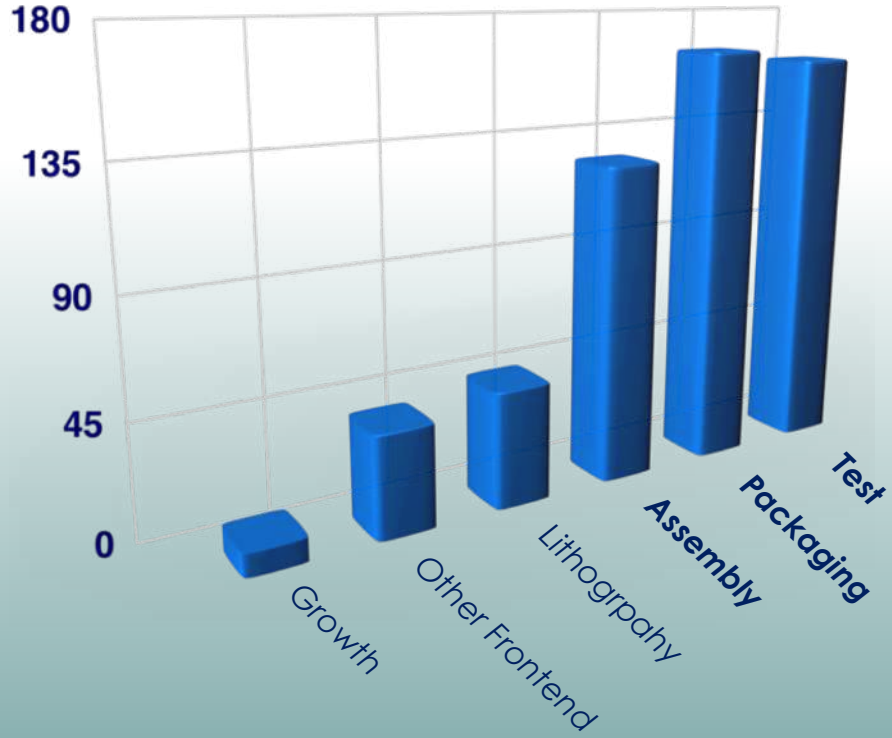
PANTHER

Single Polarization Transmitter



PICs assembly & testing: a matter of cost

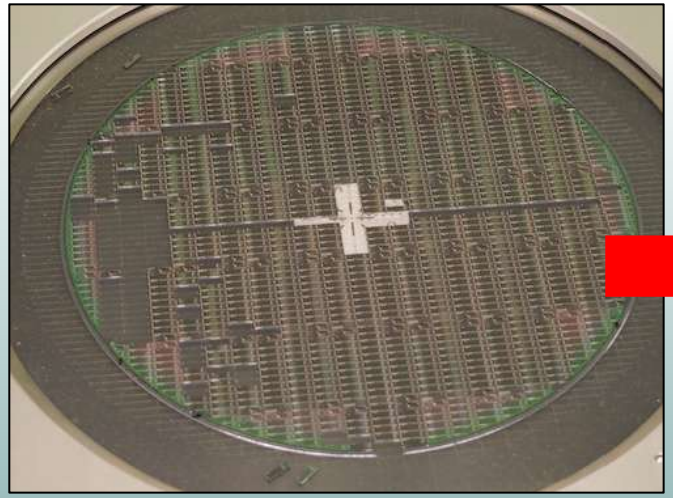
- This slide applies to the volumes of Telecom-Datacom targeting 1$/Gb ….
- Assembly, Testing, Packaging represent by far the highest costs of PICs (front-end vs back-end)
- It can soar > 80% of total cost
- It compares badly with conventional semicon (10 – 12 %)
- **It hampers the adoption of Photonics in a multitude of markets / applications**
- **The 'fix' is AUTOMATED ASSEMBLY AND TESTING**



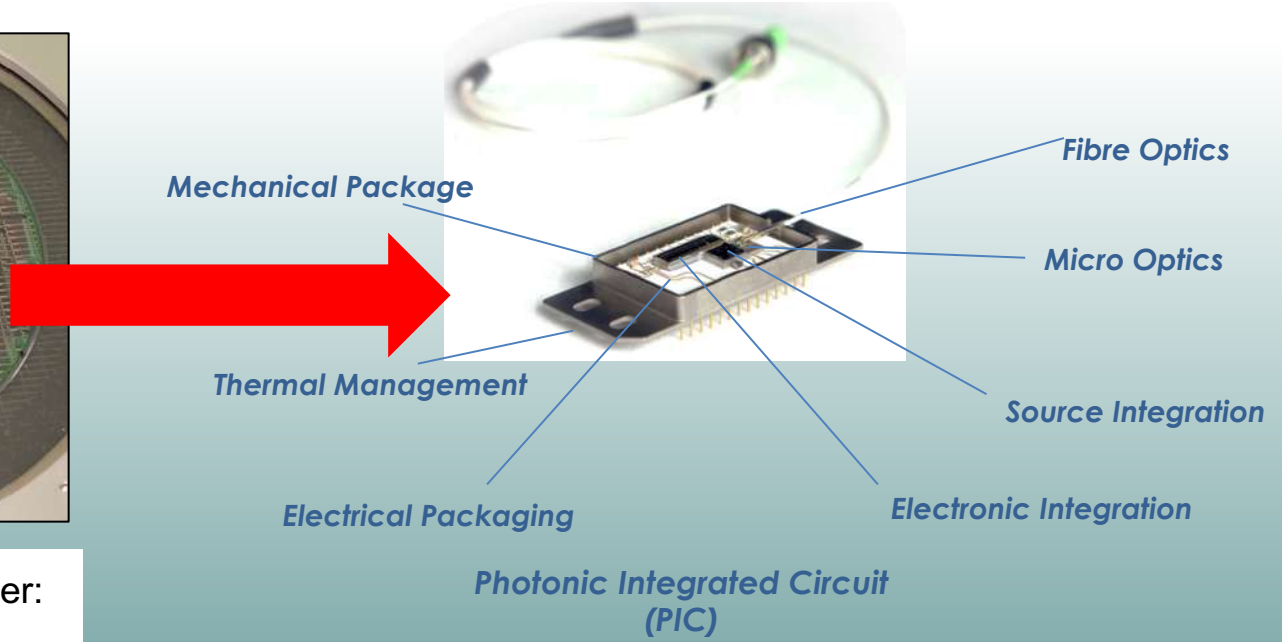
'Process-Based Cost Modeling of Photonics Manufacture: The Cost Competitiveness of Monolithic Integration of a 1550-nm DFB Laser and an Electroabsorptive Modulator on an InP Platform', Journal of Lightwave Tech, Vol. 24, No. 8, 2006.

And what is packaging?

- Singulating a tiny bit from a wafer and ‘building’ a full functional device



An 8” wafer on a 10” blue-tape carrier:
approx 1.000 devices x wafer

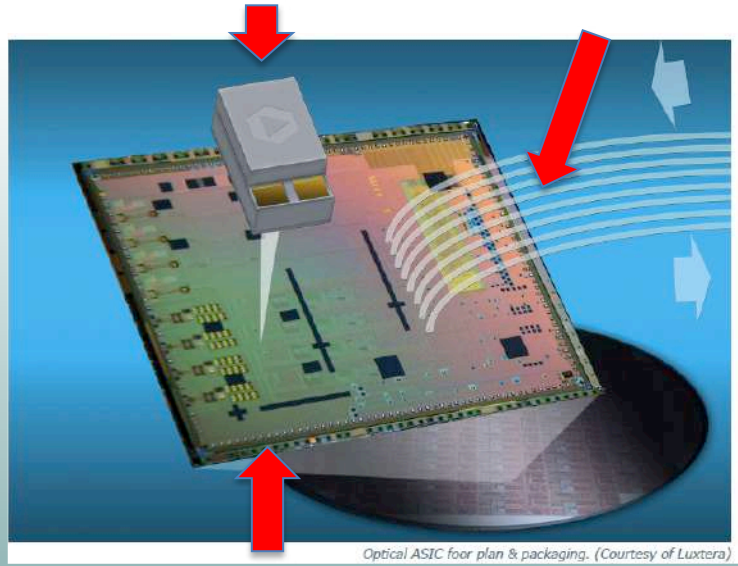


Hybrid assembly and fibres pig-tailing

- A good ‘old’ reference picture courtesy of Luxtera (now Cisco) …
- **Two things are ‘bothersome’ in the assembly process**:
  - **Different materials** are required for different bits (preventing full monolithic devices manufacturing, **at least for the time being…)**
  - Optical signals need to travel in / out, hence requiring the **connection of optical fibres**
- **Very high placement accuracies are required, down to sub-micron positioning (typ 100 nm)**
- **Positioning accuracies have to be ensured post-bond & long-term**

CW IR Laser source with collimating optics and mirrors, approx 1.5 x 2 x 2,5 mm

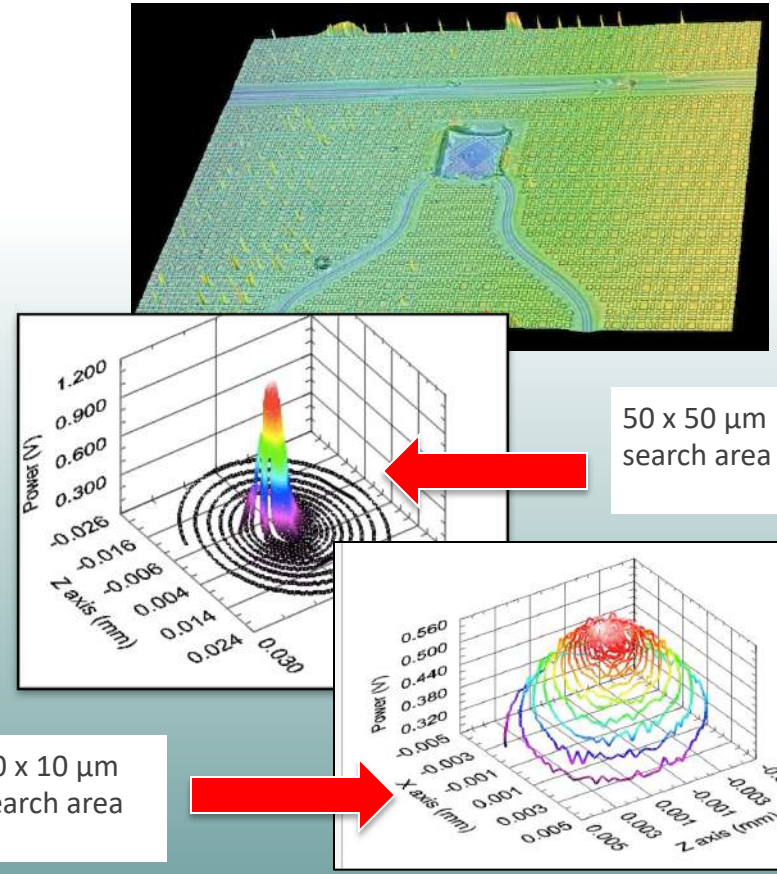
12 I/O fibers, 12 fibers spaced 250 µm apart



Chip with Mach-Zender modulators and grating optical couplers, wafer optical circuitry based on CMOS process

Active alignment / passive alignment …

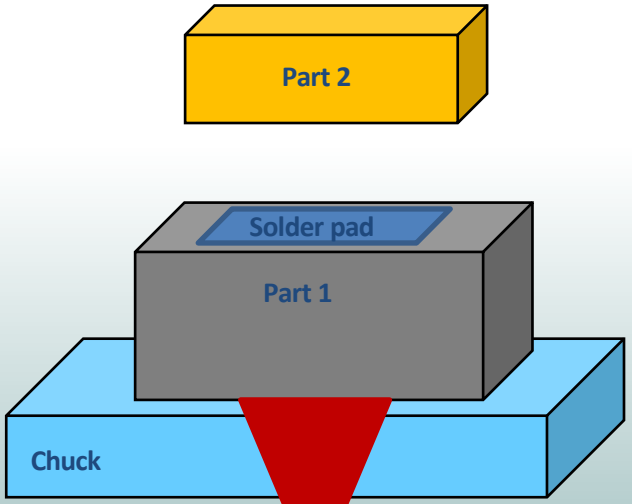
- Passive alignment: locate coupling structure using machine vision geometric features detection and ensure ‘first light’ for next step
- **Fast active alignment: dither / spiral search over a reduced area / volume while actually measuring optical signal strength**
- Works well with both gratings and edge coupling with single or arrayed fibers



- **An over-inflated debate:**
  - **Epoxy bonding takes far longer than alignment**

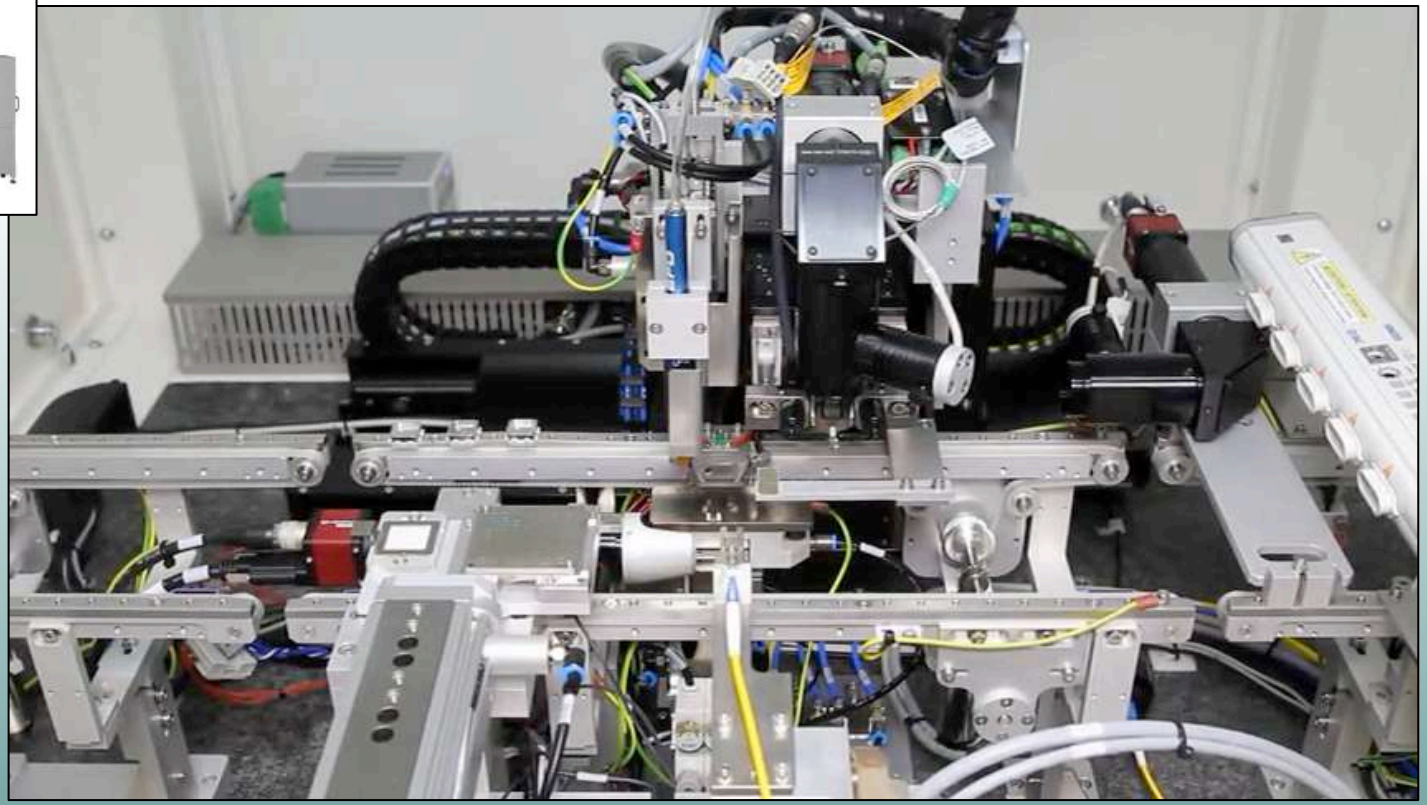
Laser-induced soldering

- A fast & accurate method applicable to single devices and to **full-wafer assembly**
- Allows placement of individual components closely spaced
- Requires substrates that are transparent to the laser beam wavelength and dedicated solder pads with appropriate alloy (AuSn, etc.)



In-line assembly of a complex transceiver …(3’35”)

- **3 machines ‘bolted’ together**
- **Active alignment and epoxy bonding across multiple machines**
- **45 UPH, but 20 sec is epoxy curing**



We are everywhere with PICs assembly …
And what about automated testing?

WLT (wafer level testing) with a full 12” extended temperature controlled chuck

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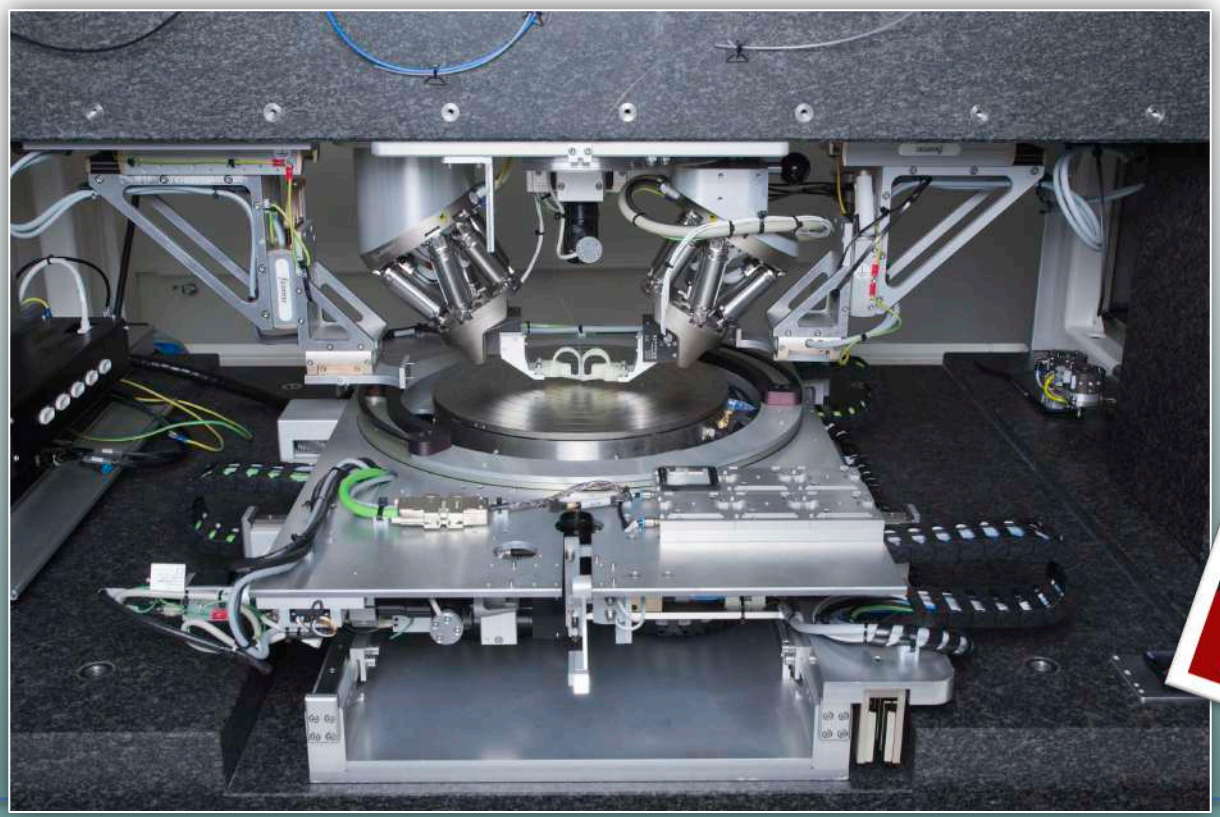
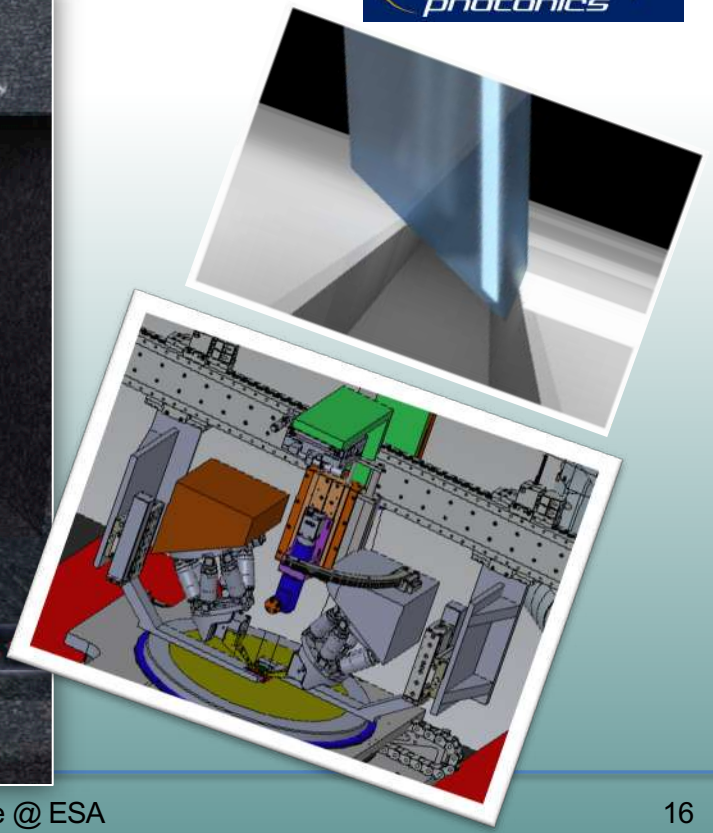
AIM photonics



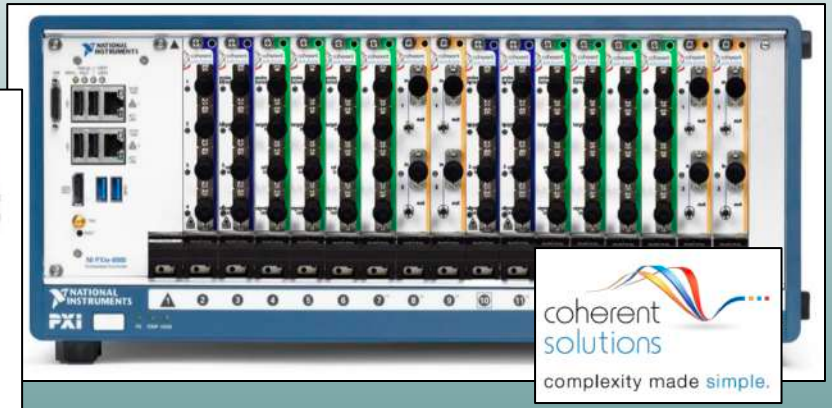


A recent integrated test platform demo … (2'30')

- At NI Week 2019, 20th-23rd May: a joint effort with Coherent Solutions and National Instruments

Modular instrumentation & mixed signals

- Instrumentation is required for both assembly and testing
- Testing requires a larger number of channels and a reduced cost per channel
- Coherent Solutions has developed a range of **optical test modules** compatible with the NI PXI platform
- Compatibility and full integration with ficonTEC machines exploits a common LabVIEW sw platform



A pre-announcement: ficonTEC Ireland

- Triggered by a DTIF grant (Disruptive Technologies Innovation Fund) from Enterprise Ireland
- Hosted at Tyndall
- Targeting packaging and testing for new photonics segments: medtech, aerospace, ..
- Skunk works, process tuning, small series, ..
- Could be seen as a follow up of PIXAPP ..
- More at ECOC 2019, Dublin

Check on Wiki: Kelly Johnson, Lockeed Martin, T-33 Shooting Star, and Skunk Works …

Conclusive remarks

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- Quoting Prof. Lionel Kimerling at the WTMF 2019 in Berlin :
  - **“Success is a collaborative venture”**

- Contact us if you need to automate your photonics assembly and testing but also if you need to discuss / revise your processes: we listen!

THANK YOU
FOR YOUR ATTENTION !!
ANY QUESTIONS??

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