A Closer Look at PIC Packaging – Motivation, Trends, and Challenges

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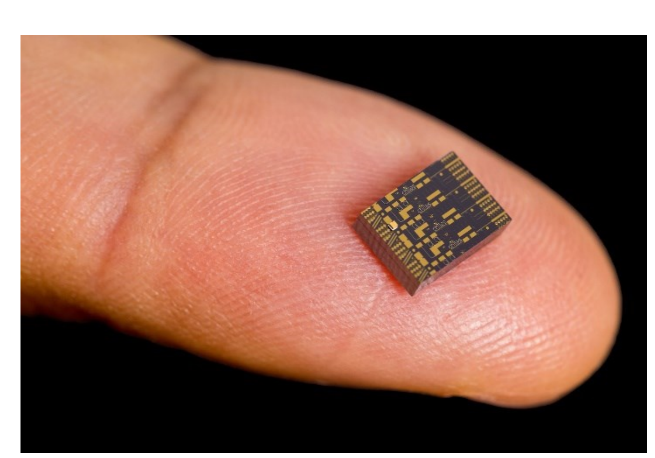
Who Are We?

PHIX is a world leading foundry for packaging and assembly of Photonic Integrated Circuits (PICs) and MEMS, supplying components and modules in scalable production volumes.

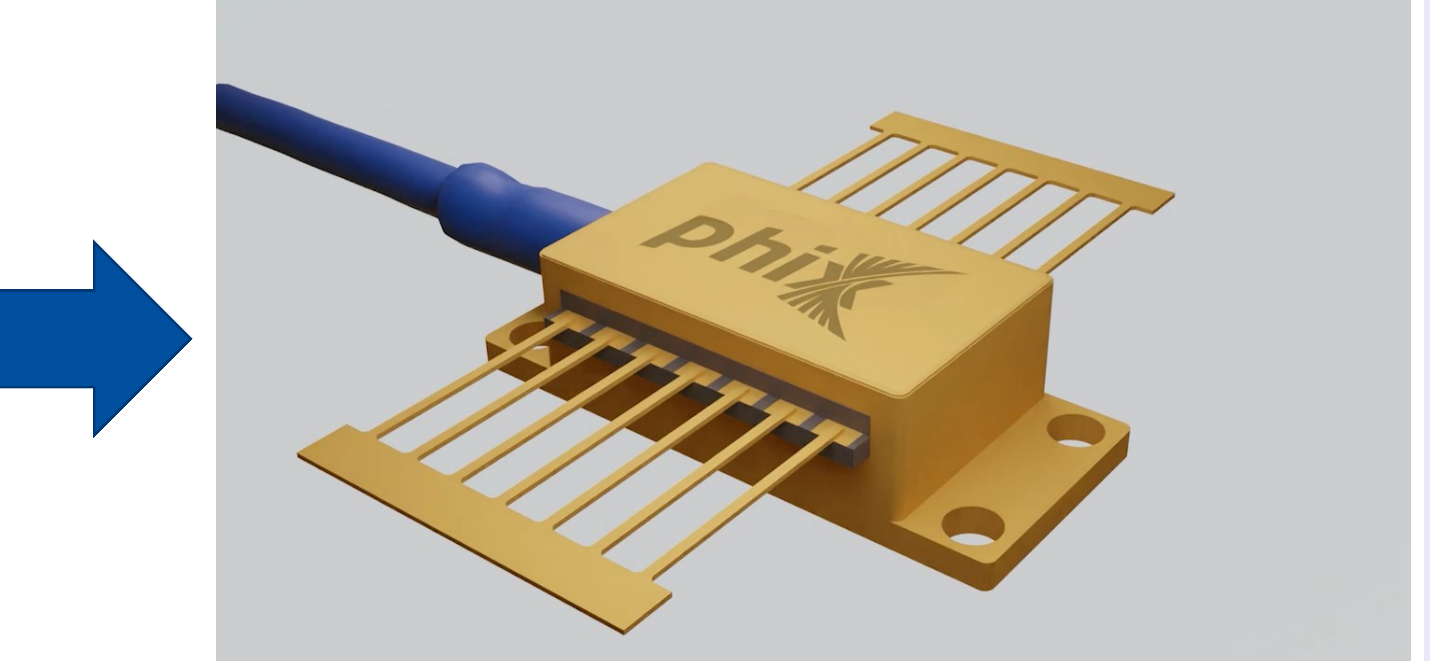
- Started operations in 2018
- Independent pure play packaging facility
- Specialized in hybrid PIC assembly and fiber array interfacing

High Tech Factory at University of Twente where PHIX is currently located

What Do We Do?

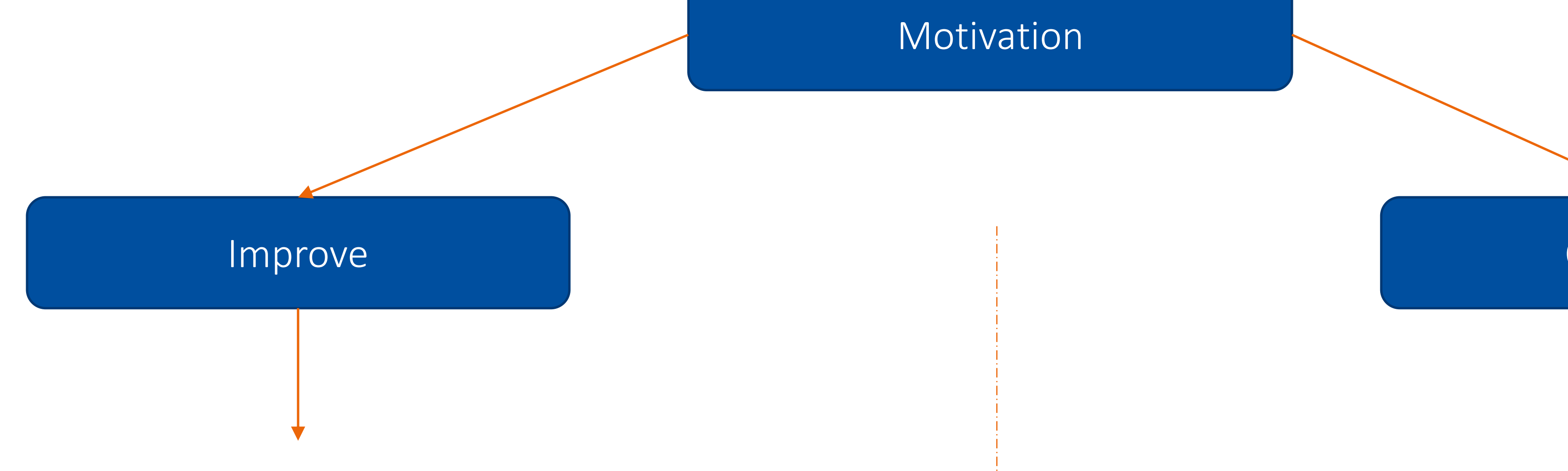


A PIC that needs to get packaged



An animation showing an example of the packaging

Motivation Behind PHIX – Why Packaging?



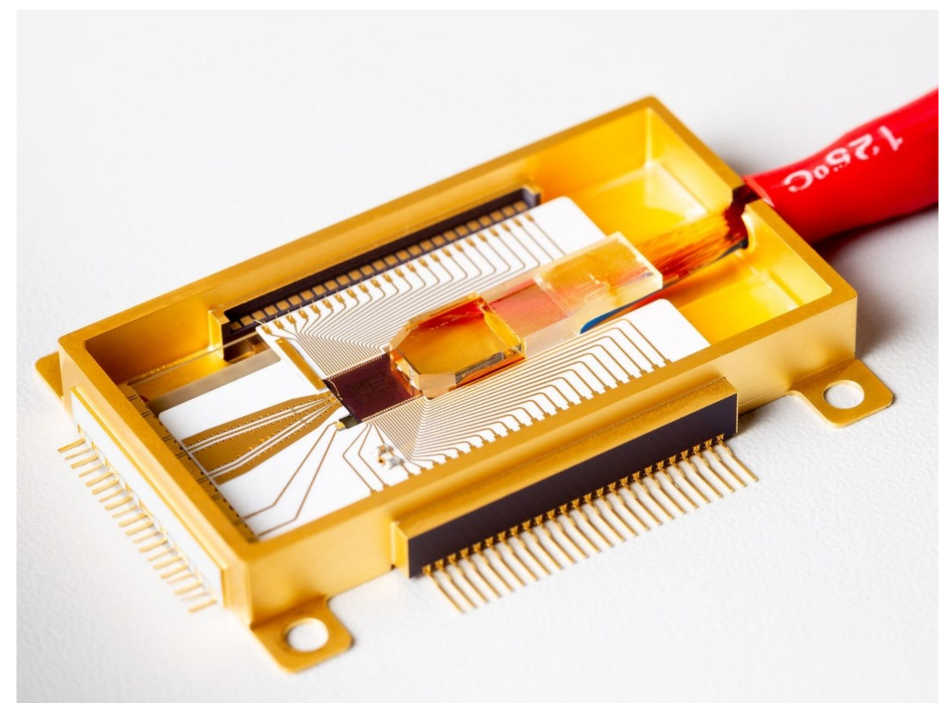
- Signal and Power Distribution
- Protection
  - Mechanical
  - Electrical
  - Hermeticity
- Optical Performance
- Thermal Management

- Increased Costs
- Reduced Reliability
- Reduced Electrical Performance

Market Drivers

The market currently has a lot of drivers:

- Lower cost
- Integration
- Miniaturization
- Increasing I/O's
- Increasing Functionality/Area
- Higher Frequencies
- Robustness



An example of the packages provided by PHIX (Large Area Gold Box)

How To Reduce Packaging Costs?

- Product and Process development accounts for more than 60% of the packaging costs
- If there is standard packaging solutions that the customers can choose from, the packaging costs will decrease
- Devices should be optimized for packaging in early design phases
- Eliminate SSC's and Polarisation Maintaining interfaces where possible
- Have margin in the power budget to allow for manufacturing tolerances

Package Types

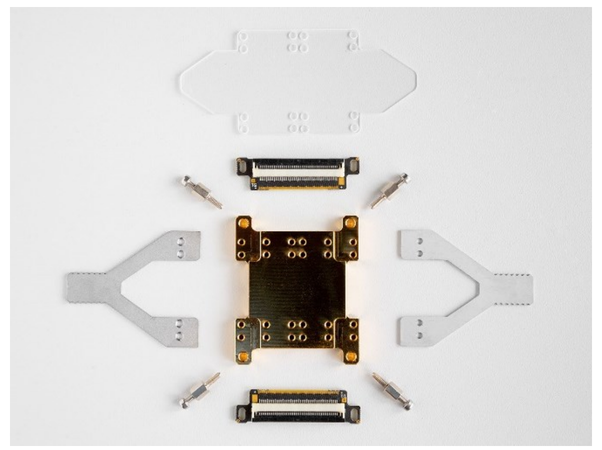
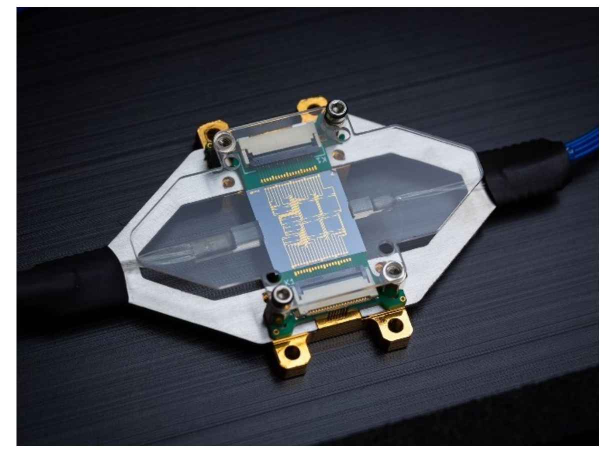
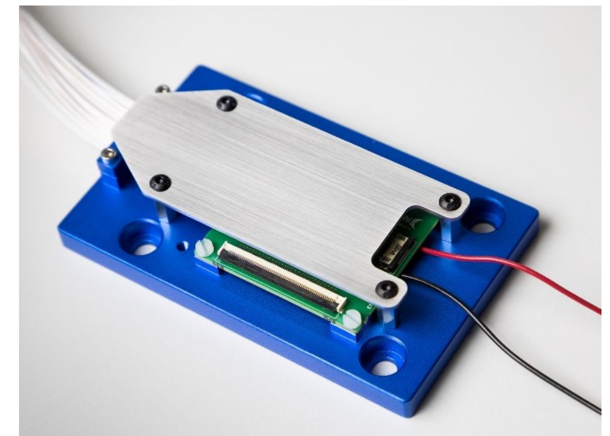
Prototype Packaging

Volume Packaging

Prototype Packaging

Prototype Packaging

- Chip measurements and system integration tests
- Feasibility studies and system demonstrators
- They provide a housing with electrical connections, optical interfaces, and thermal management
- Hybrid assembly of auxiliary chips is also supported
- 1-100 units

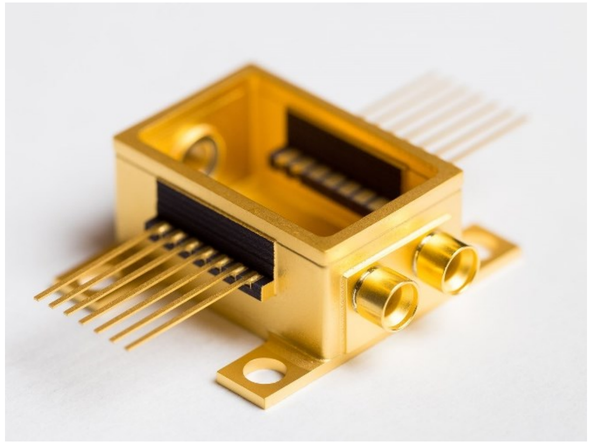
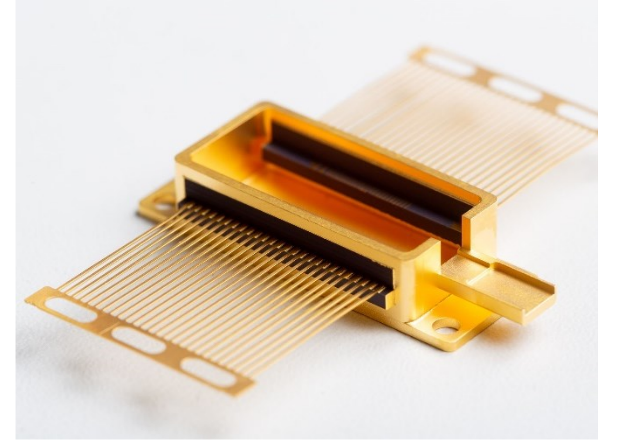
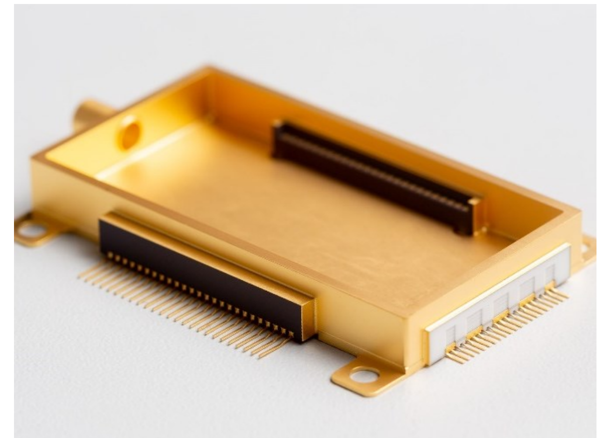




Examples of PHIX characterization packages

Volume Packaging

Volume Packaging

- Optimized for manufacturing and reliability
- Testing to firm acceptance criteria
- All major material platforms, such as Silicon Photonics, SiN, InP, PLC, BTO, LiNbO3, are supported
- Can co-package multiple PIC technologies into one product
- 100+ units

Examples of PHIX standard packages for volume manufacturing

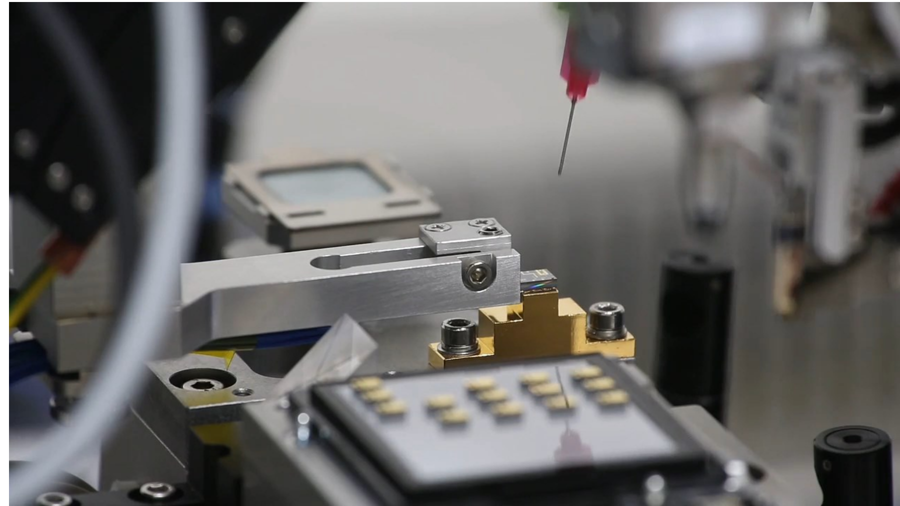
Volume Packaging continued: batch level automation

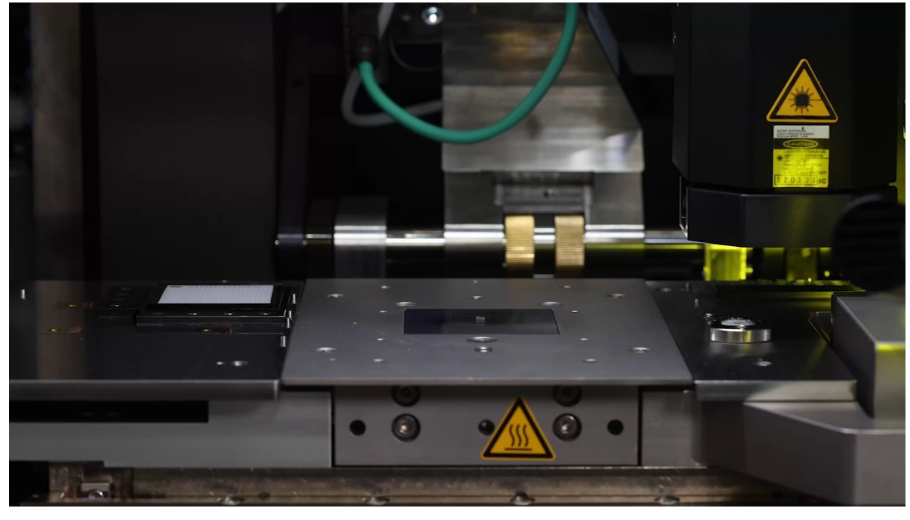
Manufacturing scale-up of:

- Hybrid tunable lasers
- LiDAR modules
- MEMS-based mass flow sensors

Automated processes for:

- Wire bonding
- Flip chip assembly
- Hybrid PIC edge coupling
- Fiber assembly
- Fiber attachment
- Epoxy dispensing
- and more…





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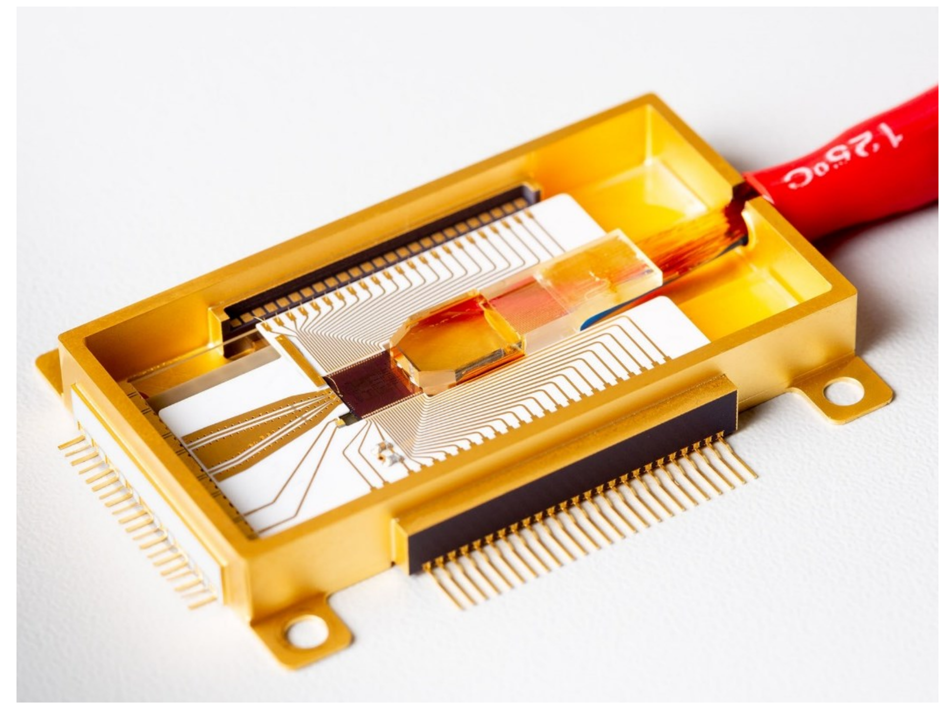
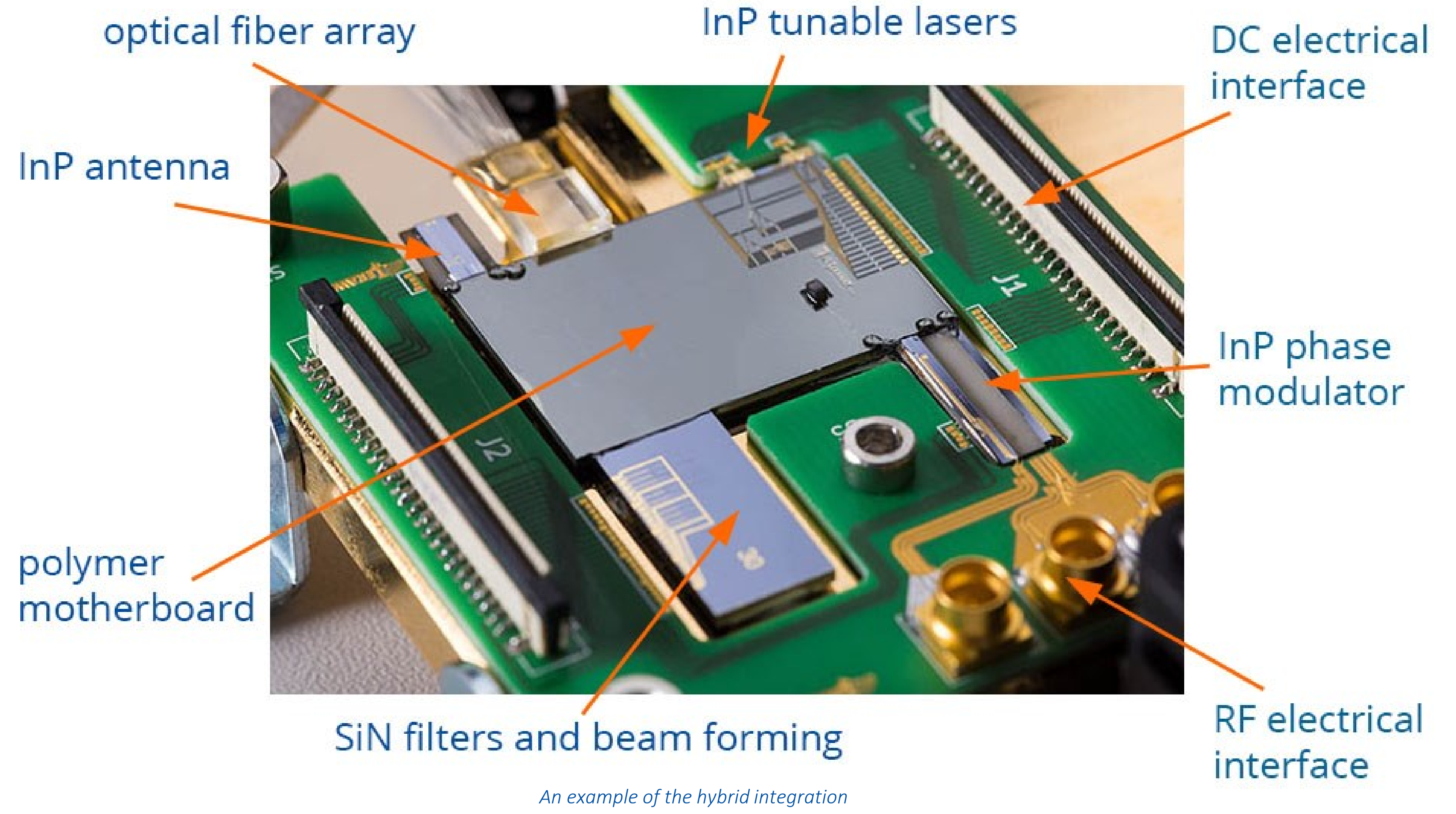


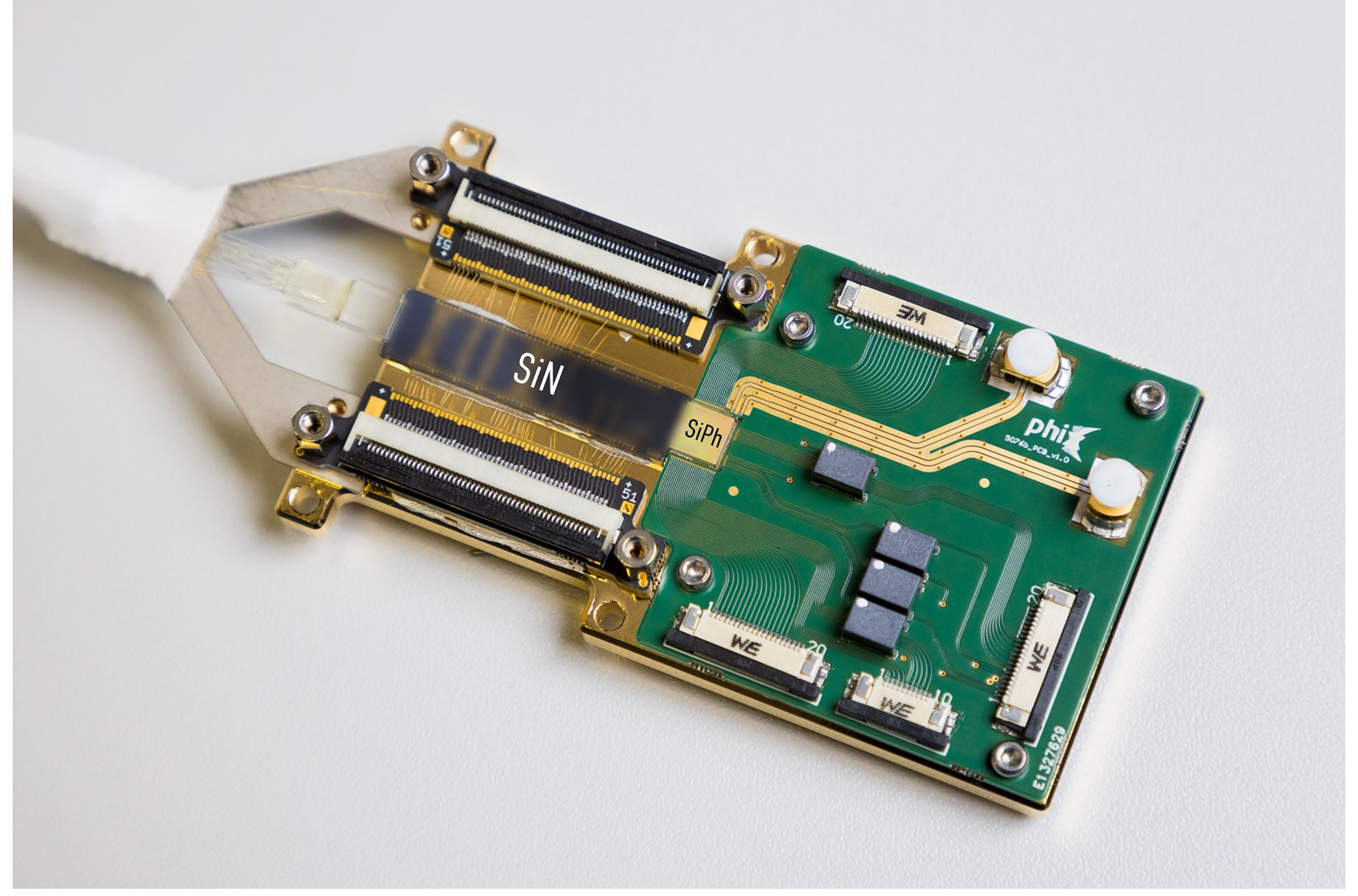
An example of the packages provided by PHIX (Large Area Gold Box)

Hybrid Integration – Leveraging the Best Properties of Each PIC Technology



An example of the hybrid integration

SiN and SiPh Prototype Module



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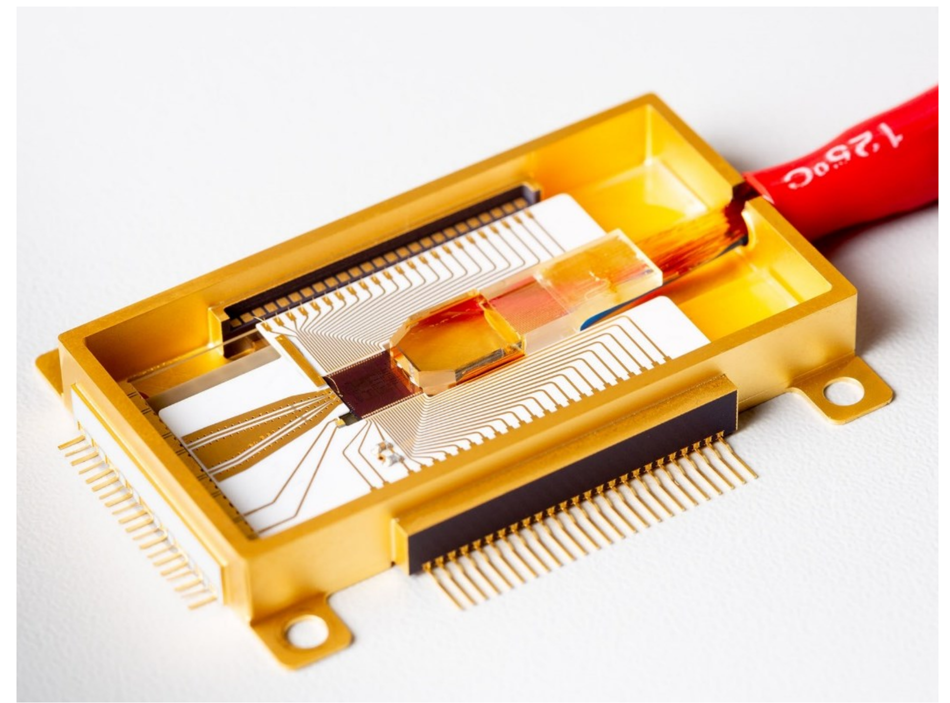

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It Is Not Always About Miniaturization!

Giant Qmode module

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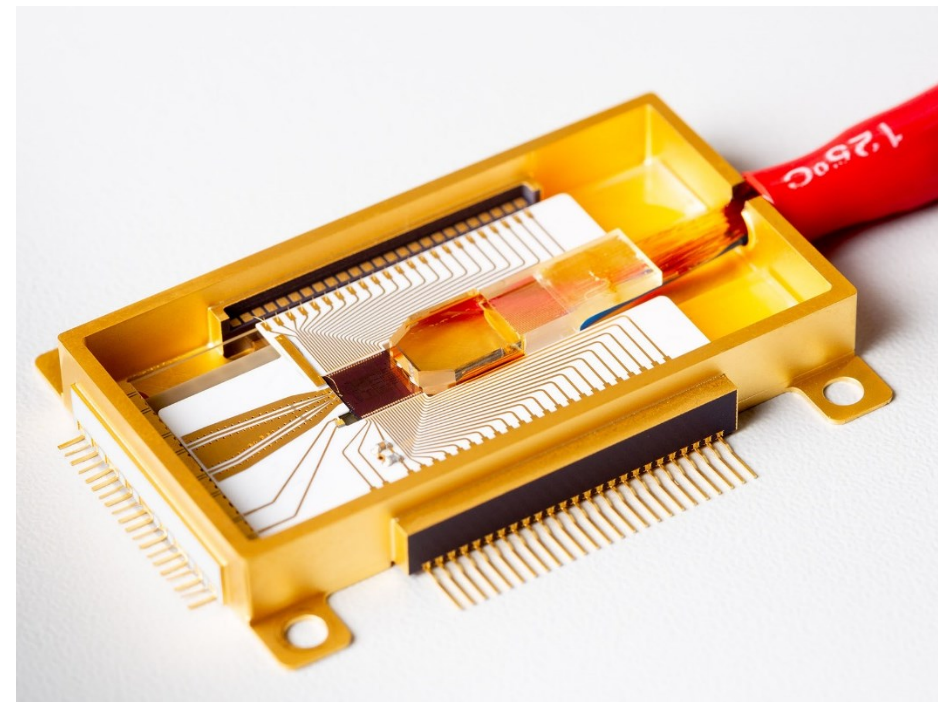

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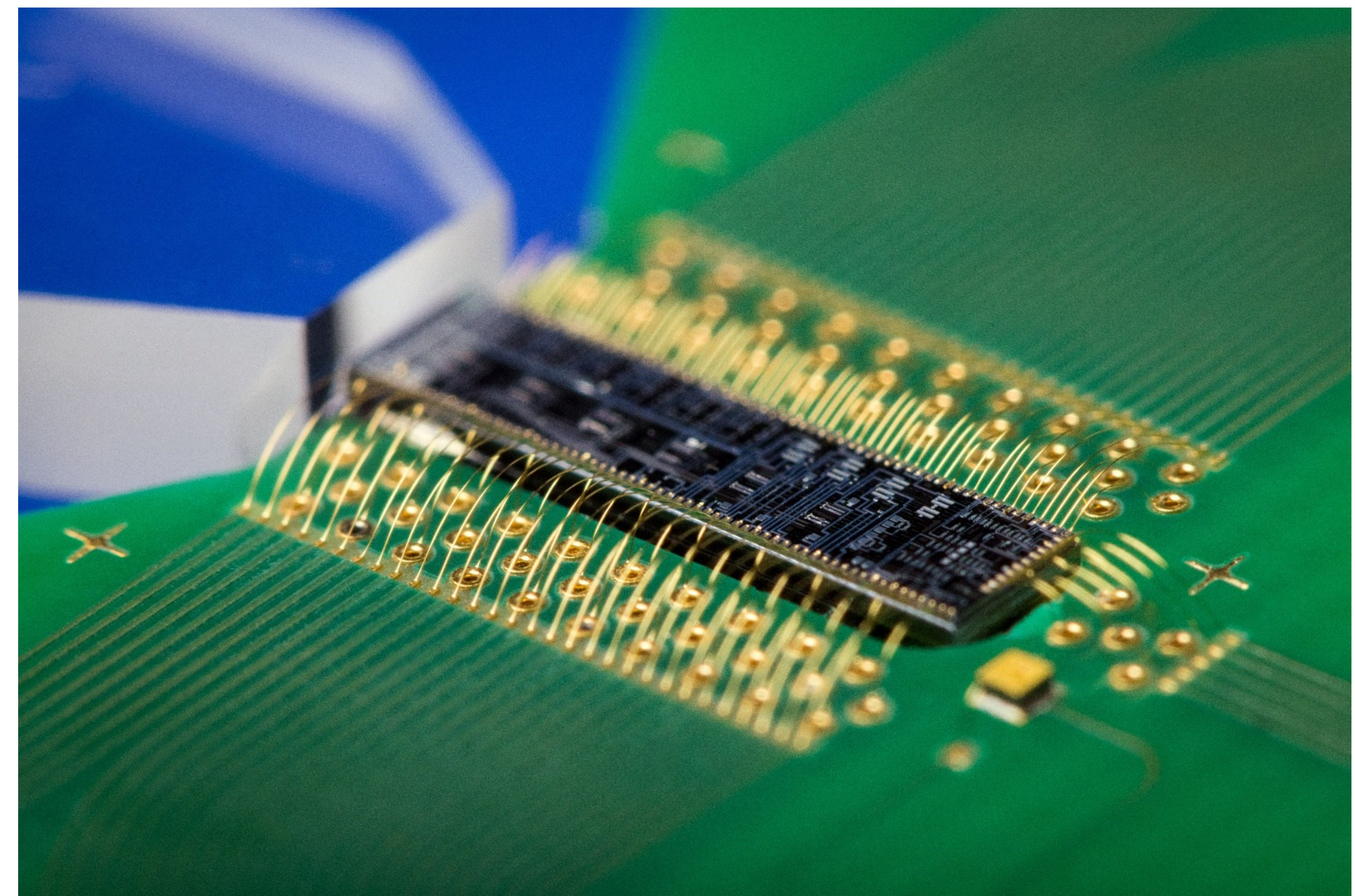
Increased I/O (density)



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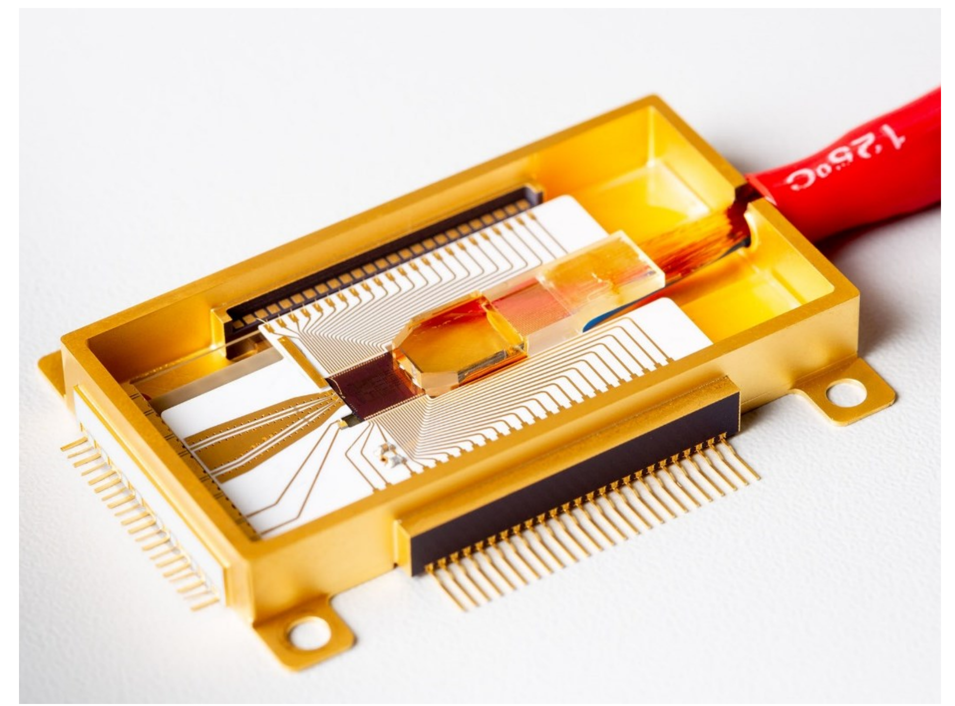

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Increasing Functionality/Area

3D printed lens on Silicon Photonics chip using Nanosribe 2PP tool

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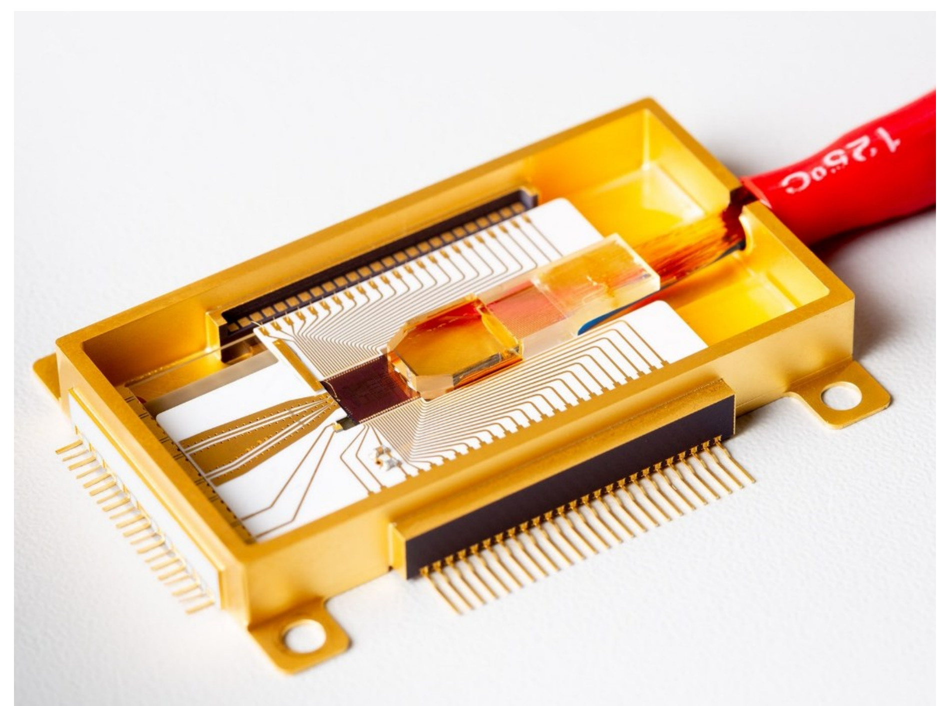

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Higher Frequencies

Module with a large RF interface built for Pilot Photonics

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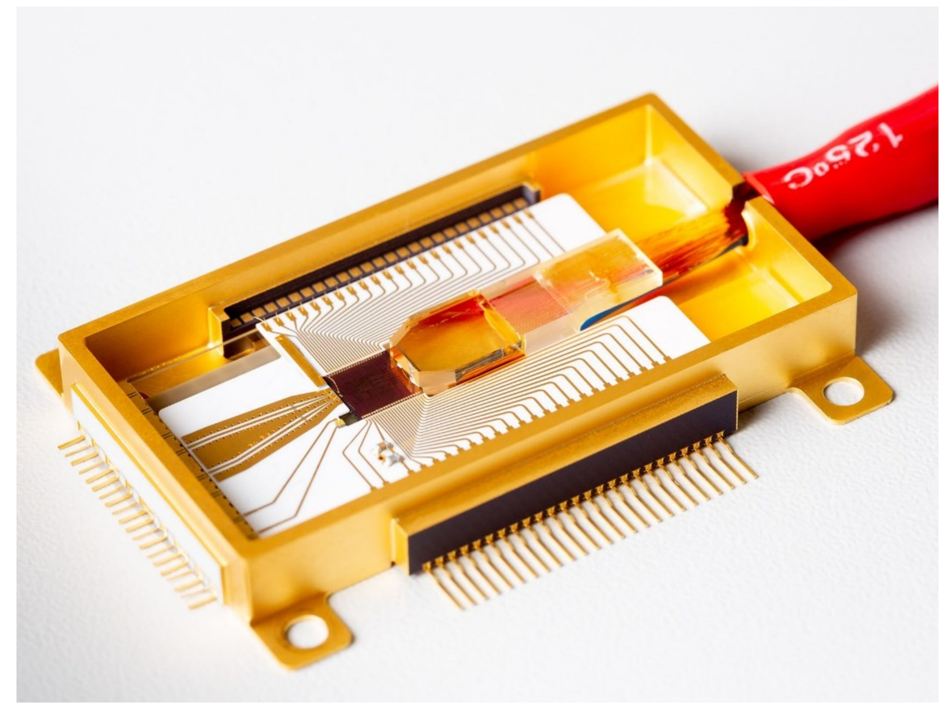

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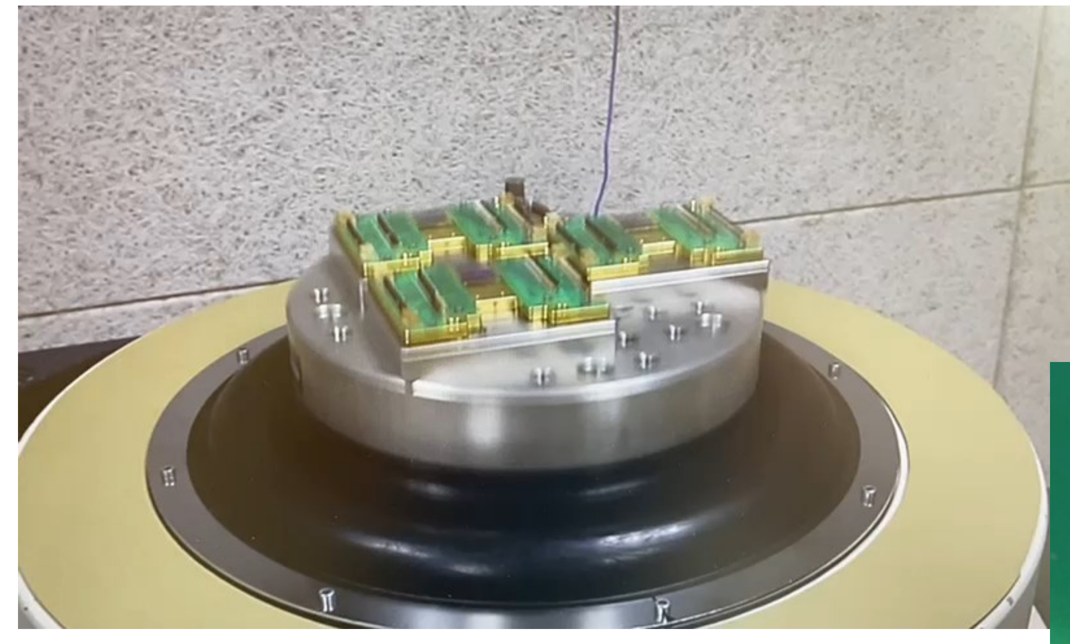
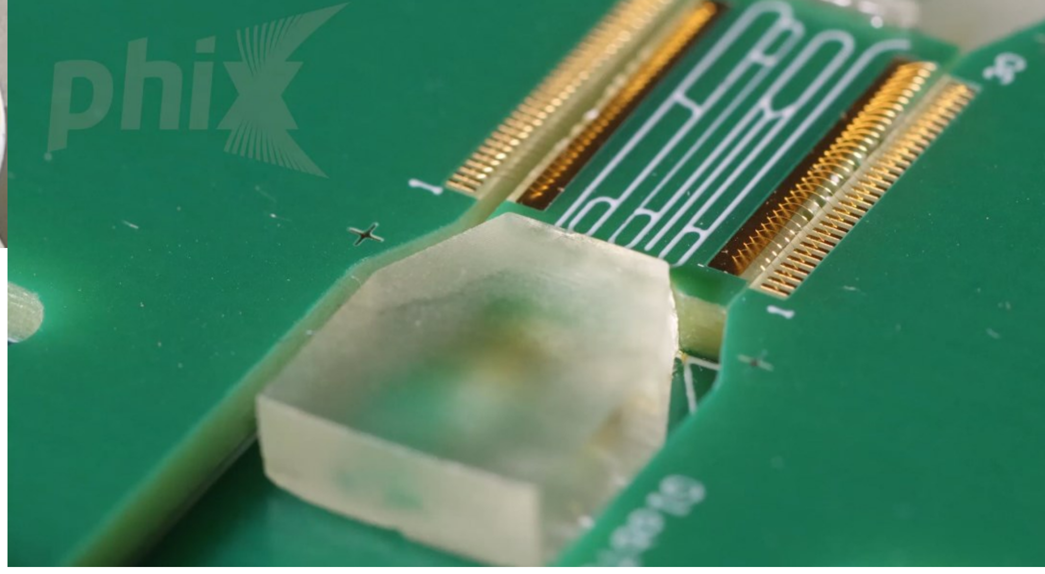
Robustness



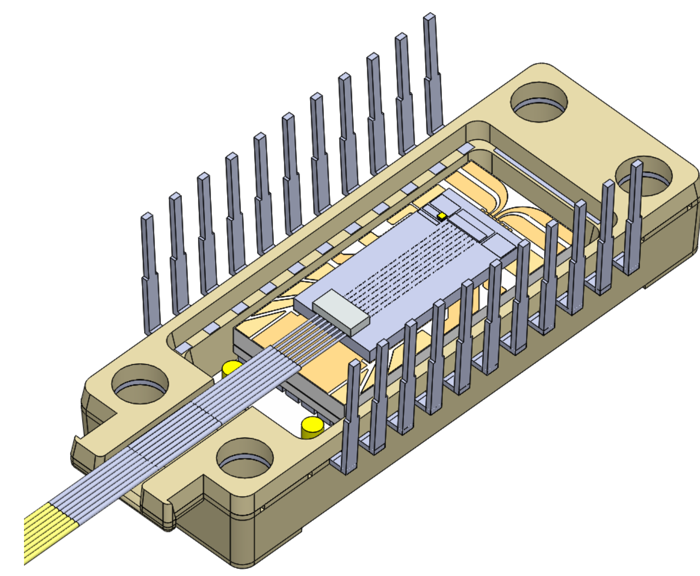
Module on shaker platform for validation



Local protection using automated glop top dispense

Take away's

- Packaging roadmap from prototype to qualified volume product
- Reuse of existing designs / knowledge
- New processes like 2 photon absorption, nanojoin material, cupper pillar soldering
- Chip interfacing (SSC, UHNA, SM, PM, Isolator)
- Photonics does not scale similar as electronics
  - Lack of on chip serialisers
  - Optical connections
  - Hermetic feedthrough
  - Automateability



Injection moulded leadfrome for fiber optics: Courtesy RJR Technologies

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	PHIX Characterization Package	PIXAPP Characterization Package	PHIX Butterfly	XLMD-MSA Butterfly	Large Area Gold Box
-- General --					
Appearance					
Solution domain	Sample characterization	Sample characterization	Device prototype / Small to medium-scale production	High-speed device prototype / Small to medium-scale production	Device prototype / Small to medium-scale production
Example applications	Initial custom proof-of-concept, photonic device learning cycle	Initial proof-of-concept using OTS PIXAPP design	Micro-ITLA, optical transmitter/receiver	Directly modulated laser, high-speed photodiode	Multi-chip photonic system module
Max. fiber count*	2 x 48	2 x 48	12	4	64
Fiber coupling scheme	Edge coupling, quasi-planar grating coupling, low-profile vertical grating coupling	Edge coupling, quasi-planar grating coupling, low-profile vertical grating coupling	Edge coupling, quasi-planar grating coupling	Edge coupling, quasi-planar grating coupling	Edge coupling, quasi-planar grating coupling
Spot size converter option	Yes	Limited by mechanical fit	Limited by mechanical fit	Limited by mechanical fit	Supported by most devices
Optional electrical fan-out	Yes, DC to header connector	No	No	No	Yes, 64 GHz RF fan-out
Documentation	Quick Start Guide (video)				