Physik Instrumente

# As Photonics Applications Multiply, New Ways to Subtract Costs

Scott Jordan
Head of Photonics
PI

# The PI Group

## Precision Automation, Nanopositioning, Piezo Technology

- ~1700 Employees
- 15 Subsidiaries
- Design & Service Centers in USA, Asia, Europe
- >100 man Years of Alignment Expertise

- Privately Owned – Not Driven by Quarterly Results
- Focused on Long Term Relationships w/Customers & Suppliers

**Americas**
North America
Central America
South America

**Europe**
PI UK
PI France
PI Italy
miCos Iberia
PI Benelux

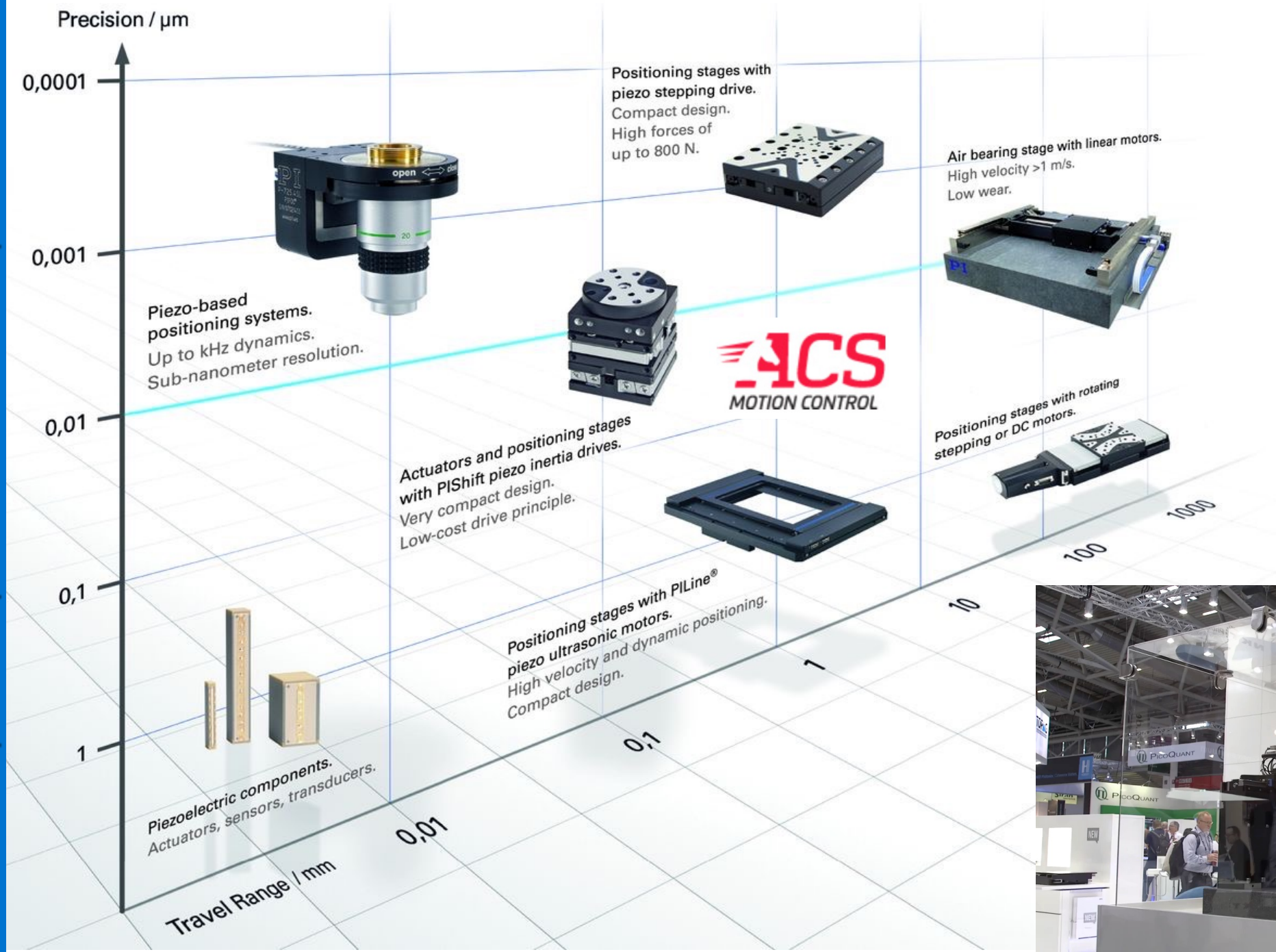
**Germany**
**PI Karlsruhe**
**PI Ceramic**
**PI miCos**

**Israel**
ACS MOTION CONTROL

**Asia**
PI Japan
**PI Shanghai**
PI Singapore
PI Taiwan
PI Korea

50 YEARS ENABLING INNOVATION SINCE 1970

PI's spectrum spans the world of ultra-precision

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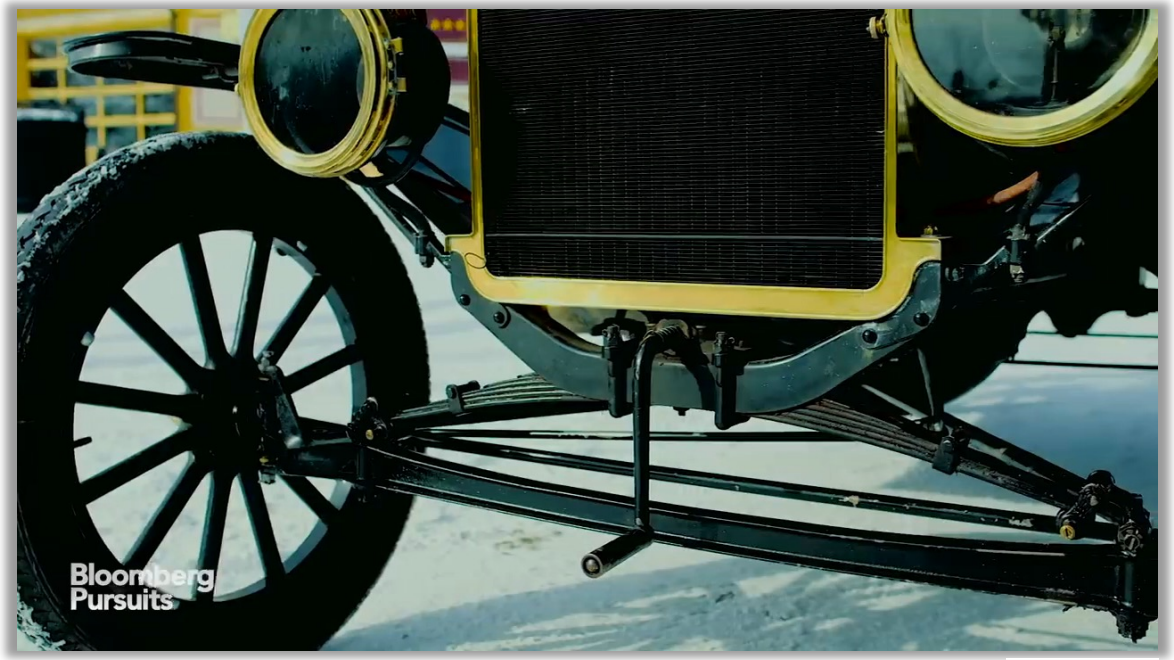
PI's Engineered Systems Group Builds World-Class Automation Platforms

# After Motion Control: *Micro-Robotics*

**Built-in functionality *and intelligence* mark the future (and not just for motion control)**




Courtesy Bloomberg
"Driving a Ford Model T Is a Lot Harder Than You'd Think!"

***"Do what I tell you to do"***

- **Accelerate**
- **Brake**
- **Turn…**

Courtesy Tesla
"Full Self-Driving"

***"Do what I <u>want</u> you to do"***

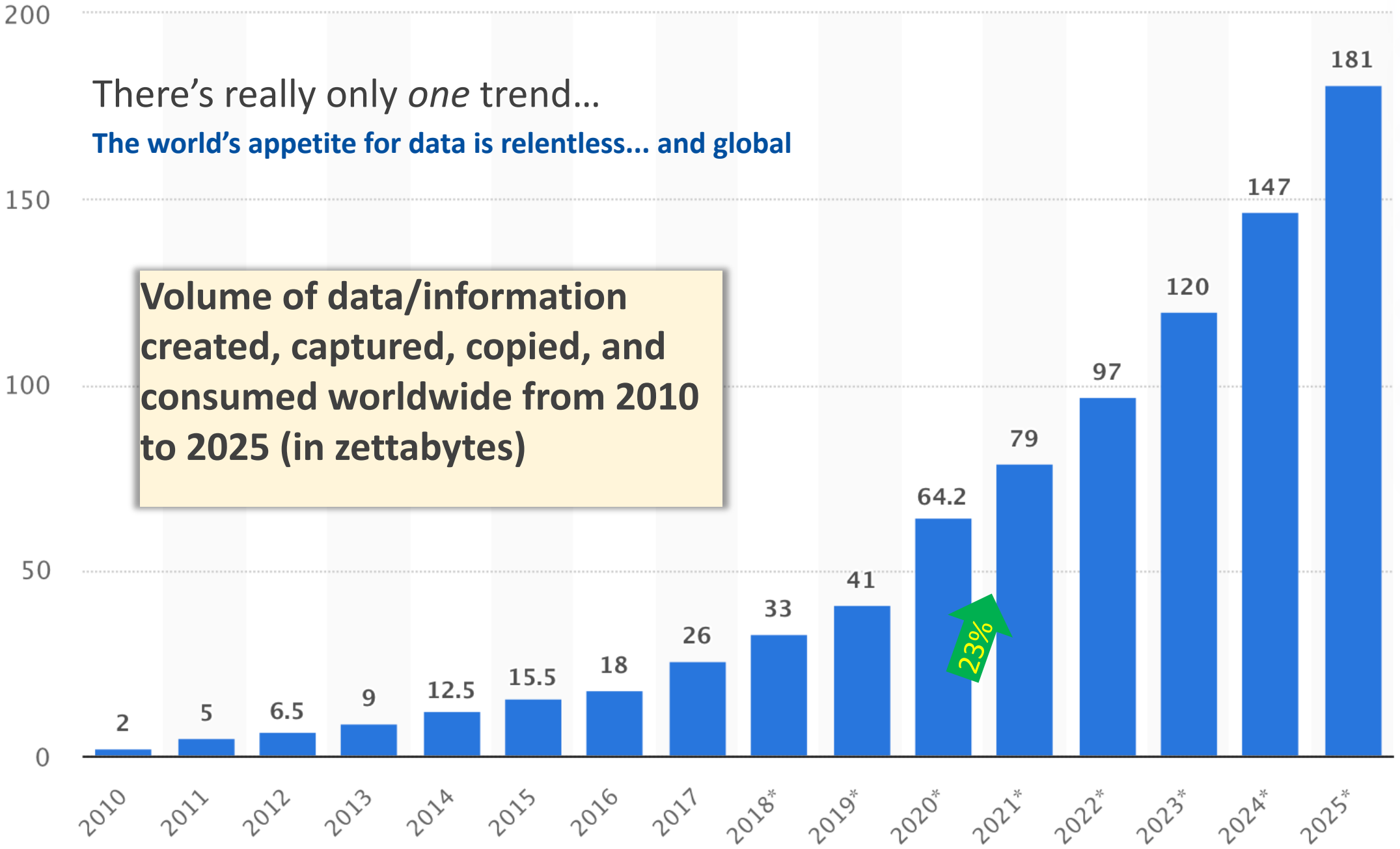
- **Go to Aldi**

"10 exabytes per month"
--VisualCapitalist.com

# There's really only *one* trend…

**The world's appetite for data is relentless… and global**

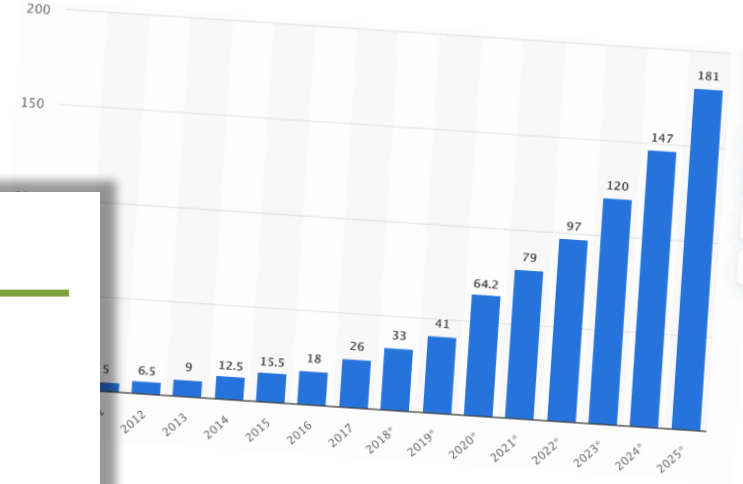
**Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2025 (in zettabytes)**

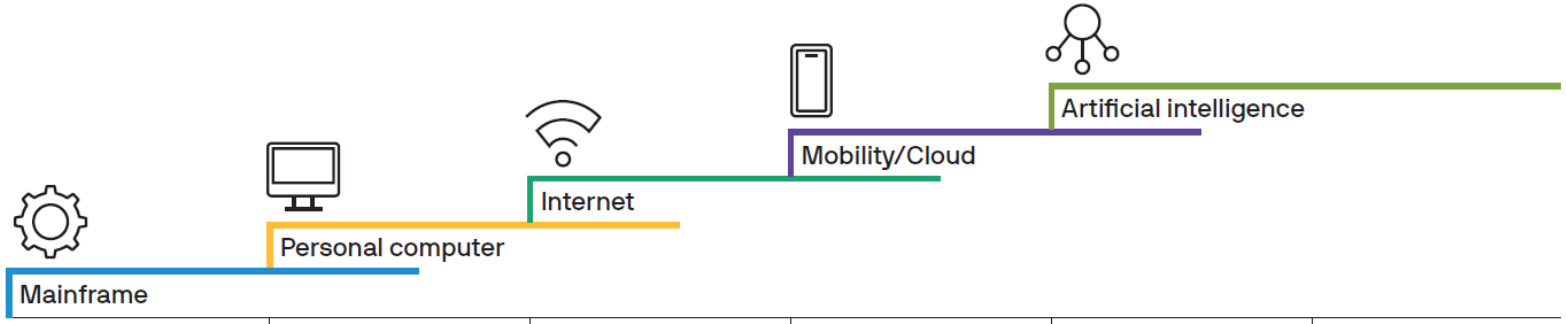



*Throughout: Latest available data from credible sources*

https://www.statista.com/statistics/871513/worldwide-data-created/

# AI: The new accelerant



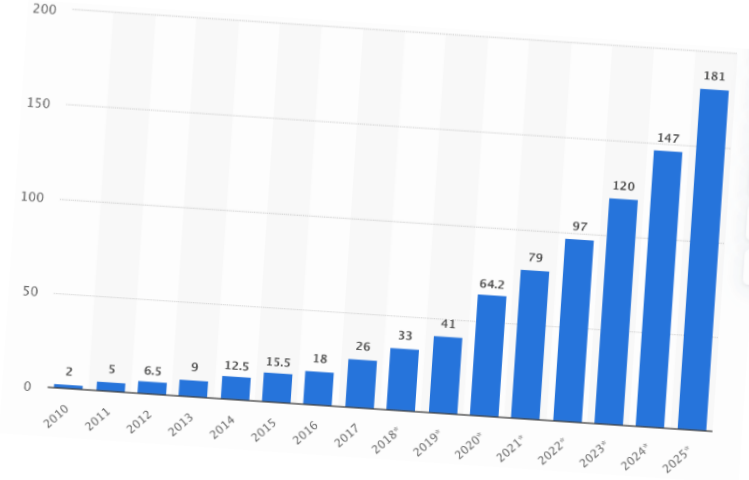




| 1980 | | 1990 | | 2000 | | 2010 | | 2020 | | 2030 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Company | Mkt cap (USD bn) | Company | Mkt cap (USD bn) | Company | Mkt cap (USD bn) | Company | Mkt cap (USD bn) | Company | Mkt cap (USD bn) | Company | Mkt cap (USD bn) |
| IBM | 38 | IBM | 54 | Microsoft | 604 | Microsoft | 269 | Apple | 2,232 | | |
| Eastman Kodak | 8 | Panasonic | 33 | Cisco Systems | 355 | Google | 197 | Microsoft | 1,682 | | |
| Xerox | 5 | Toshiba | 27 | Intel | 274 | Apple | 191 | Amazon | 1,634 | | |
| Hewlett-Packard | 4 | NEC | 19 | Lucent Technologies | 238 | IBM | 171 | Alphabet | 1,185 | | |
| Emerson Electric | 2 | Fujitsu | 19 | Nokia | 210 | Cisco Systems | 138 | Facebook | 778 | ? | |
| Texas Instruments | 2 | Mitsubishi Electric | 16 | IBM | 193 | Oracle | 123 | Tencent | 698 | | |
| Motorola Solutions | 2 | Eastman Kodak | 13 | Oracle | 158 | Hewlett-Packard | 122 | Tesla | 669 | | |
| Nortel Networks | 2 | Sanyo Electric | 13 | Nortel Networks | 139 | Intel | 113 | Alibaba | 649 | | |
| Intel | 1 | FUJIFILM Holdings | 12 | Sun Microsystems | 135 | Samsung | 88 | Samsung | 501 | | |
| Harris | 1 | Hewlett-Packard | 11 | Dell | 130 | QUALCOMM | 77 | TSMC | 489 | | |

"Often, when a major platform shift occurs – think mainframes to minicomputers, PCs to mobile devices, CPUs to GPUs (central processing units to graphics processing units) – it creates entirely new pools of demand. In the next few years, we expect a record pace of new, densely packed, high powered data center builds. These will be filled with GPUs, custom silicon, advanced memory packages and photonics to support network bandwidth."

--J.P. Morgan Asset Management, 10/2023

# mm-scale to planetary scale, humanity's appetite for data drives Photonics



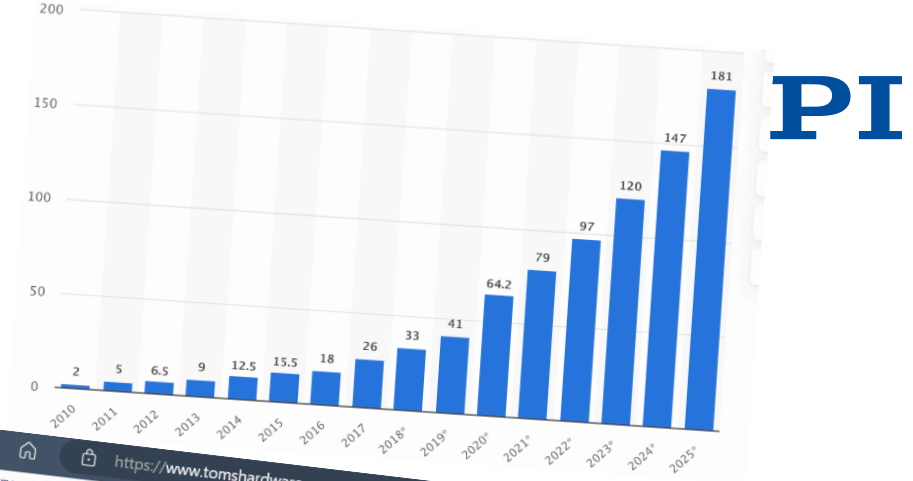


"...a chip maker could build a co-packaged optical transceiver on to the edge of a package, and then use UCIe to connect it to another chiplet..." *--Anandtech*

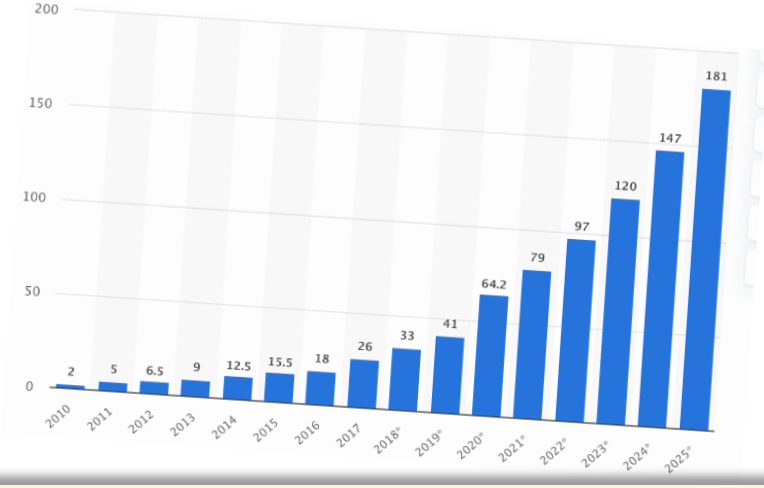
"Good ideas are always crazy until they're not."
*--Elon Musk*

# mm-scale to planetary scale, humanity's appetite for data drives Photonics


"...a chip maker could build a co-packaged optical transceiver on to the edge of a package, and then use UCIe to connect it to another chiplet..." *--Anandtech*




mm-scale to planetary scale,
humanity's appetite for data drives Photonics

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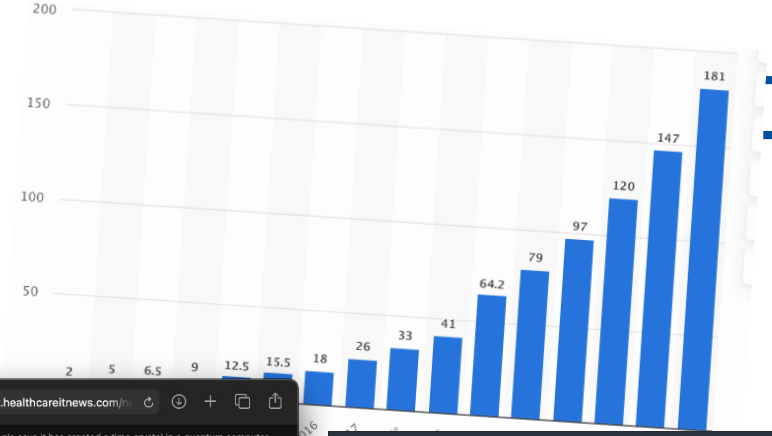
"Introducing inter-chip optical interconnects could obliterate bandwidth and capacity limitations coming from today's copper interconnects, which are hampered by impedance mismatches between the CPU and the dual-inline memory modules."

--Dongjae Shin, Samsung, at PIC 2019

# Observation:

## Silicon Photonics is *not just about the data center anymore*




PI

Expanding the Range: Wearables

https://www.photonics.com/Articles/Expanding_the_Range_...

PHOTONICS spectra

**Expanding the Range: Wearables Enable the Next Level of Mobile Health Data Monitoring**

Deep UV Powers Micro-LED Manufacture

*LED arrays, specialized lasers, and a gamut of sensors mark the newes devices, capable of detecting the early onset of cancer and other disease*

DOUGLAS FARMER, SENIOR EDITOR DOUG.FARMER@PHOTONIC

The next generation of wearable devices will no longer be created only fo monitor their daily steps or heart rate on a smartwatch. Increasingly sop components such as LED arrays and specialized lasers, as well as a gamu contained within mobile equipment attached to the body, will be able to both the visible and infrared ranges.

www.healthcareitnews.com/n

Deloitte's quantum computing leader on the technology's healt...

Google says it has created a time crystal in a quantum computer...

Healthcare IT News

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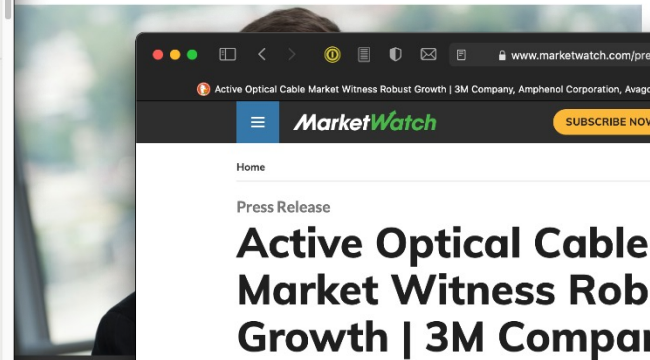
**Deloitte's quantum computing leader on the technology's healthcare future**

tum computing offers significant speed and analytics power and
ts the ability to track and diagnose disease, modernize supply chains
elp with drug discovery, says Scott Buchholz.

Siwicki | August 17, 2021 | 11:44 AM



Buchholz, emergin
Deloitte Consulting

Health and Life Sc
Experience Surve
ps://googleads.g.doublec

This Chip for AI Works Using Ligl

https://www.wired....

WIRED BACKCHANNEL BUSINESS CULTURE GEAR IDEAS POLITICS SCIENCE SECURITY MERCH SIGN

**This Chip for AI Works Using Light, Not Electrons**

Lightmatter says the computing and power demands of complex neural networks need new technologies like thes

inal computer motherboard. COURTESY OF LIGHTMATTER

atabase →

UD COMPUTING END USER: BIG COMPANY

DUCTORS TECHNOLOGY: PHOTONICS, CHIPS

FOR artificial intelligence grows, so does hunger for power needed to keep AI running.

TRENDING NOW

spectrum.ieee.org/lidar-on-a-chip-at-l

Aeva Unveils Lidar on a Chip - IEEE Spectrum

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**Aeva Unveils Lidar on a Chip** › Aeva says its high-performance lidar will sell for less than US $500; VW is buying it

BY PHILIP E. ROSS | 11 DEC 2019 | 3 MIN READ

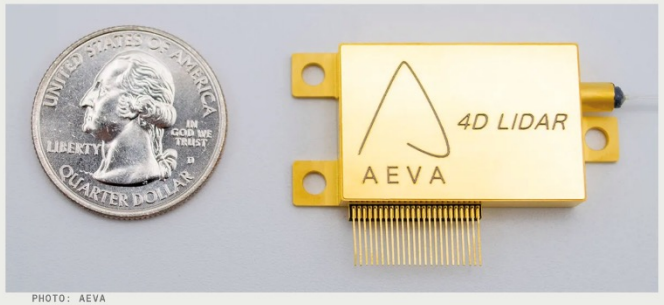


PHOTO: AEVA

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Press Release

**Active Optical Cable Market Witness Robust Growth | 3M Company, Amphenol Corporation, Avago Technologies Limited**

Published: July 8, 2021 at 4:00 p.m. ET

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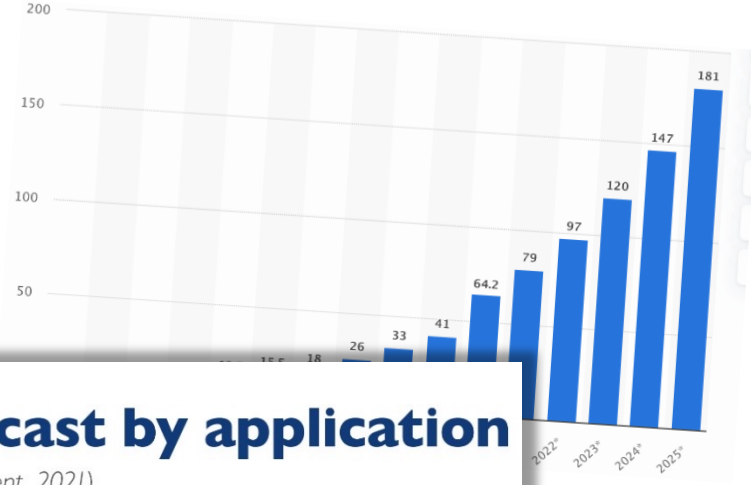
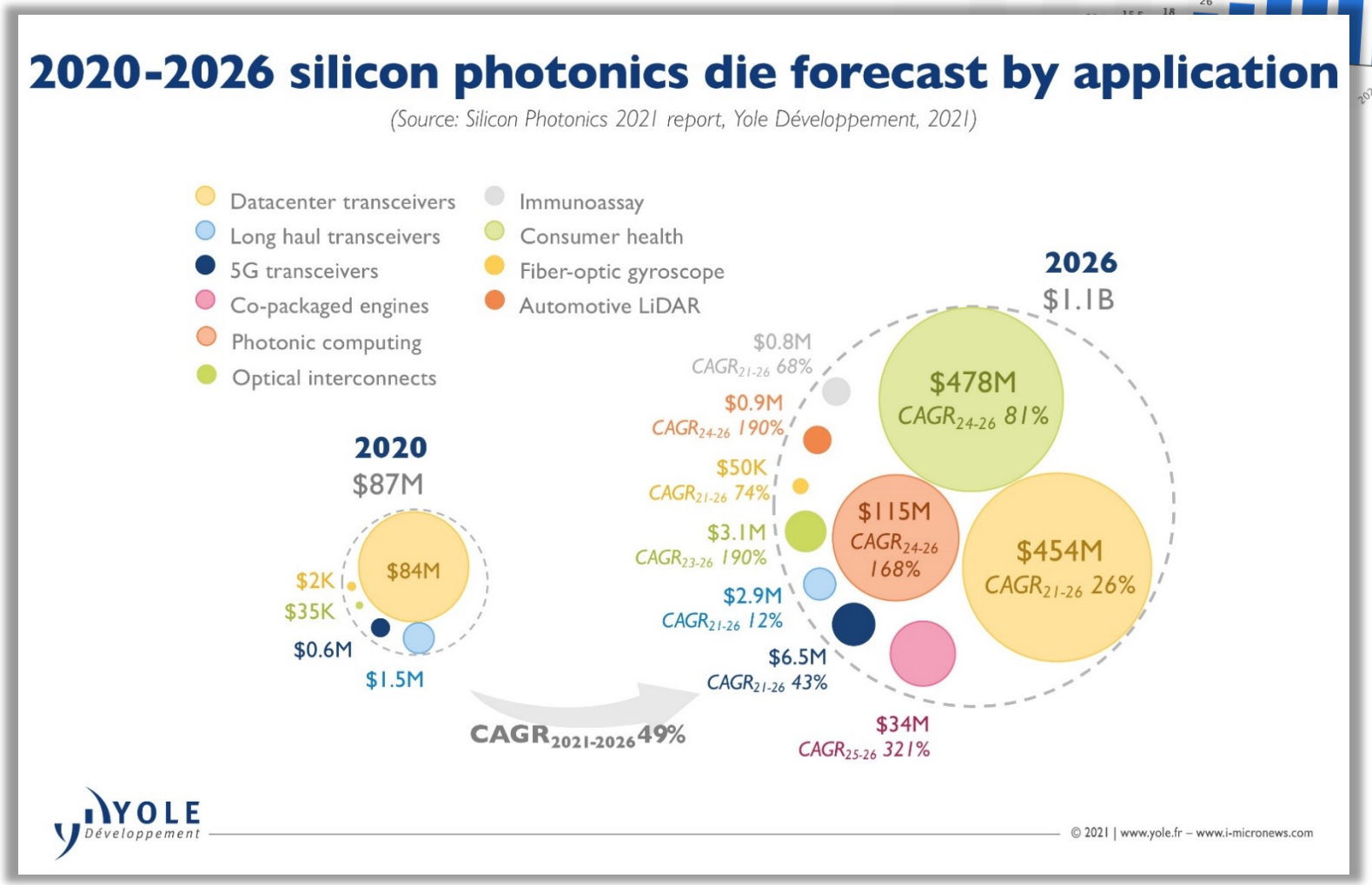
*The MarketWatch News Department was not involved in the creation of this content.*

Jul 08, 2021 (AB Digital via COMTEX) -- Active Optical Cable Market By

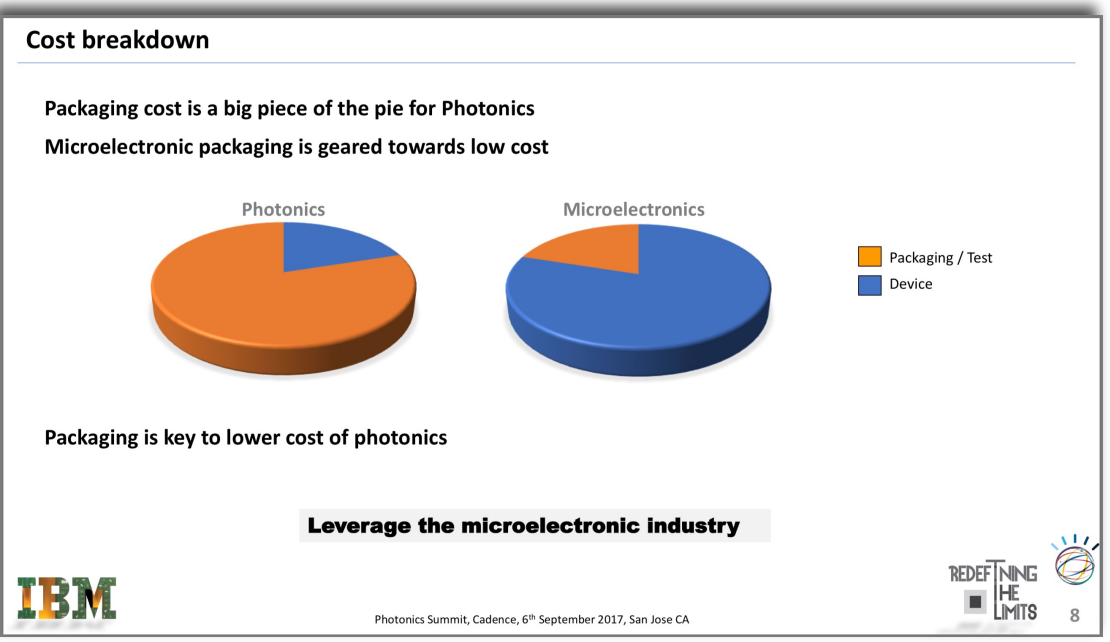
# Driving Photonics: New applications

→ *no single point of market failure*



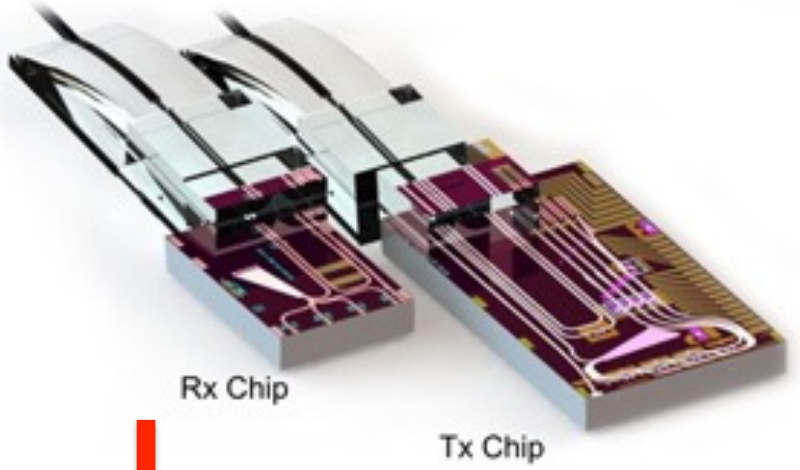



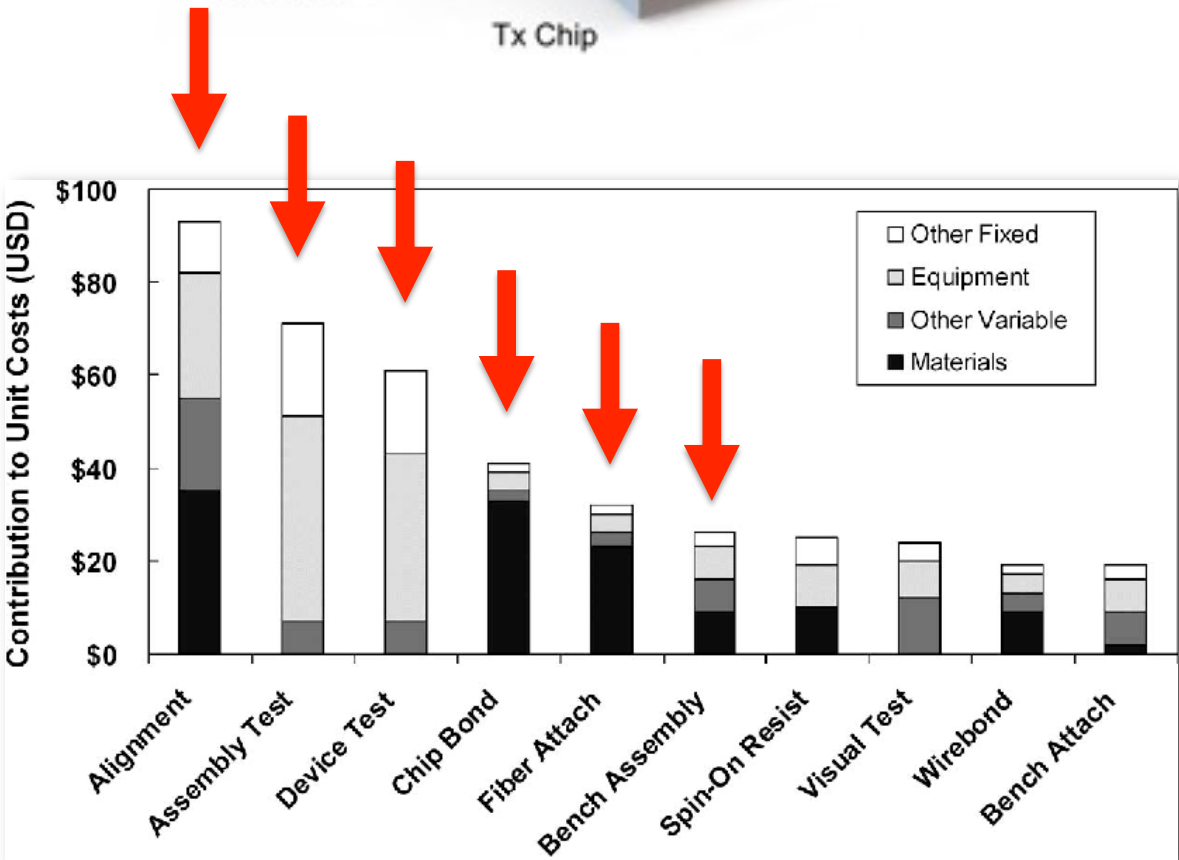
# Alignment: The Repetitive Cost




"Automated High-Throughput Assembly for Photonic Packaging", Barwicz et al, *Photonics Summit*, Cadence, 2017, https://www.cadence.com/content/dam/cadence-www/global/en_US/documents/company/Events/summits/photonics/fortier-2017.pdf

"Process-based cost modeling of photonics manufacture…", E. Fuchs et al, J. Lightwave Tech., 2006, https://www.semanticscholar.org/paper/Process-based-cost-modeling-of-photonics-the-cost-a-Fuchs-Bruce/125e24b2e2e71860f088526441ee5ce16e6ce42c



# A Modular Approach to Meet all Needs

**Hexapods**

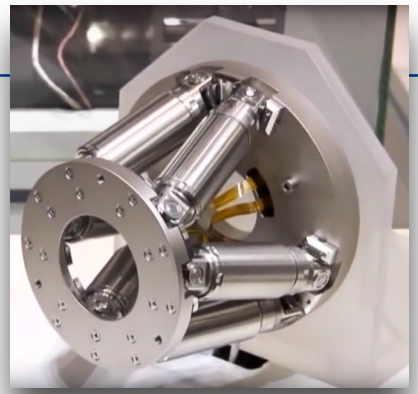
- Trajectory is not defined by bearings
- Compact, 6 degrees-of-freedom, rigid
- No moving cables

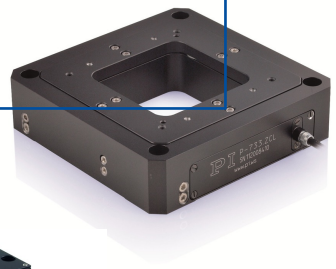
**Stacks**

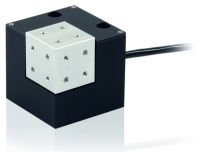
- Modular
- ACS controls

**Both**

- Rotate about optical channel, focus, etc.







**Use Nanocubes**:

- For speed
- For tracking
- For resolution

**Nanocubes & Air Bearings**

- Long lifetime, zero maintenance, no lubrication, nanometer resolution, high dynamics

**All**

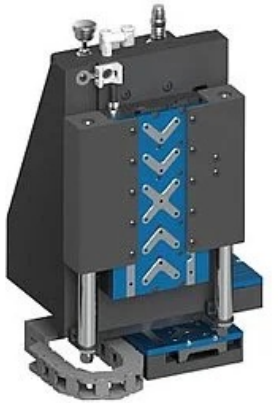
- Leverage proven technologies
- ***Firmware-based alignment***
- ***Parallel alignment processes***

# A Modular Approach to Meet all Needs

Unique: High-Speed Air Bearing stacks for Alignment

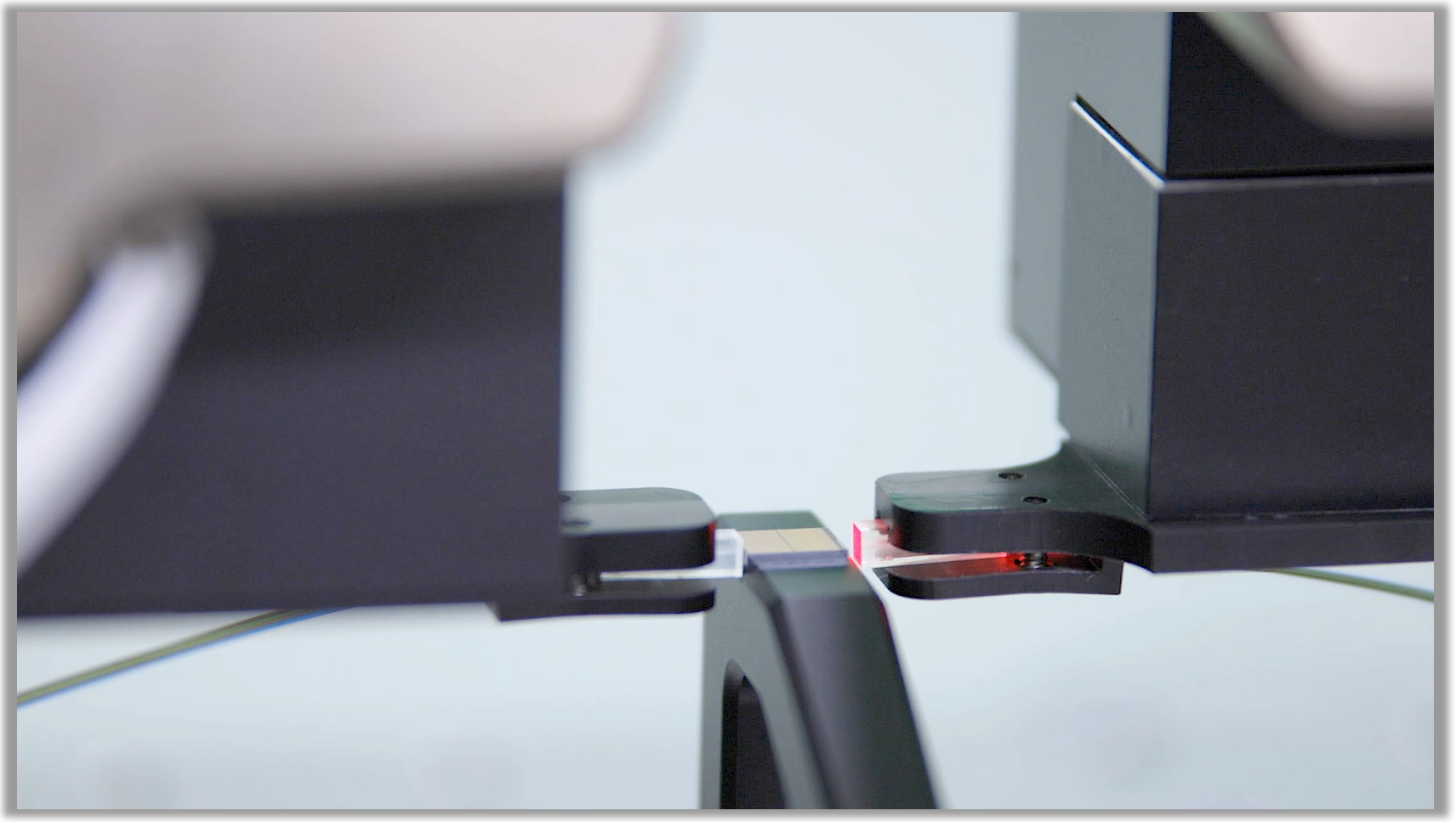
- Unlimited lifetime
- No lubricants
- Clean
- Up to 6DOF



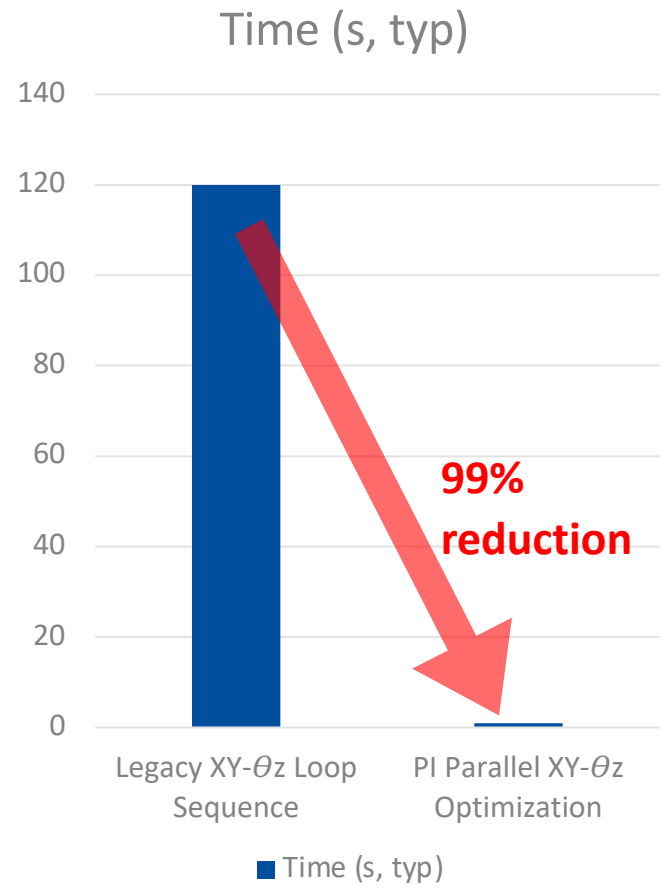





ACS MOTION CONTROL



## PI's Novel Parallel Multi-DOF Optimization

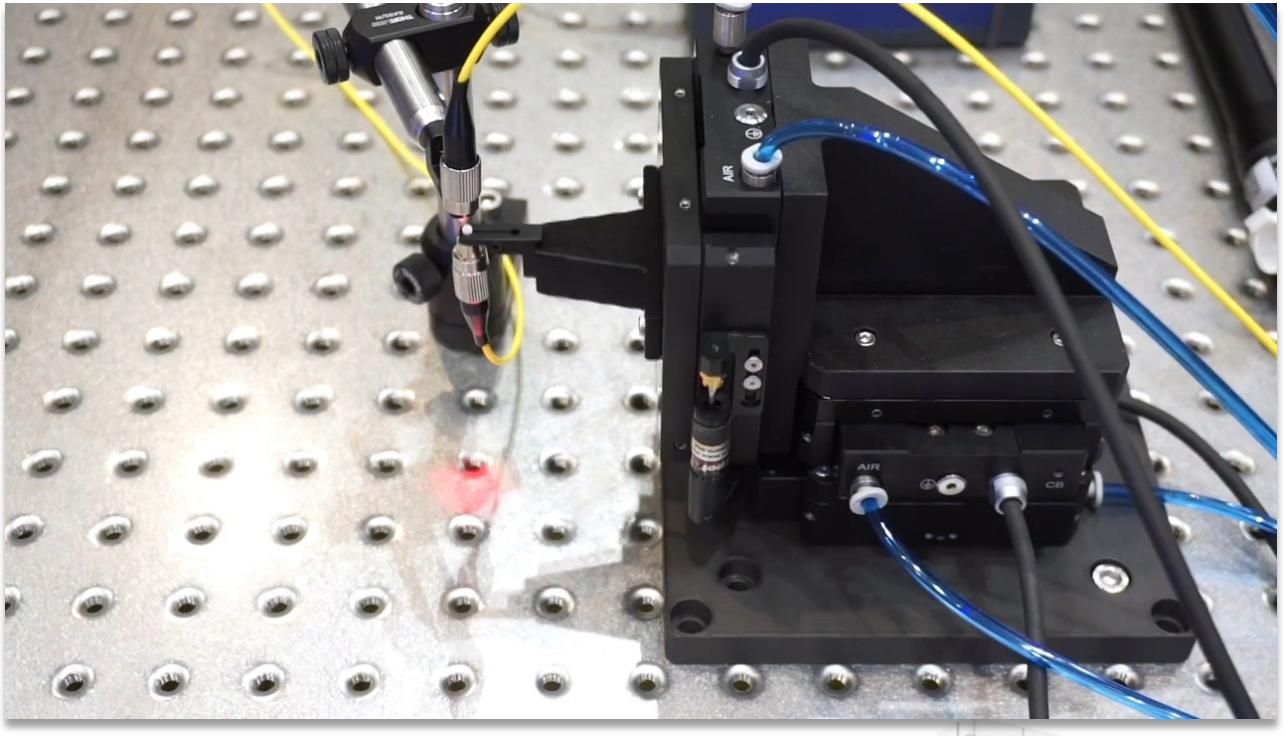


# *New: Air Bearing* Fast Alignment Engines

***Super cleanliness***

***Zero maintenance, Zero wear***

***Highest MTBF***

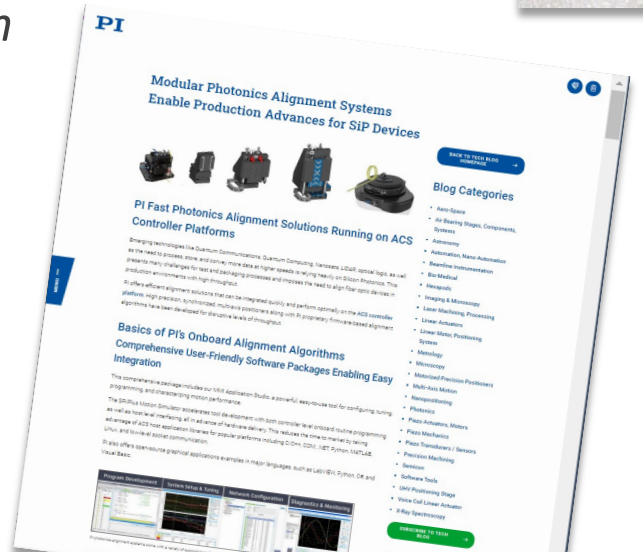


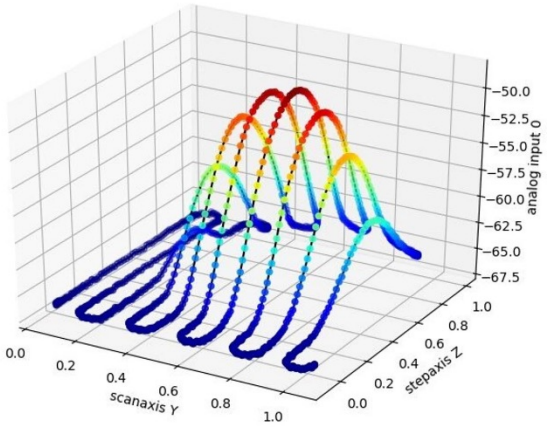
***Fast Area Scan***

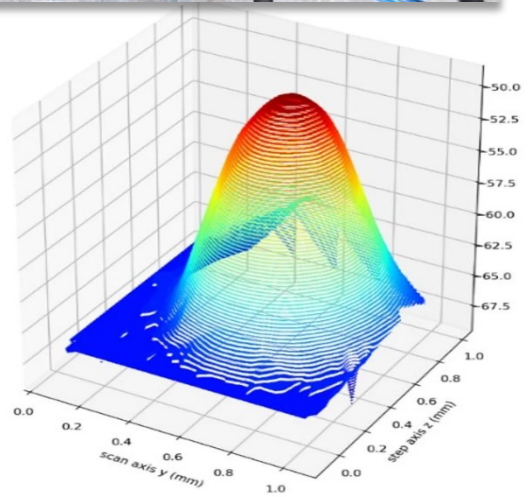
- *First light acquisition*
- *Profiling & characterization*

***Parallel Gradient Search***

- *Fast Optimization*
- *Real-time tracking across multiple DOFs*
- *Drift compensation*
- *Lock-on*



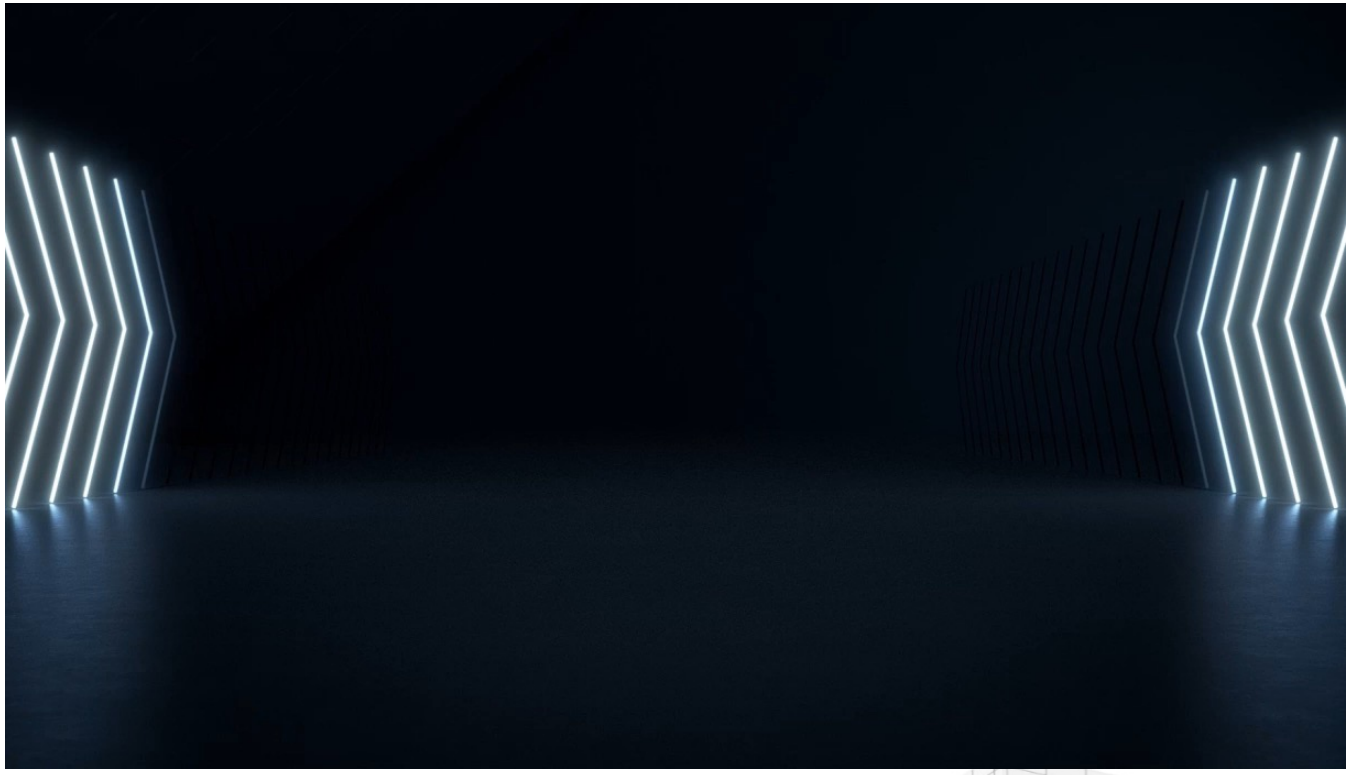



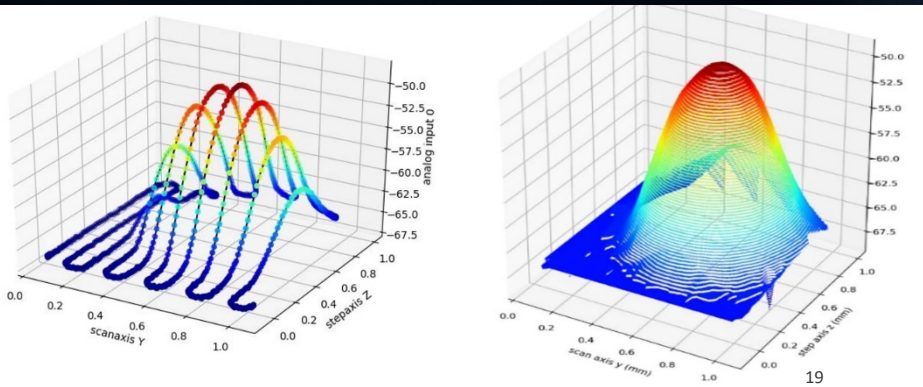
# *NEW:* Revolutionary Fast First-Light Acquisition

## *PILightning: Solving the First-Light Problem*

***Now:***

- *Typ. >10X faster first-light acquisition*
- *Even higher gains for double-sided first-light acquisition*
  - *Parallel first-light seek!  Typ. <1sec*
- *Single command, fully autonomous, respects soft limits*
- *Integrated with full FMPA alignment suite*





# *NEW:* Revolutionary Fast First-Light Acquisition

## *PILightning: Solving the First-Light Problem*

# *The Ecosystem Emerges:* Contract Manufacturing

## The silent partner

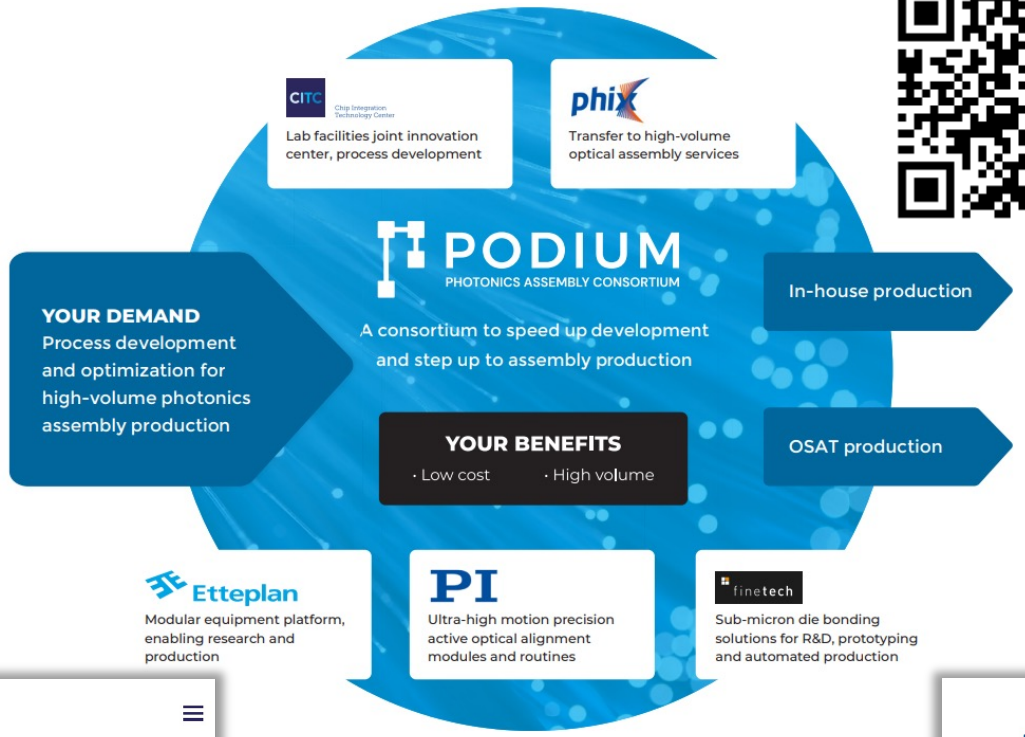
- Photonic-competent players exist
  - Example: Fabrinet →
- Scalability
- Global presence
  - Geographically strategic

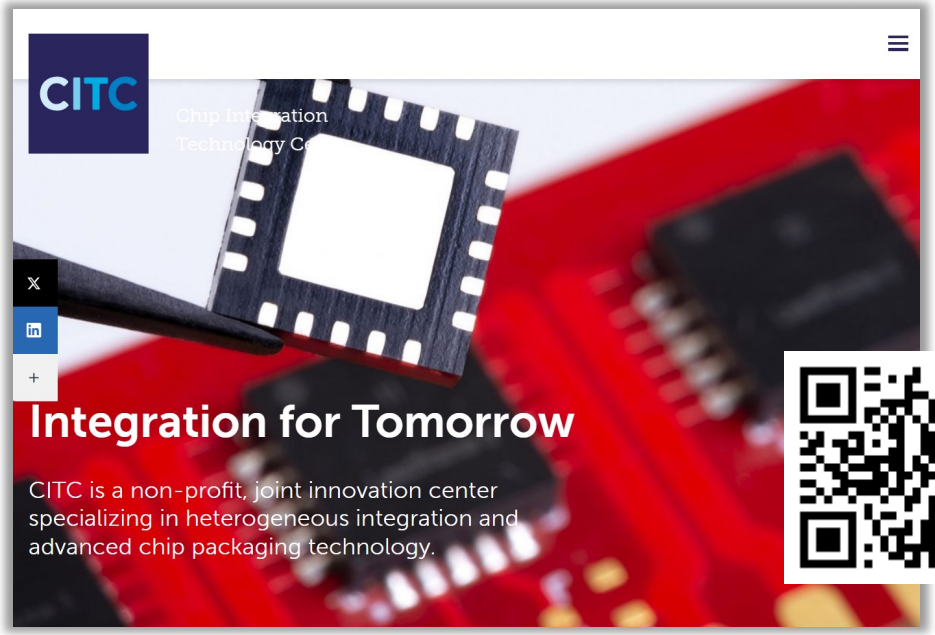

Courtesy Fabrinet
Used with permission

# *The Ecosystem Emerges:* Consortia and Foundries

## The pathfinders

- Expertise from packaging concept to scaling

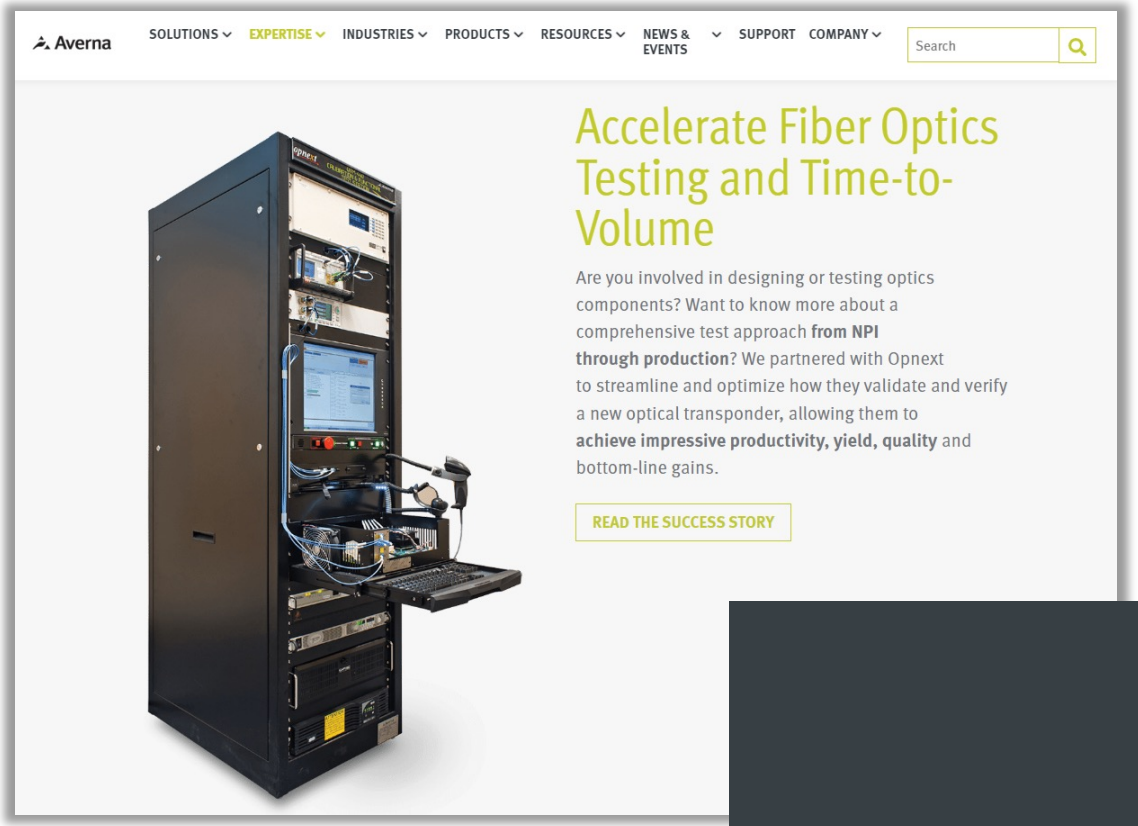



# *The Ecosystem Emerges:* Systems Integrators

## The builders

- Custom tools to accomplish mission-critical tasks
- From concept to scale
  - Example: Averna →




Averna

# *The Ecosystem Emerges:* Toolmakers

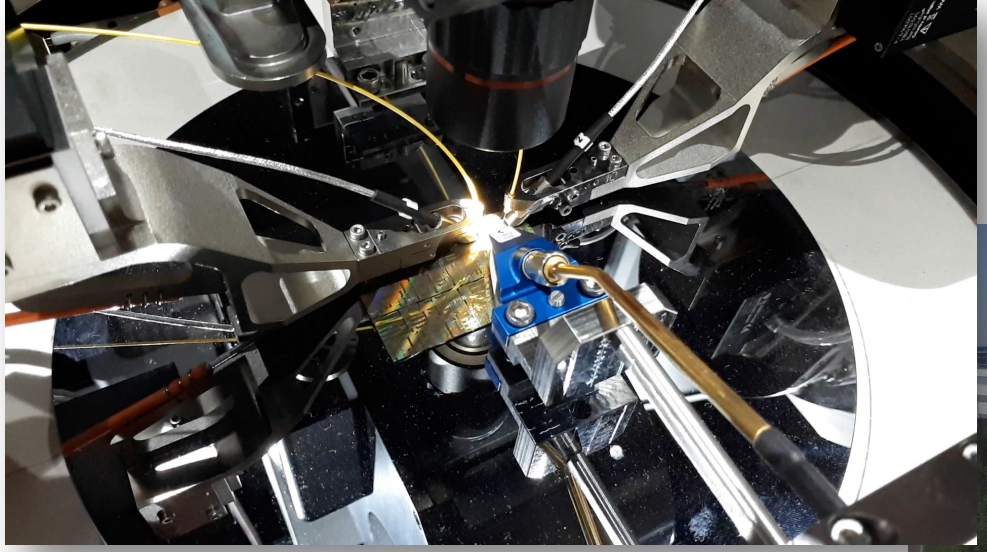
## The avatars of market maturity

- Standard solutions for economic scaling

  Examples:

  FormFactor →
  *Wafer-test pioneer*

Etteplan →
*High-throughput assembly*



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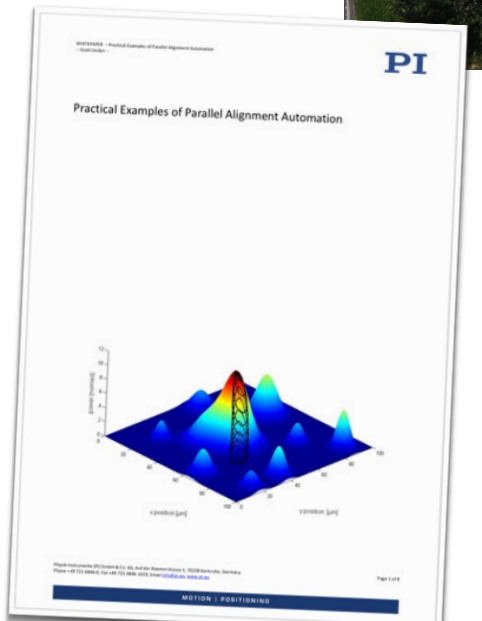


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