



## Better and faster assembly and testing:

recent advances and innovations in automated manufacturing equipment

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**ficonTEC**  
photonics assembly & testing

PHOTONICS AUTOMATED  
ASSEMBLY AND TESTING

FROM  
LAB TO **FAB**



ficonTEC

## 15 minutes on what?

At previous PIC Int'l events I have presented an overview of **automated photonics assembly (2016) and test equipment (2018)** and the need to prepare for **volume manufacturing**. 2017 has been a year of **rapid growth**: ficonTEC had to concentrate on fulfilling existing customers requests, while also engaging in a number of R&D activities that will help in developing the **next generation of manufacturing machines**. A 'carousel' of different topics will cover advances in testing, some innovative micro-optics assembly techniques, the 'recycling' of well-proven industrial robotics for photonics assembly tasks, and the automation of optical wire bonding techniques. Harmonizing and integrating all of these developments with existing solutions will be made possible by our software platform.

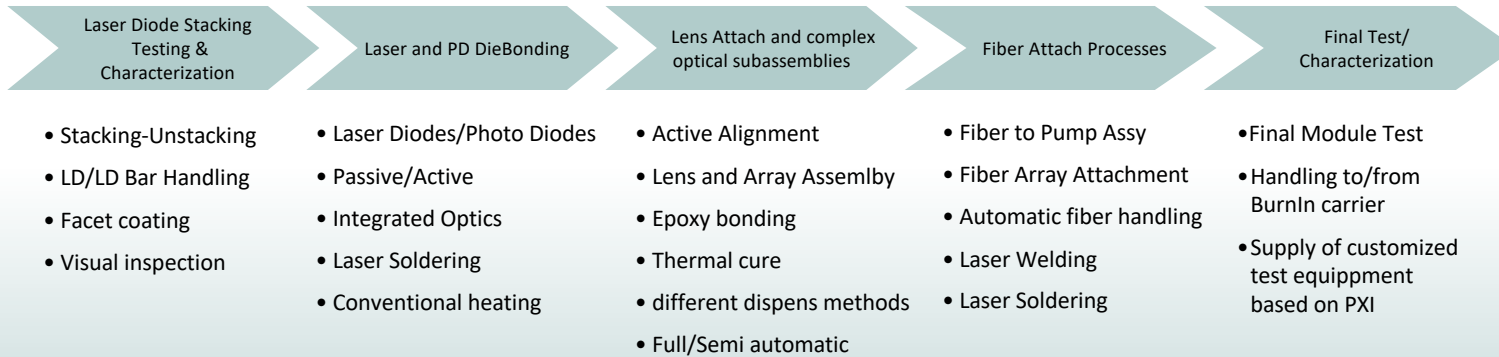
## Our mission / what we do

- We are a machines manufacturer for medium and high volume micro-assembly and test of PIC devices
- **Our machines are the ‘embodiment’ of customer process needs**
- Customized machines tailored to customers requirements based on a modular platform
- > 200 employees mainly engineers with photonics and mechatronic engineering background
- > 500 machines shipped to the biggest photonic companies world wide with support teams in China, US, Thailand and Taiwan
- **45 machines shipped since January 2018**

**ficonTEC**  
photonics assembly & testing



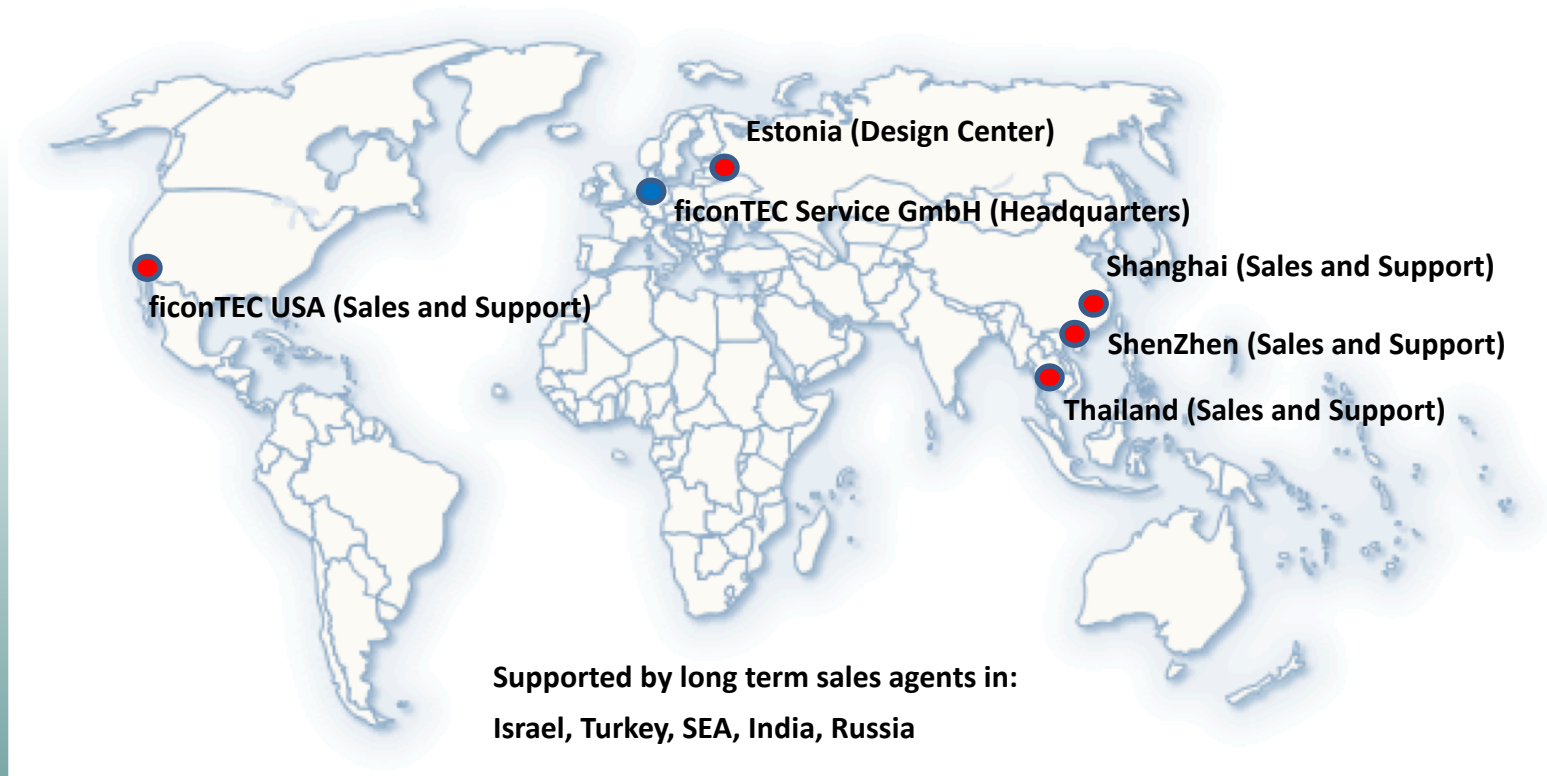
# Multi-Solution | One-Source



AL300 Lens Alignment	BL300 Die Bonding	FL300 Fiber Alignment	CL2000 Passive Alignment	LW4000 Laser Welding
<p>Active or Passive alignment for Lens</p> <p>Typical Application:</p> <ul style="list-style-type: none"> <li>Fiber laser pump module</li> <li>SLED packages</li> <li>Transceiver</li> <li>Mux/Demux</li> </ul> <p>Mini-DIL</p>	<p>Eutectic Bonding</p> <p>Typical Application:</p> <ul style="list-style-type: none"> <li>Chip on Sub-mount Bonding (CoS)</li> <li>Chip on Carrier Bonding (CoC)</li> </ul> <p>Chip on Submount</p>	<p>Fiber Alignment</p> <p>Typical Application:</p> <ul style="list-style-type: none"> <li>Fiber to LD/PD</li> <li>Fiber Array to LD/PD array</li> <li>LaMP to Fiber Array</li> </ul> <p>Butterfly</p>	<p>Stamping, Eutectic and Dispensing</p> <p>Typical Application:</p> <ul style="list-style-type: none"> <li>CoS (Chip on Sub-mount)</li> <li>CoC (Chip on Carrier)</li> <li>CoB (Chip on PCB)</li> <li>Lens or Lens Array Attachment</li> </ul> <p>QFPS</p>	<p>Fiber Alignment and Laser Welding</p> <p>Typical Application:</p> <ul style="list-style-type: none"> <li>TO or Butterfly Coaxial packages</li> <li>Up to four parts alignment (TO, Ferrell, second lens and fiber)</li> </ul> <p>TOSA/ROSA</p>

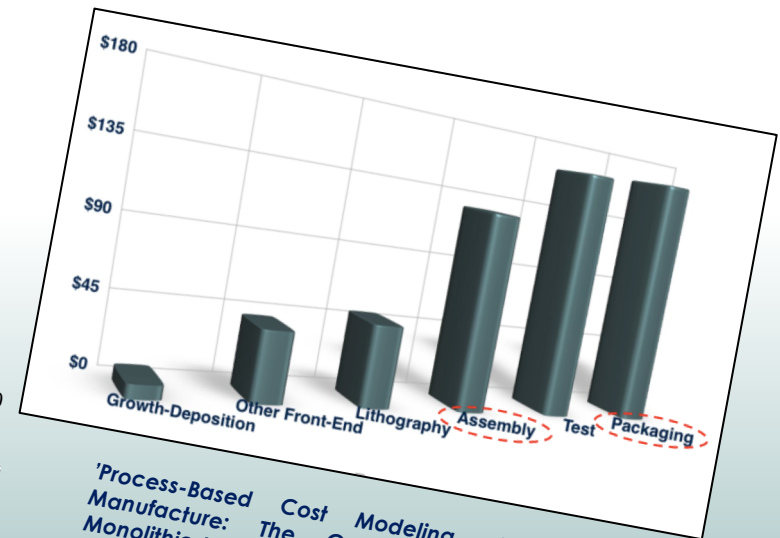
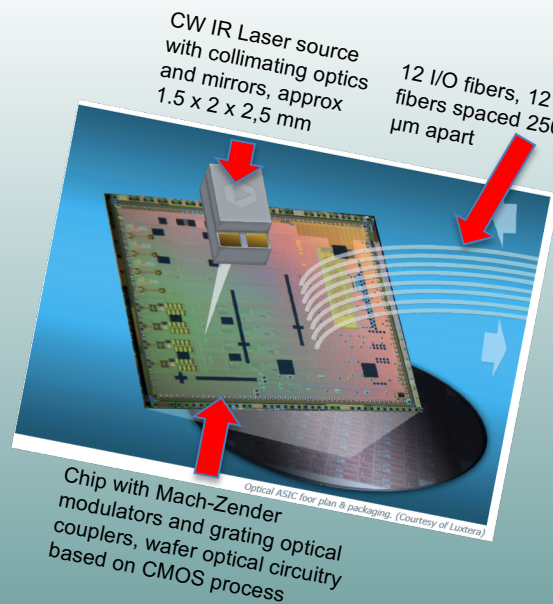
**Have a look at our web-site! [www.ficontec.com](http://www.ficontec.com)**

# Strong International Presence (> 90% Export)



# PICs assembly & testing: tackling the cost per part

- Assembly, Testing, Packaging represent by far the highest costs of PICs (front-end vs back-end)
- Moving to volume manufacturing ...
- Trade machine flexibility for speed?
- **Cost per part**
- **Big impact on future machines design and move to in-line solutions**



'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.

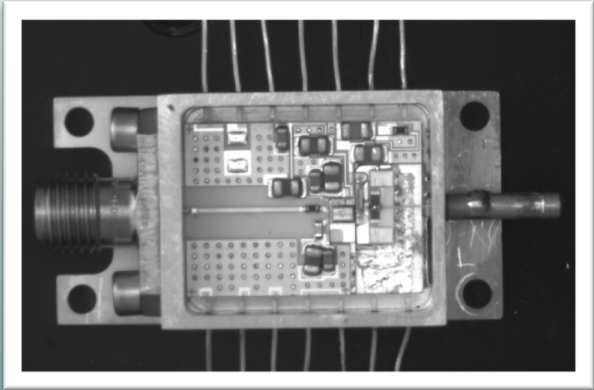
## PIC market growth / company growth

- 45 machines shipped in Q1/2018
- Numbers of large multiple-machine POs have substantially increased
- Dedicated assembly site for fast single-type machines duplications in Estonia
- Covering all other requests at German HQ
- Maintain FAT and PIC Assembly Process optimization at HQ
- Reduce delivery time through more modularity / better procurement / better production / balanced outsourcing

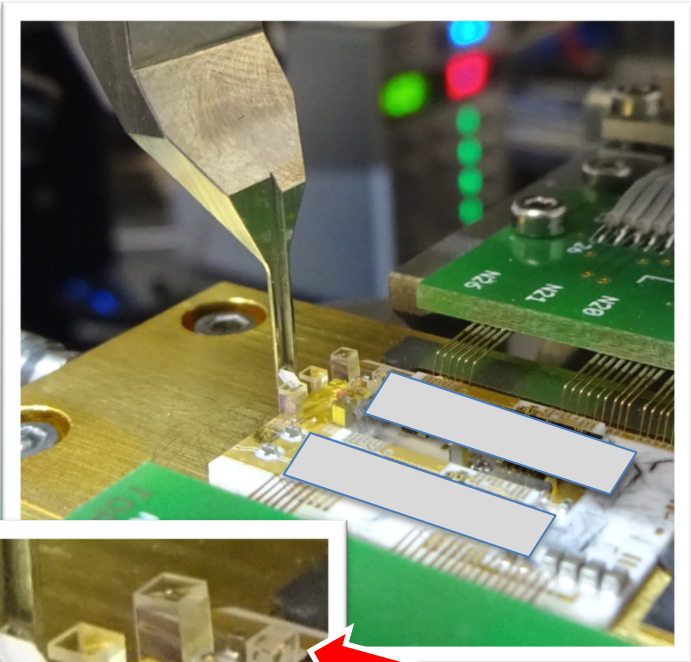


# Increasing assembly complexity of hybrid PICs

- From 'simple' TOSA-ROSA (Transmitter / Receiver Sub Assembly) assembly to very complex applications with active/passive alignment of > 30 elements for complex fully integrated transceivers



*An optical receiver from the mid nineties*



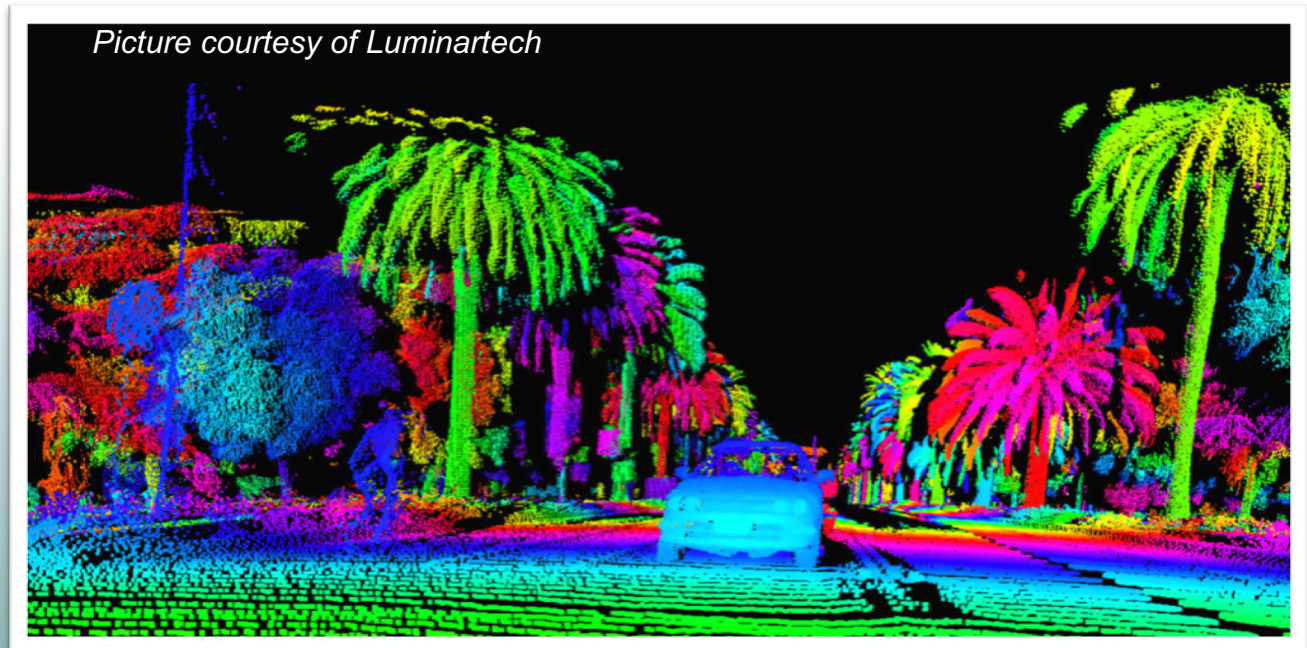
**1 x1 mm lens**

Passive & active alignment, bonding, electrical probing



## Emerging photonics market segments

- Not only Datacom / Telecom
- **Autonomous vehicles and LiDAR (recently acquired contracts)**
- **AR / VR / MR**
- Biomedical (diagnostic at individual level ..)
- Sensing (everything that was once built on an optical bench and can be squeezed onto a chip ...)
- RF Photonics (aerospace, defence, ...)
- IoT & Consumer goods
- .....

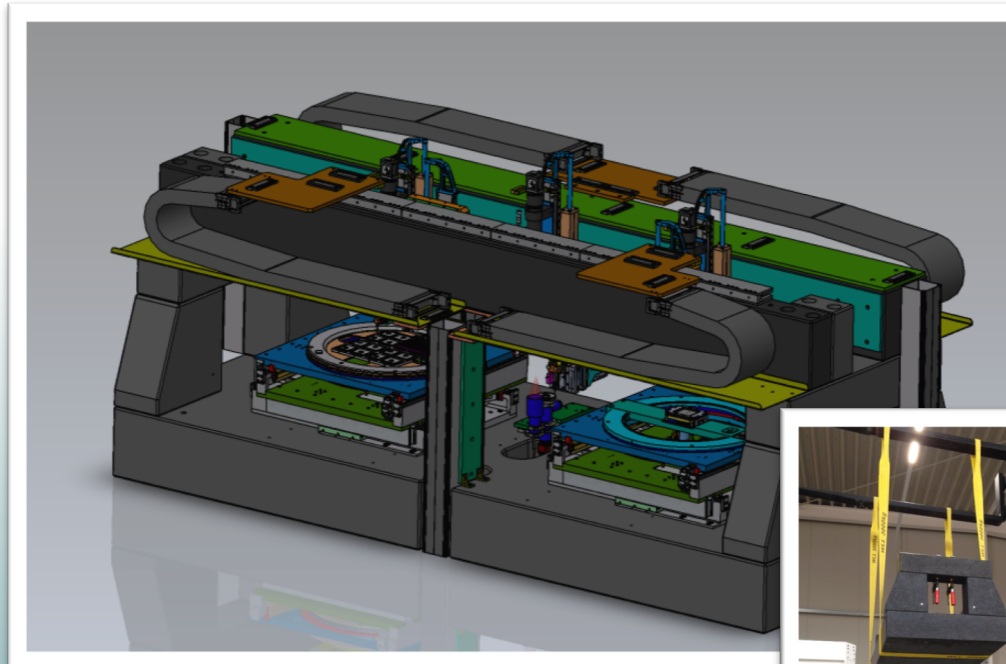


The following slides present mainly 2017 activities.

Please refer to previous presentations at PIC Int'l (2016, 2017) for more details on the assembly & testing automation 'ingredients'

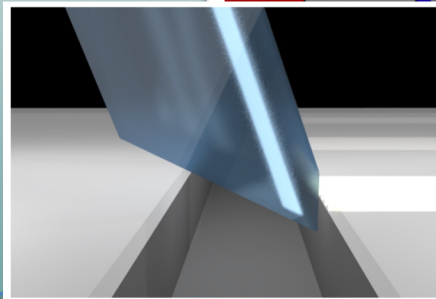
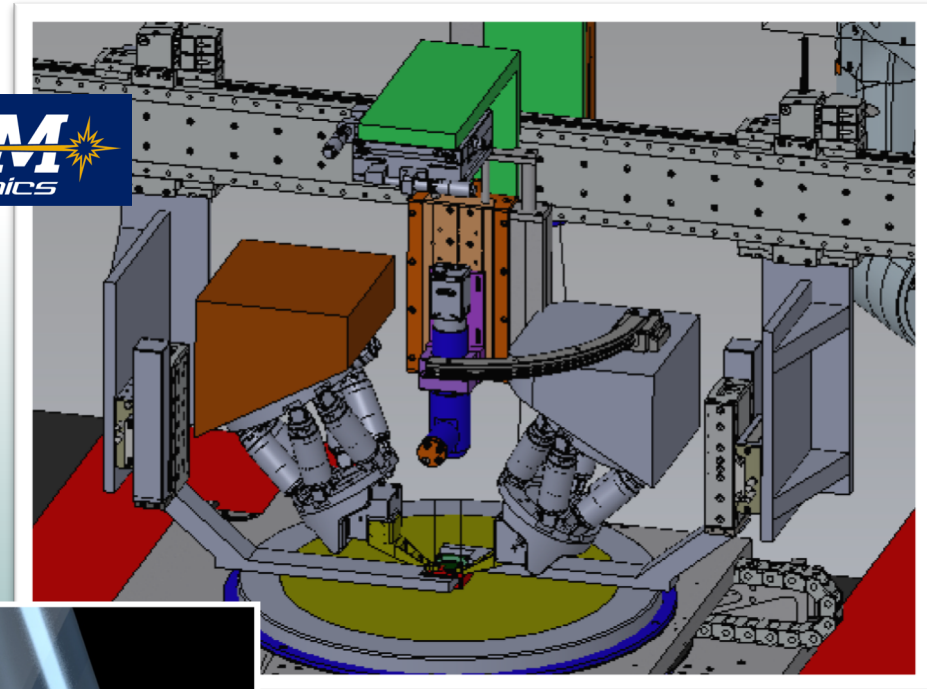
## Moving to wafer-level assembly

- There is an increasing trend to move to full wafer level assembly
- A flexible 2 x 12" wafer chuck, 4.5 ton machine for the Inphotec Lab in Pisa, Italy
- Full wafers, singulated chips on 'blue tape', gel-packs, ...
- Active and passive alignment and different bonding techniques: epoxy, thermo-compression, **laser-induced soldering** (through the backside of the wafer)



# Moving to wafer-level testing

- As volumes grow there is also an increasing trend to move to full wafer level testing
- A flexible full 12" wafer machine for MPW and single-device wafer for electrical-optical testing commissioned by AIM Photonics, USA
- Fully automated test cycles for both **top grating couplers and edge coupling**
- Dual Hexapod + Piezocube aligner (from PI)
- **Now working on 'combo' optical / electrical probe heads**

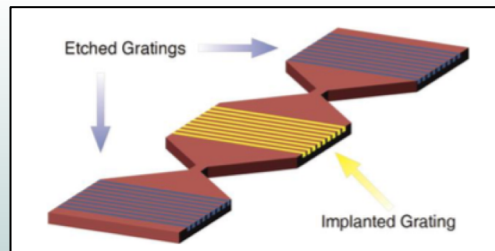


MPF 2.pdf OFC 2018 © OSA 2018

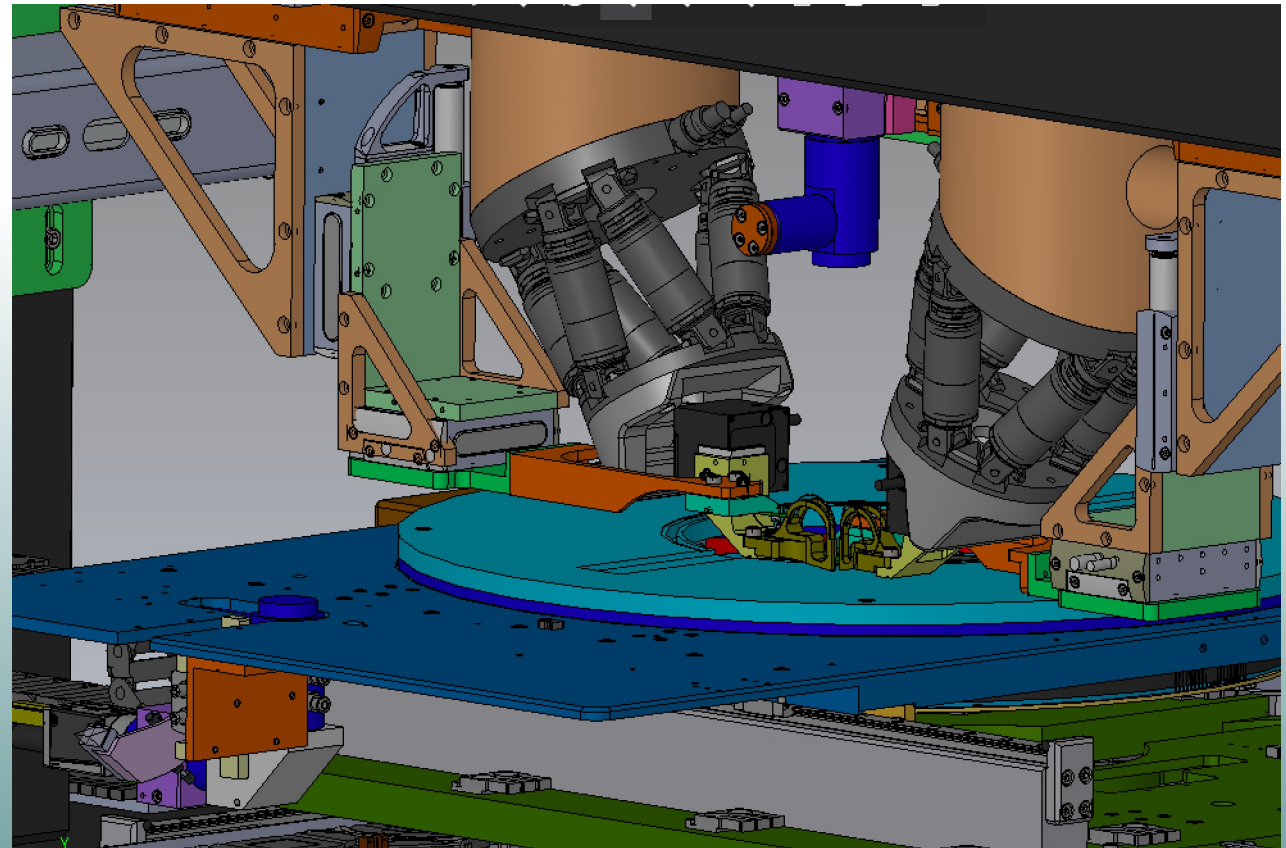
**Wafer-scale high-density edge coupling for high throughput testing of silicon photonics**

Robert Polster, Liang Yuan Dai, Oscar A. Jimenez, Qixiang Cheng, Michal Lipson, Keren Bergman  
Electrical Engineering, Columbia University, 550 West 120th Street, New York, NY 10027, USA  
rpolster@columbia.edu

# SOTON: wafer level testing with erasable gratings



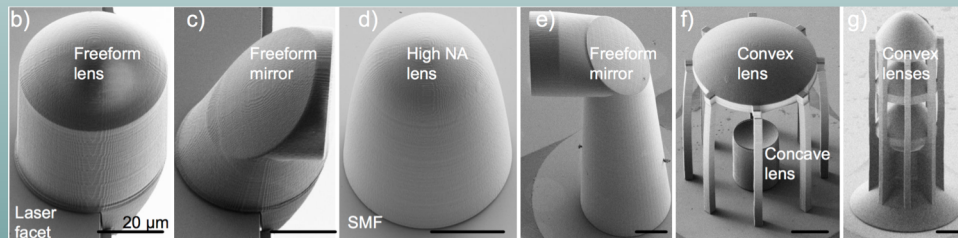
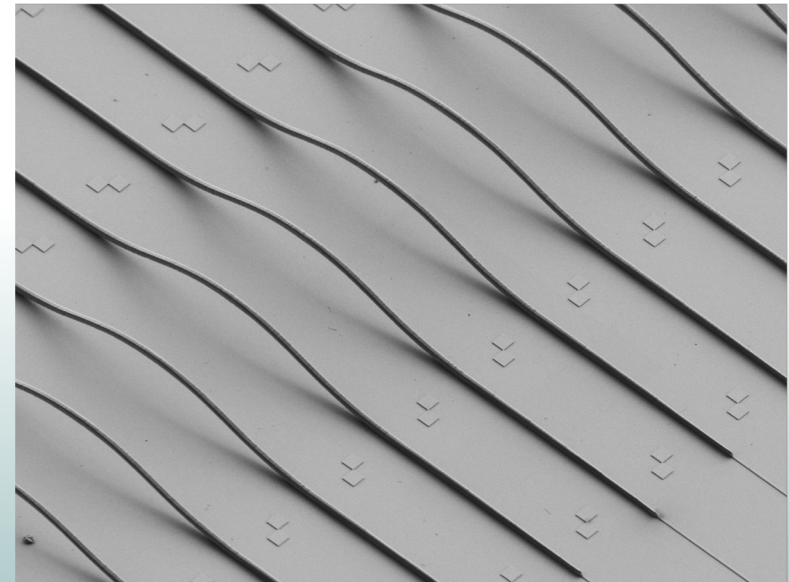
- Erasable structures: SOTON
  - ‘removable optical test-point’ laser-ablated after use
- An automated 8” wafer machine for VALIDATION



## Industrializing innovative technologies

- A ficonTEC / Vanguard joint venture
- 2-photon laser polymerization
- Automating photonics wire bonding and 3D micro-optics printing
- Moving to fully engineered in-line machines

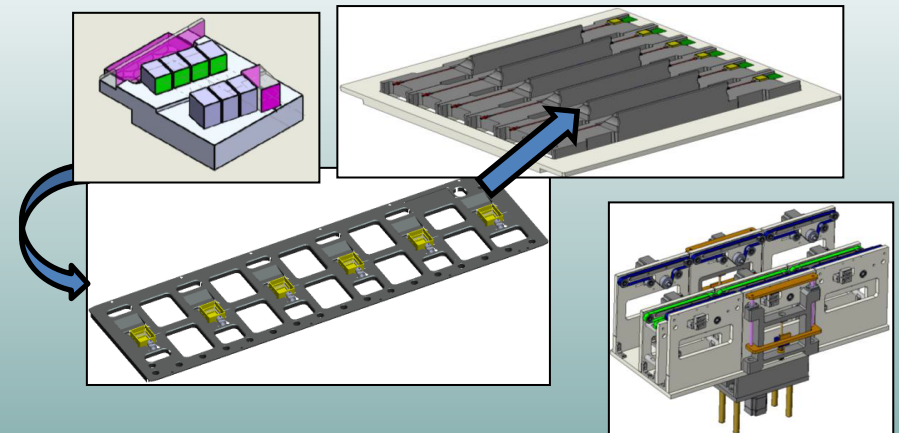
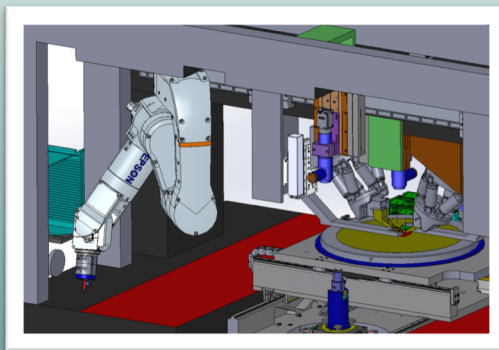
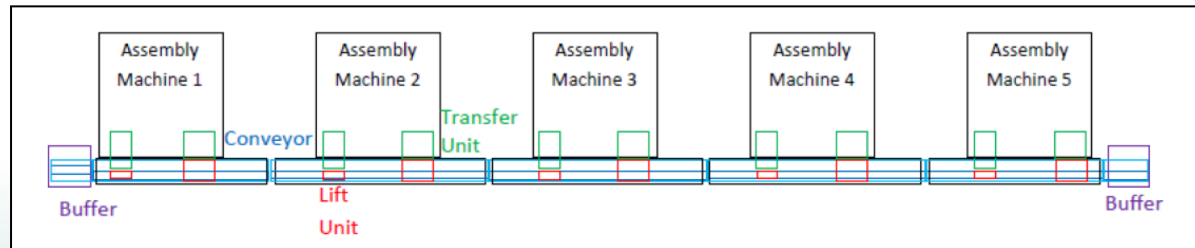
**ficonTEC**  
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**vanguard**  
**PHOTONICS**  
bright connections

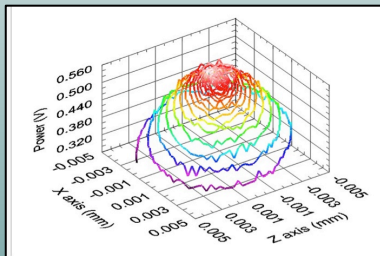
# Adopting / adding established industrial solutions

- Move from single very complex 'do-all' machines to in-line modular units
- Adopt clean-room compatible conveyors, cassette, trays
- Balance slow / fast process steps
- Adopt cost effective and reliable industrial robots for ancillary operations

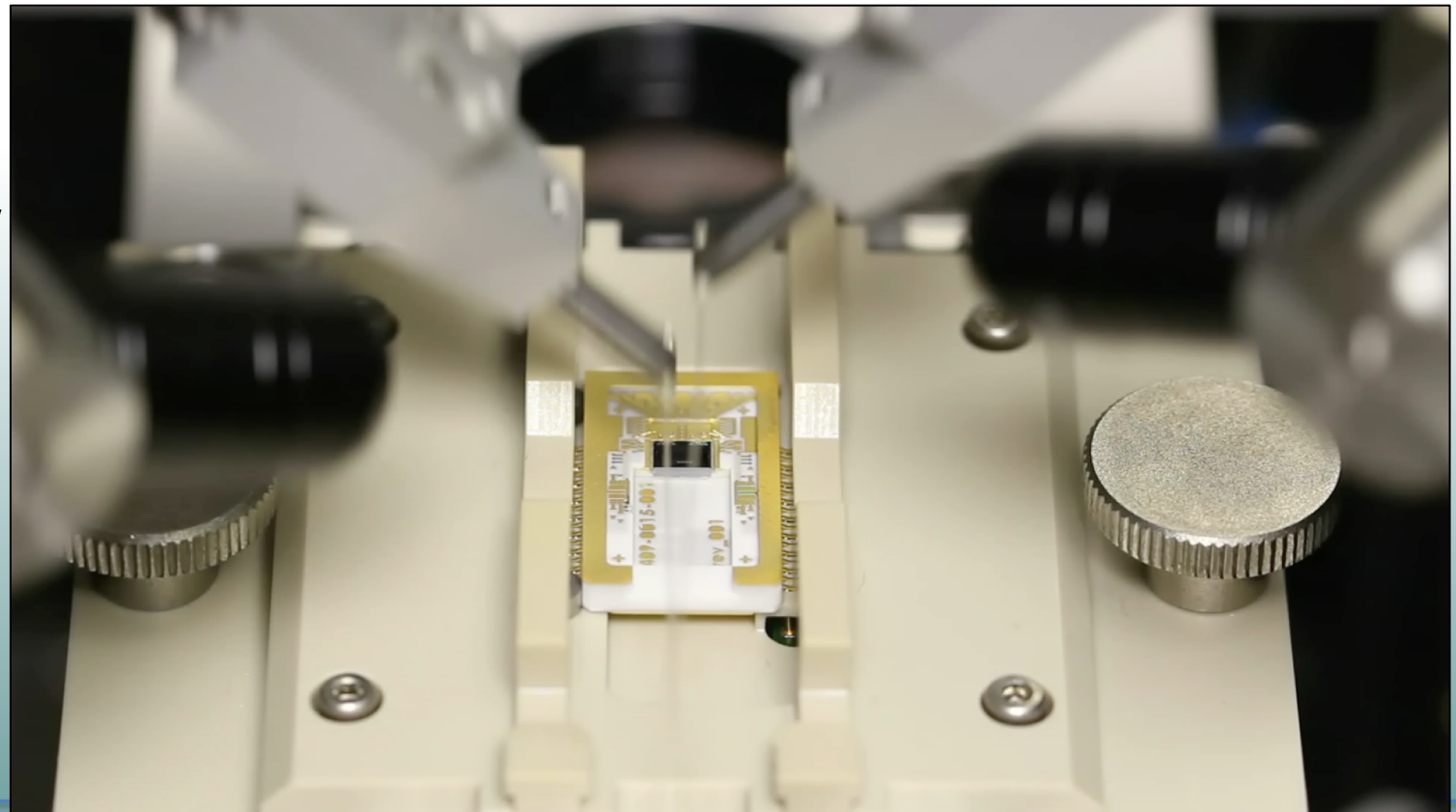


# Passive / active alignment debate ... and twin FO ferrule alignment on a FL300 machine (50 sec)

Active alignment can be cut down to few seconds, but it is only one of the many steps of automated assembly



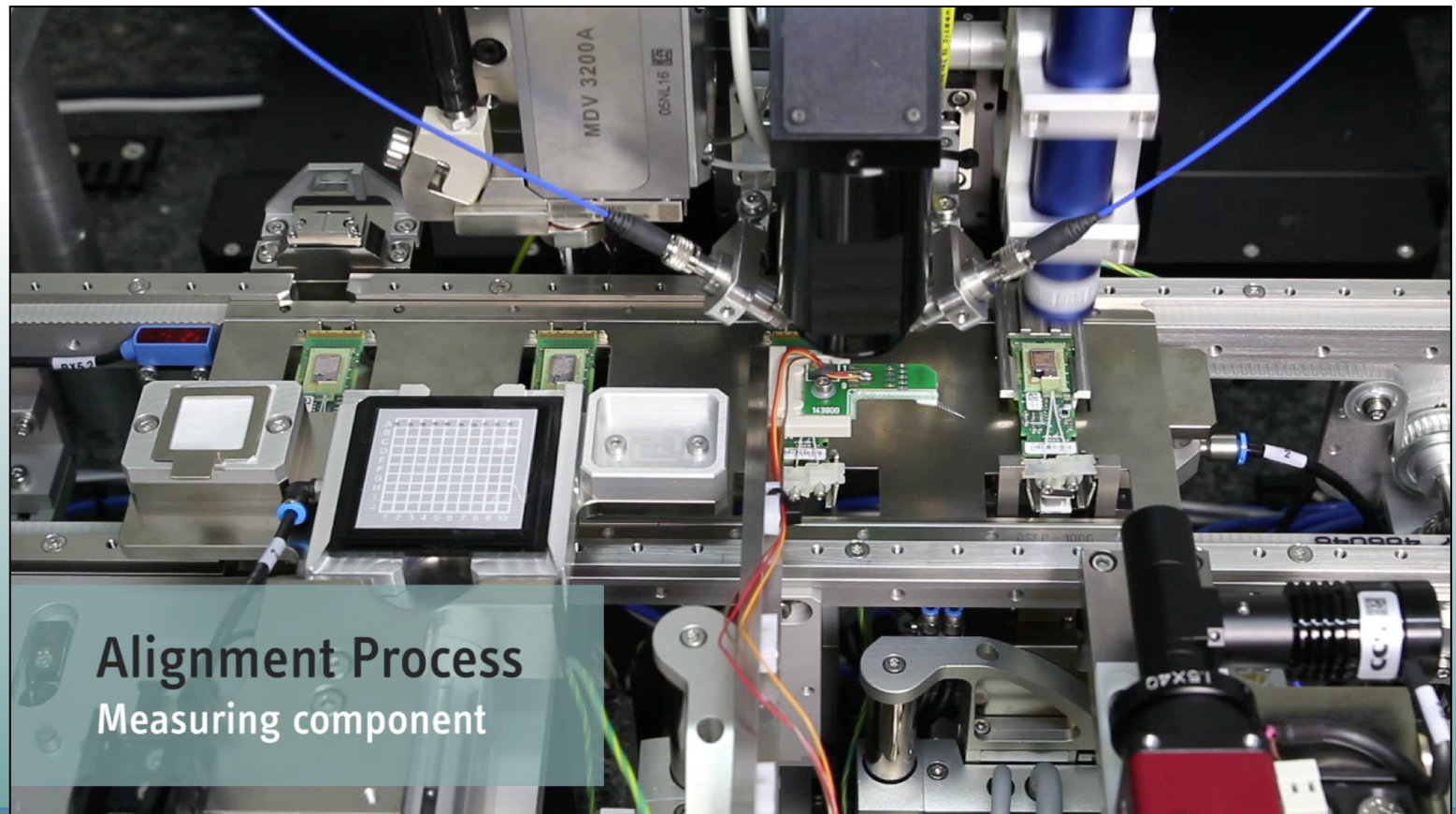
10 x 10  $\mu$ m search area





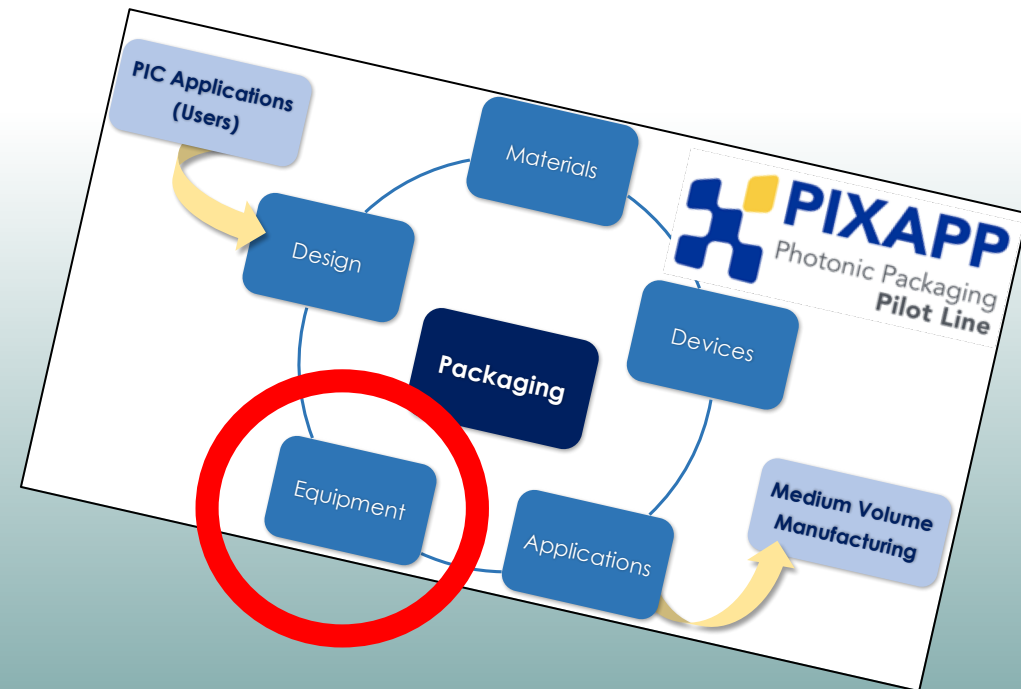
A fully automated (but could be faster ..) complex assembly (2 min)

- OLA, Output Lens Aligner with automated tray / cassette feeder
- 'Dry' alignment check followed by epoxy dispensing and actual alignment and UV curing
- Designed for unattended operation



# A collaborative approach: work with partners !

- A view of a complete PIC Packaging Supply Chain
- Linking design tools to automated assembly and test machines: **design for packaging, design for test / design for automation**
- A 4-year (and more ..) interaction with very valuable partners
- A better understanding of PICs manufacturing & testing needs in different market segments



## Conclusive remarks

- ficonTEC could be seen as a cross-breed between a very specialized system integrators and a machine manufacturer (with the pros and cons that this entails ...)
- Part of our success is probably due to the company attitude to say yes to all the 'weird and wonderful' projects of photonics packaging
- Volume manufacturing in photonics is only starting
- Standards will slowly emerge, leading to more efficient manufacturing equipment
- The success of our company will largely depend on our capacity to adapt to the new requirements of rapidly increasing manufacturing volumes
- **SPEED – SPEED – SPEED – SPEED – SPEED – SPEED – SPEED**

**THANK YOU  
FOR YOUR ATTENTION !!  
ANY QUESTIONS??  
(come to our booth ...)**

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