Scaling up PIC packaging from Prototype to Production

EPIC Technology Meeting on Photonic Integration and Packaging at Fraunhofer IZM

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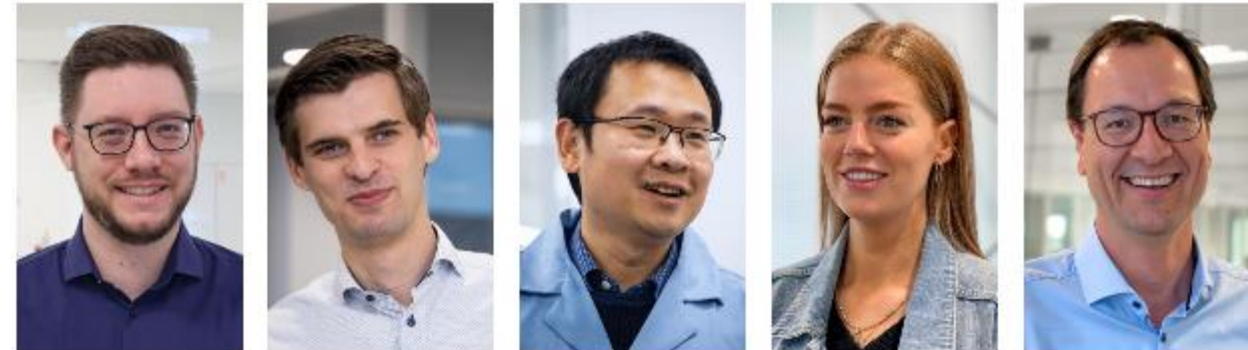
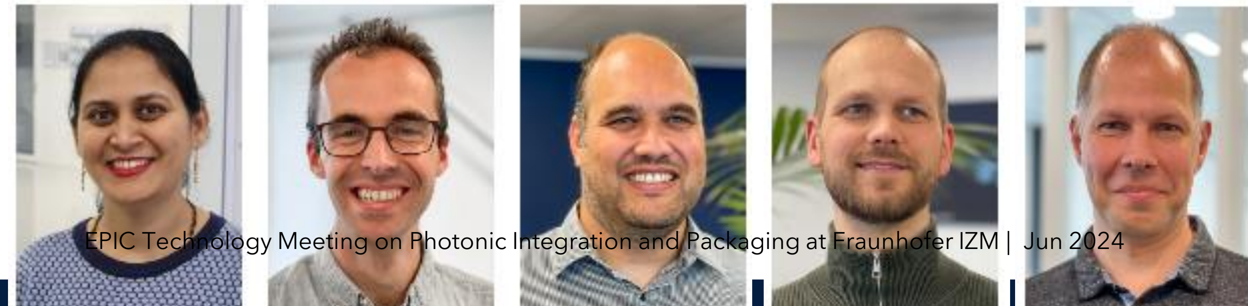
PHOTONFIRST

Integrated Photonics Sensing

PhotonFirst Technologies

18+ years' experience in Photonics





Headquartered in Alkmaar

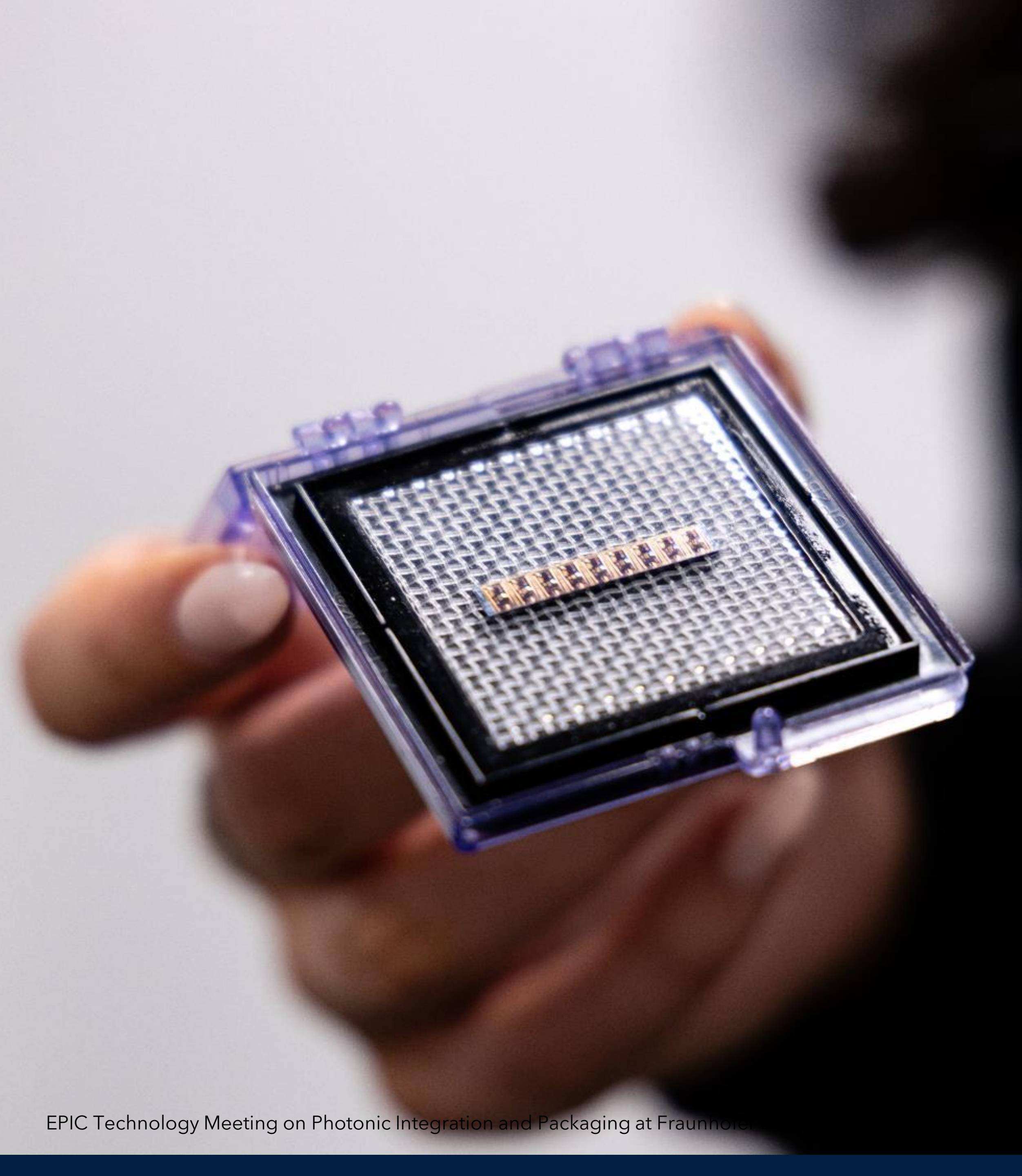
- Research & Development
- Application Development
- Program & Project Management
- Production & PIC Packaging
- Finance & Support
- Marketing & Business Development

PHOTONFIRST

Integrated circuits allow for **smaller**, **faster** and **affordable** solutions

PhotonFirst' s founder Pim Kat, a visionary in our field, started 18 years ago with the World's first photonic sensing application development, and in 2008 designed the first chip for integrated photonics sensing.

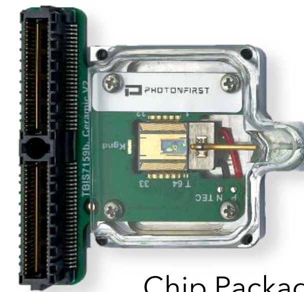
Ever since, our company has invested in the development of proprietary integrated photonics sensing solutions and PIC packaging capabilities for aerospace, medical, automotive, energy, infrastructure and high-tech systems.



EPIC Technology Meeting on Photonic Integration and Packaging at Fraunho

PIC based system development

Photonics Integrated Chip (PIC)

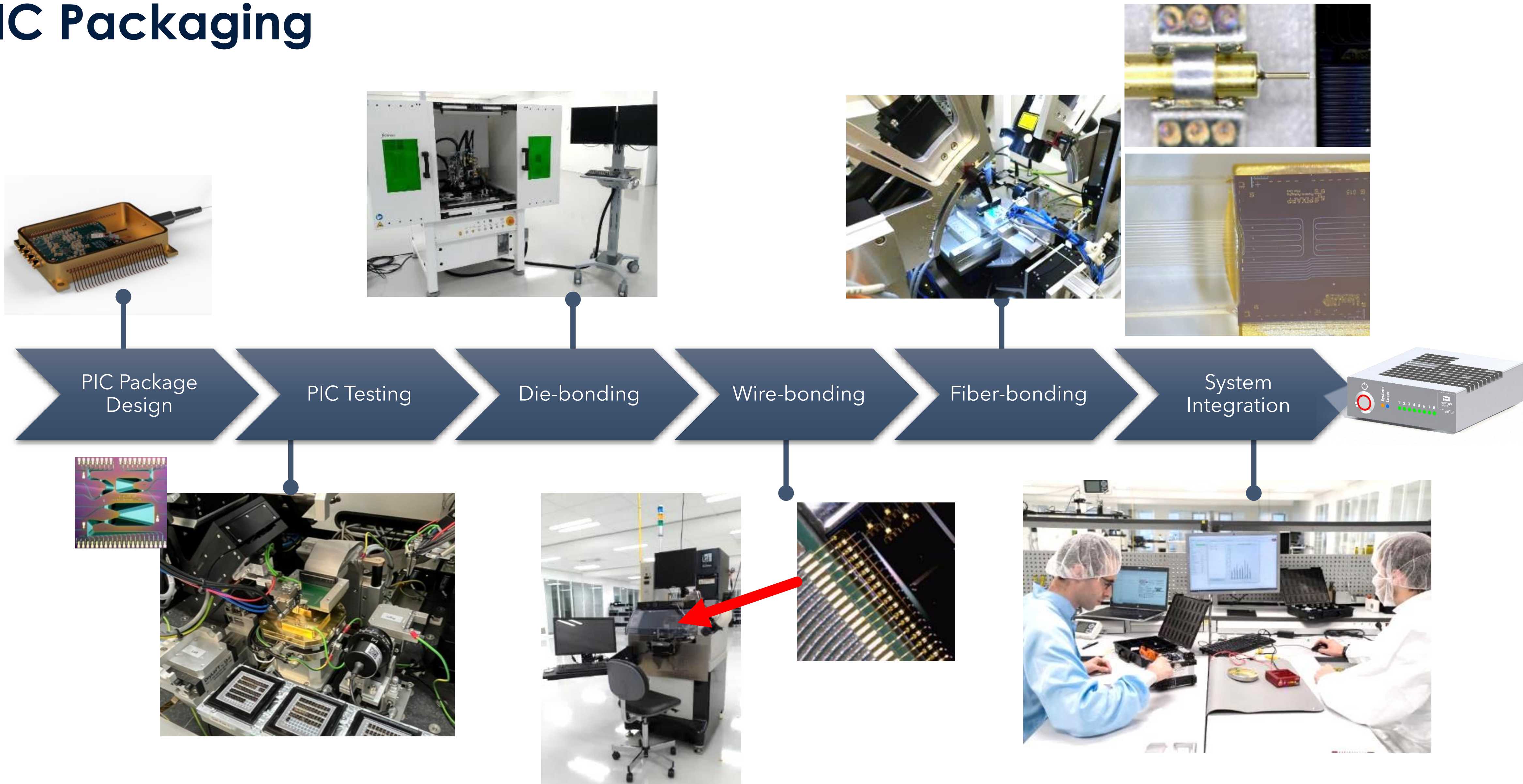


Chip Package

Chip based systems

500m2 cleanroom

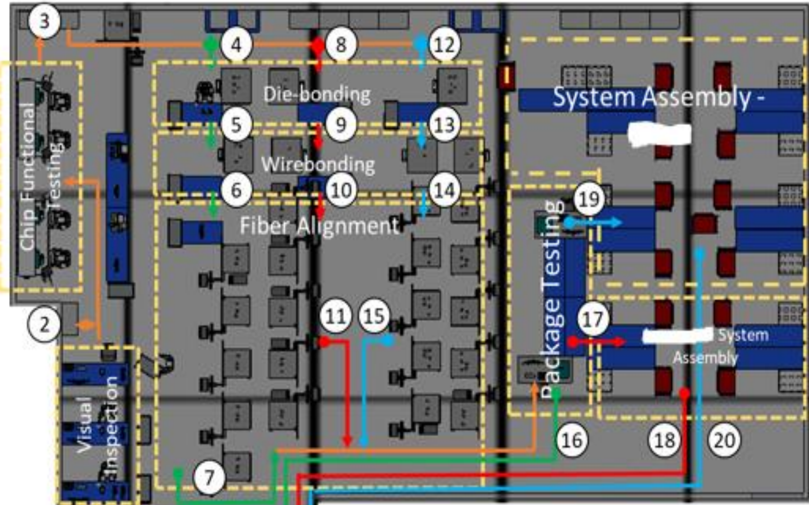
PIC Packaging



Getting from prototype to production

Proof of concept

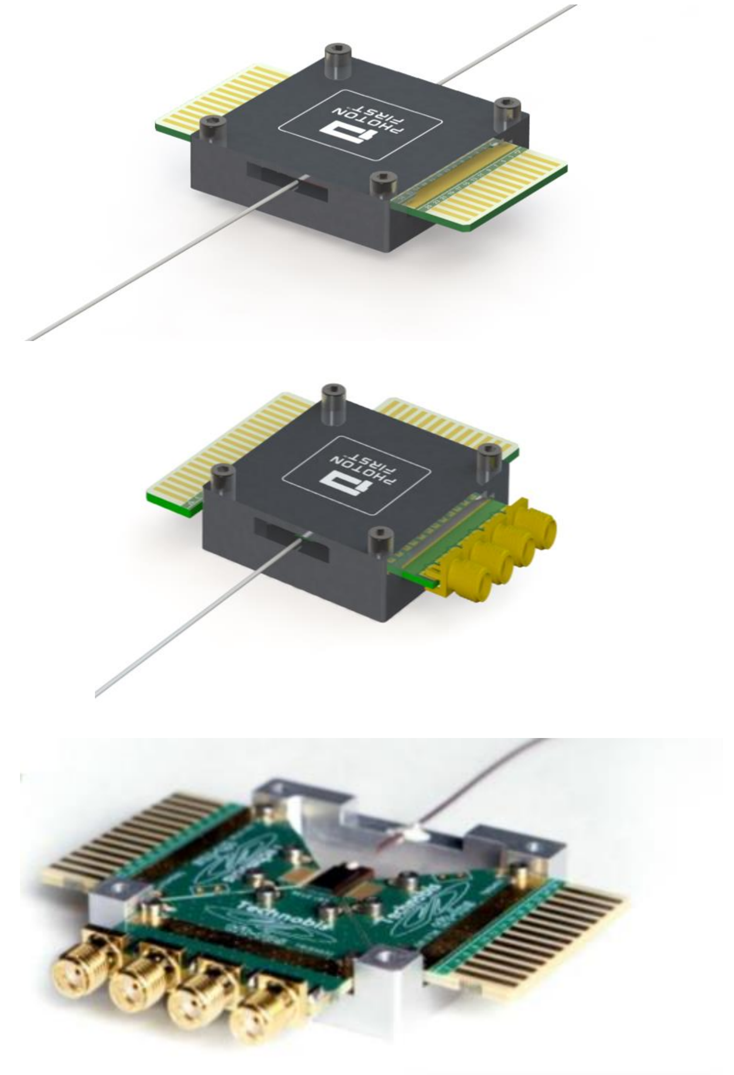
Pre-series



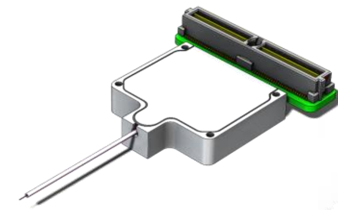
Ramp up production

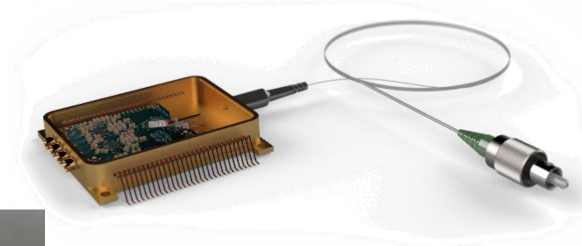
PoC: balancing cost, development time and performance

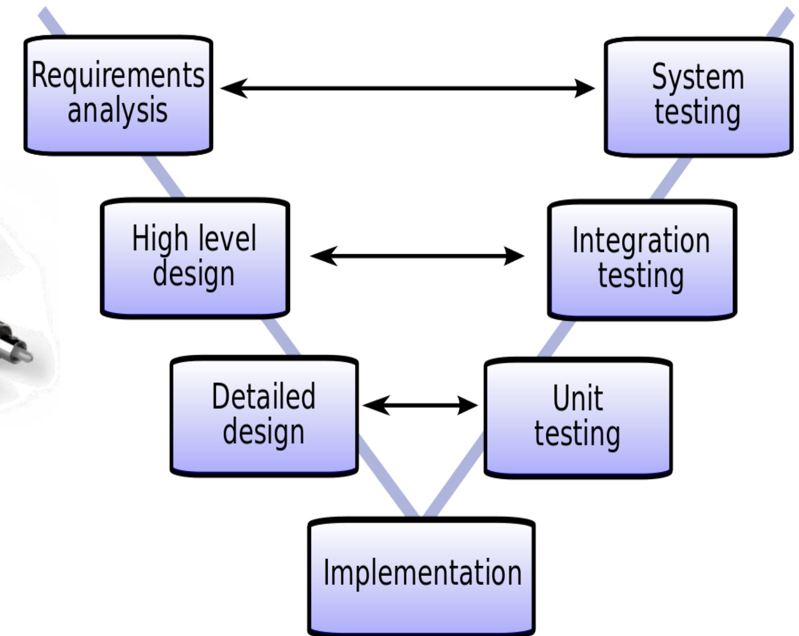
1. Leverage PIC and packaging foundry design rules
2. Design for test
3. Perform multiple iterations to validate and optimize PIC and package designs
4. Small batch, but not too small …



From prototype to pre-series: requirement-driven design and development

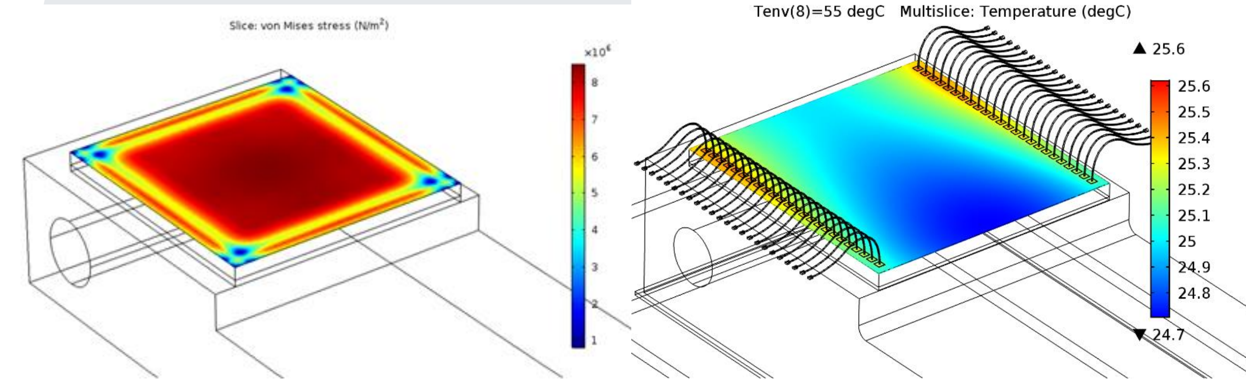






Generic Tailored

Custom design & engineering

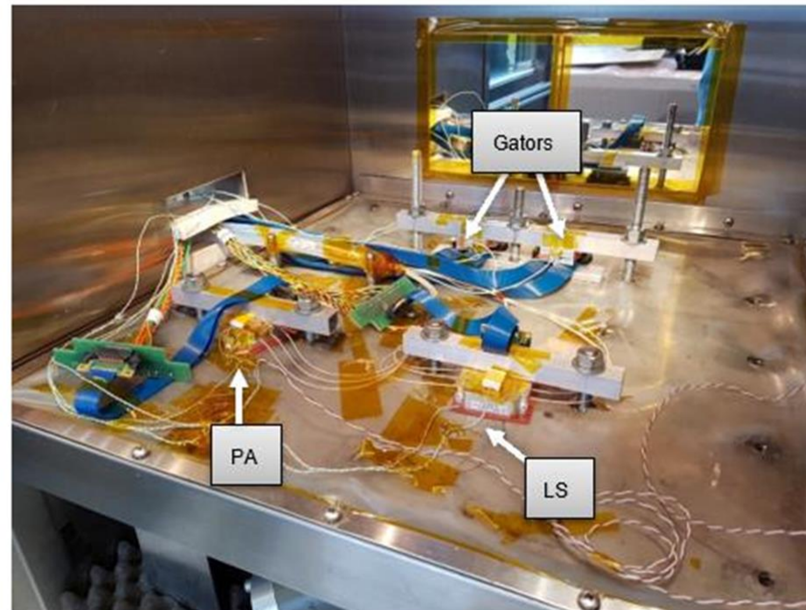


Custom design packaging

- Form-factors, materials, connectors, etc
- Thermal mgmt. (sinks, high ctrl)
- Electronic integration
- Robust fiber (array) coupling architectures
- Heterogeneous/hybrid packaging architectures
- Hermiticity

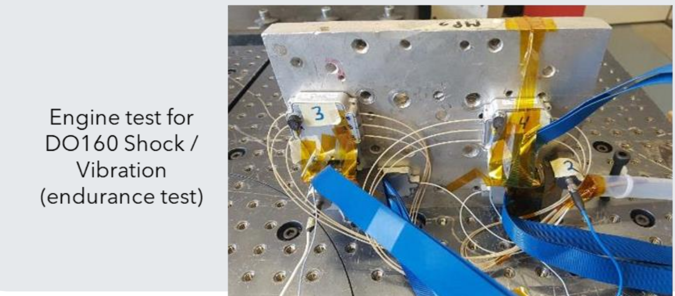
Verification and Validation

- Environmental qualification
- Accelerating aging tests (thermal)
- Challenges:
  - Defining test protocol and setup
  - Translating results to expected reliabilities



HALT test chamber installation

Damp heat climate chamber installation



Engine test for DO160 Shock / Vibration (endurance test)

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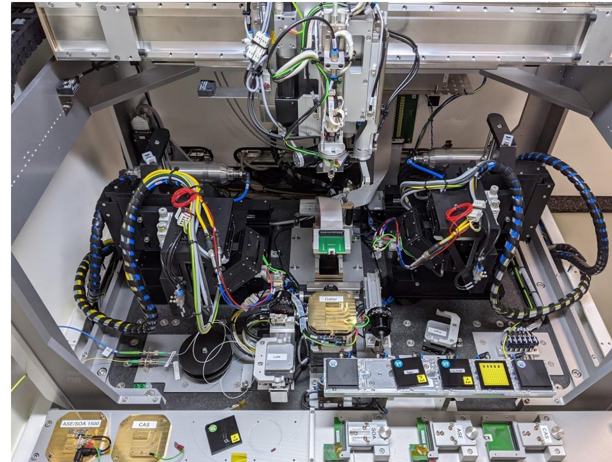
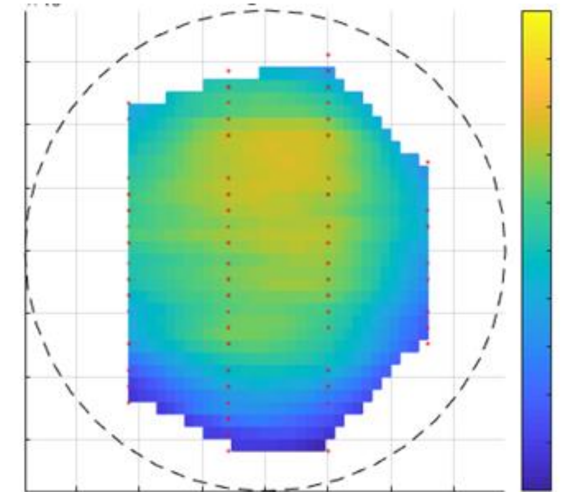
From pre-series to ramping up production: introducing control measures

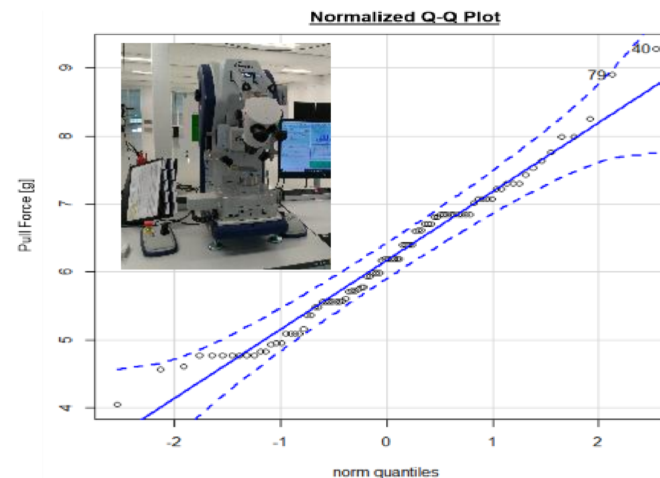
1. Optimize design for manufacturability
2. Production **control**, process KPIs, should enable the product requirements OTIF
3. Strong focus on yield
4. Automation, de-risking, supply chain



Automated Die-tester at PhotonFirst

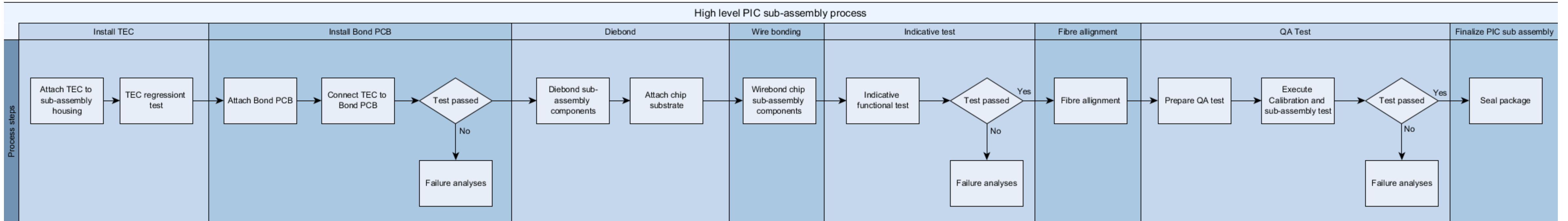


Map of a measured device KPI across a wafer



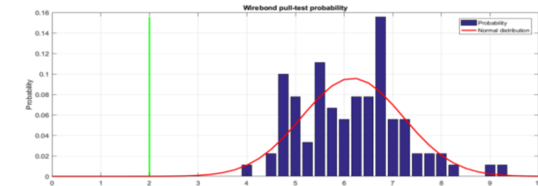
Wire-bond process validation

Production process control

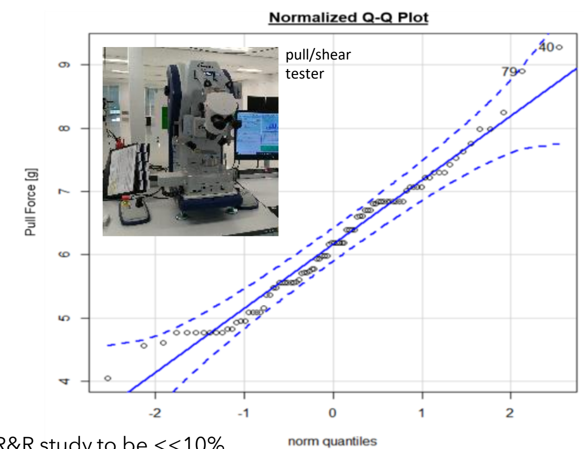


- Process FMEA
- Machine and measurement system maintenance
- Production process
  - IQ/OQ/PQ, production implementation steps, from requirements to design, controls, process definition, training, release etc.
  - Dedicated test plan and equipment for process maintenance per production step

- Example: Validation of wire-bonding process



Test condition	Wire composition and diameter 1/	Construction 2/	Minimum bond strength (grams force)	
			Pre seal	Post seal and any other processing and screening when applicable
A	---	---	Given in applicable document	Given in applicable document
C or D	AL 0.0007 in AU 0.0007 in	Wire	1.5 2.0	1.0 1.5
C or D	AL 0.0010 in AU 0.0010 in	Wire	2.5 3.0	1.5 2.5
C or D	AL 0.00125 in AU 0.00125 in	Wire	Same bond strength limits as the 0.0013 in wire	
C or D	AL 0.0013 in AU 0.0013 in	Wire	3.0 4.0	2.0 3.0
C or D	AL 0.0015 in AU 0.0015 in	Wire	4.0 5.0	2.5 4.0
C or D	AL 0.0030 in AU 0.0030 in	Wire	12.0 15.0	8.0 12.0
F	Any	Flip-clip	5 grams-force x number of bonds (bumps)	
G or H	Any	Beam lead	30 grams force in accordance with linear millimeter of nominal undeformed (before bonding) beam width. 3/	

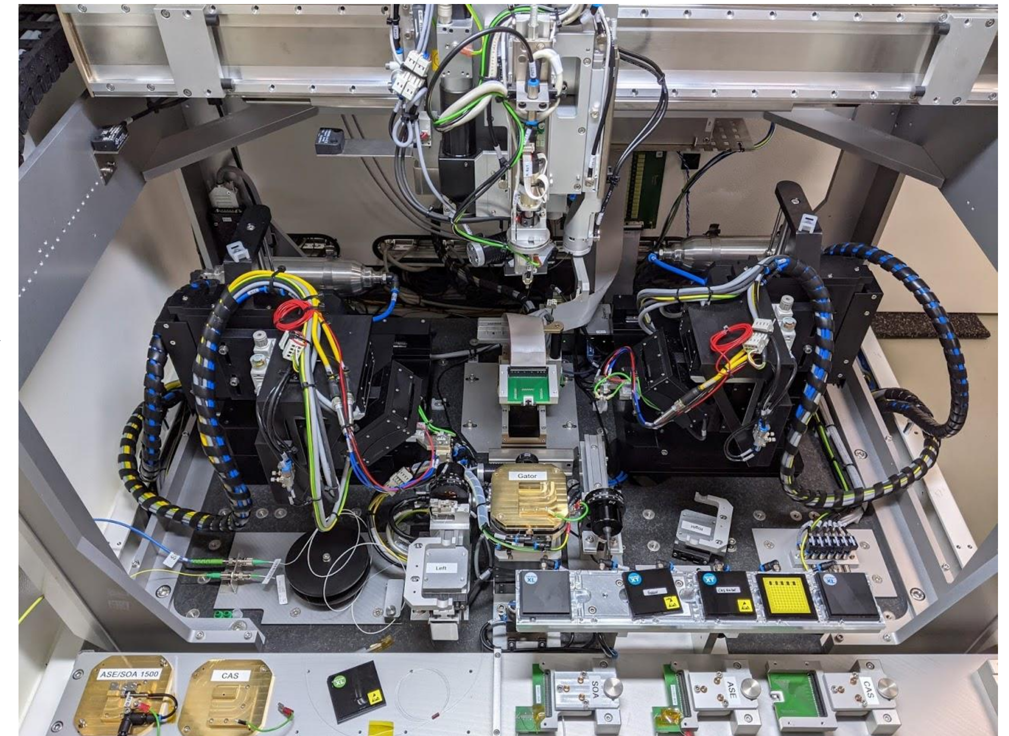


Validated according to MIL-STD-883
Equipment for pull test has been validated with Gage R&R study to be <<10%

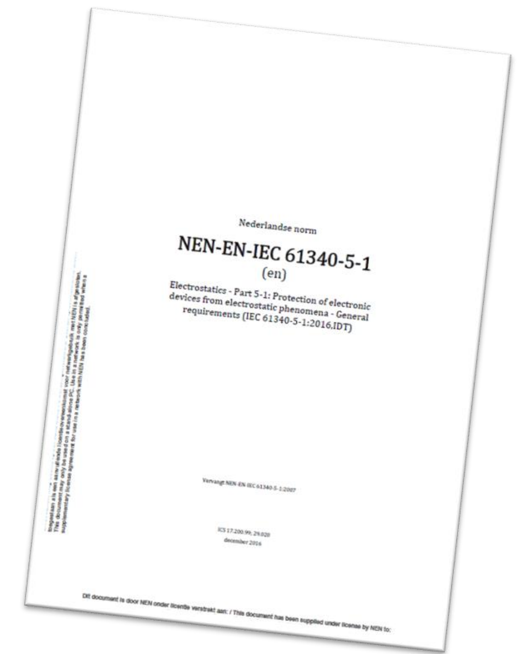
Volume PIC Testing

- Test facility for full opto-electronic characterization, testing, qualification

- Full die-testing process automated for volume production PICs



Facility Control


Nederlandse norm

NEN-EN-IEC 61340-5-1
(en)

Electrostatics - Part 5-1: Protection of electronic devices from electrostatic phenomena - General requirements (IEC 61340-5-1:2016,IDT)

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ElectroStatic Discharge (ESD) can damage PIC’s!

- All materials can tribocharge and generate electro-static charges
- Discharges < 3000V you cannot feel, hear or see.
- Voltages of < 100V can already damage PIC’s
- <u>Most ESD damage is latent → 85% exposes within 1,5 year</u>

Take care of a safe environment when handling PIC’s

- Work in an EPA (ESD Protected Area) when handling PIC’s.
- Use storage material with shielded properties.

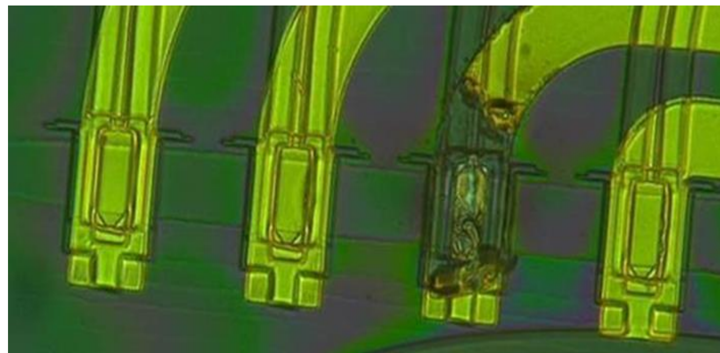
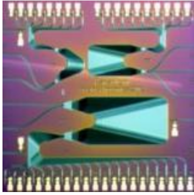


Figure. ESD damage on PIC Photodiode

Thank you



PIC

Product

Thank you for your attention.
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